ABC's of Treatment Strategies for Upper Extremity Instabilities

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Objectives

• Describe the basic functional anatomy and biomechanics of the shoulder, wrist and elbow
• Implement the concepts of functional rehabilitation
• Assess pathomechanics of instabilities of the shoulder, elbow and wrist
• Utilize evaluation tests and interpret diagnostic values of tests for application to daily clinical practice
• Implement neuromuscular training and core strengthening to treatment strategies

THEMES

• Rehabilitation concepts
  – Themes of stabilization functional rehabilitation
  – Rest and immobilization required for healing
  – Specific structures require protection
  – Gradual ROM progressions based on soft tissue healing
  – The core matters
  – Gradual progression towards strengthening and return to previous level of function
  – Proximal and distal joint movement patterns addressed to avoid further injury
  – Proprioception training/sensorimotor activities
THEMES: Secrets to Stabilization
Functional Rehabilitation

Core
Motor Control
Dynamic Stability
Static Stability

Local Stabilizers

Global Stabilizers

Function Rehabilitation
Core Stability

Motor Control

Global Mobilizers

Local Stabilizers

Global Stabilizers

Global Mobilizers

Dysfunction

Local Stabilizers

• Abnormal movement at 1 segment
• Reflex inhibition
• Poor response to load
• Poor movement patterns at segment

Global Stabilizers

• Decreased force production
• Reflex inhibition
• Dysfunctional recruitment pattern

Global Mobilizers

• Overactive & tight muscles
• Spasms
• Results in decreased movement patterns at several joints
GLENOHUMERAL STABILIZERS

STATIC
- Ligaments/Capsule
- Geometry of GH joint
- Glenoid Labrum
- Negative intra-articular pressures


Glenohumeral Static Stabilizers

- Ligaments
- Labrum
- Capsule
- Boney Architect

Ligaments of the Shoulder Girdle
- Sternoclavicular (SC)
  - Anterior, Posterior
  - Costoclavicular
- Acromio-clavicular (AC)
  - Coracoacromial
  - Coracoclavicular (conoid, trapzoid)
- Superior Transverse Ligament
- Coracohumeral ligament (CHL)
- Glenohumeral ligament (superior, middle, inferior)
Ligaments of the Shoulder Girdle

Sternoclavicular

- **Interclavicular** (holds shoulder up)
- **Anterior/posterior**
- **Costoclavicular**

Mechanism of Injury SC ligament

**Direct or Indirect force**

**Anterior dislocation**
- 8 wks in sling
- Elbow/wrist ROM
- 8 wks: ROM below 90° (gradual reduce sling wear)
- **12 wks**: Full ROM and strengthening

**Posterior dislocation**
- Posterior dislocation: 6-8 wks figure of eight clavicle strap and gentle pendulums. Avoid flex and abduction above 90°


Ligaments of the Shoulder Girdle

- **Acromio-clavicular**
- **Acromoclavicular** ant/post translation, provides horizontal stabilization
- **Coracoacromial** ant/post. translation
- **Coracoclavicular** vertical displacement
Mechanism of Injury AC ligament

Fall directly on shoulder

Types I & II
- 1 to 3 wks wear sling (discharge as pain subsides)
- ROM and strengthening

Type III (conservative)
- 3 to 4 wks wear sling
- Progress ROM & strength

Types IV, V (Reconstruction Procedures)
- 6-8 wks Gunslinger Shoulder Orthosis
- AROM elbow, wrist and hand
- 7 to 10 days PROM to 90° flexion supine
- AROM 6 to 8 wks
- Strengthening at 12 wks if no pain with arom.
- 12 to 16 wks gradual return to pre-injury activity level


Glenohumeral Ligaments
- Coracohumeral ligament (CHL)

- Glenohumeral ligament (superior, middle, inferior)

Glenohumeral Ligaments
- Coracohumeral ligament (CHL)

- Superior glenohumeral ligament (SGHL)
- Middle glenohumeral ligament (MGHL)
- Inferior glenohumeral ligament (IGHL)
- Posterior band glenohumeral ligament
Ligaments of the Glenohumeral Joint/Coracohumeral

- **Coracohumeral ligament (CHL)**
  Connects coracoid process to greater and lesser tuberosities of the humerus

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Ligaments of the Glenohumeral Joint/Coracohumeral (SGHL, MGHL, IGHL)

- **Superior glenohumeral ligament (SGHL)**
  Connects anterosuperior edge of the glenoid to the lesser tubercle of the humerus
- **Middle glenohumeral ligament (MGHL)**
  Connects supra-glenoid tubercle, superior labrum or scapular neck to lesser tuberosity
- **Inferior glenohumeral ligament (IGHL)**
  Connects anteroinferior labrum and glenoid lip to lesser tuberosity

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Stabilizers Against Anterior Translations

- **Humerus adducted**: Subscapularis
- **Humerus abducted 45°**: Subscapularis, middle anterior GH ligament, and superior portion of inferior anterior GH ligament
- **Humerus at 90° abduction**: Inferior anterior GH ligament

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*Turkel et al 1981*
Glenohumeral Static Stabilizers

- Ligaments
- Labrum
- Capsule
- Boney Architect

http://www.ithaca.edu/faculty/AH/norton/1298/Scalp_Lab.pdf
**Static Stabilizers**

Glenoid Labrum

Fibrocartilage Structure

- ^ depth of glenoid fossa by 50%
- Provides attachment of GH ligaments
- Firmly attached in all regions except loosely superiorly

Illustration retrieved from:
http://www.sportsinjuryclinic.net/gallery/shoulder/glenoid_labrum2.jpg

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**Glenohumeral Static Stabilizers**

- Ligaments
- Labrum
  - **Capsule**
- Boney Architect

Illustration retrieved from:
http://www.ithaca.edu/faculty/lahr/LE2000/UE_Ind_Study_99/shoulder/edited/glenoid_fossa.jpeg

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**Static Stabilizers**

Negative Intra-articular Pressure

- Creates a vacuum effect across GH joint
- Primary stabilizer against inferior instability
- Also prevents instability in other directions

Illustration retrieved on 2/26/12 from:
http://www.shoulderdoc.co.uk/images/uploaded/labrum_depth.jpg

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Glenohumeral Static Stabilizers

- Ligaments
- Labrum
- Capsule
- Boney Architect

Static Stability


Secrets to Stabilization Part 1

130° to 150°
Retroverted 30°

Defining Shoulder Instability

- Shoulder instability is the inability to maintain the humeral head in the glenoid fossa.
  - Dislocation: the humeral head is forced completely out of its normal position in the glenoid fossa.
  - Subluxation: the humeral head slips partially out of glenoid fossa causing symptoms
  - Laxity: partial lost of glenohumeral articulation without symptoms
Circle Concept of the Shoulder

- Capsuloligamentous restraints act in a ring fashion
- Translations of the humerus create tension on the same and opposite sides. Therefore, translation in one direction may require damage to restraints on the same and opposite sides of the joint.
- Contra-coup concept is injury can occur to the opposite side of the injury

Epidemiology of Shoulder Dislocations

Acute

- Approximately 24 out of 100,000 are estimated to have acute shoulder dislocations
- 4% to 8% of all injuries sustained by active population
- TUBS: traumatic, unilateral, bankart
- High Risk Factors:
  - Young males (ages 15 to 29 years old)
  - Dislocations most often occur from sports or recreation
  - Most frequently seen as a result of a fall
  - The estimated incident is on the rise

Acute Shoulder Dislocations

- High recurrent rate in younger population

Incidence of Recurrent Dislocation %

<table>
<thead>
<tr>
<th>Age Group</th>
<th>No Recurrent</th>
<th>Recurrent</th>
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<tbody>
<tr>
<td>&lt;20 yrs</td>
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<tr>
<td>20-40 yrs</td>
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<tr>
<td>&gt;40 yrs</td>
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</tbody>
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Holevis et al. 2008
Sensorimotor Insufficiencies

• Recurrent anterior instability sensorimotor insufficiency increase with dominant side involvement (Edouard, Gasq, Calmes & Degache, 2014)

Etiology of Traumatic Shoulder Dislocations

• Unidirectional from traumatic event (anterior is the most common)
  ➢ Most commonly caused by a fall on an outstretched hand or a sudden forceful motion in the abd/er position
  ➢ Bankhart
  ➢ Superior Labrum Anterior Posterior (SLAP)
  ➢ Most common direction of instability is anterior/inferior from falling in 90/90 position (ABD/ER)

(Sacchi & Deve, 2010)

Special Tests Anterior Instability

Apprehension & Relocation

Sensitivity .81, Specificity .98 (Farber et al 2006)
Pathomechanics:
Bankart Lesion/Anterior Instability

- Instability of the anterior-inferior glenohumeral joint capsule.
  
  OR
  
- Detachment of the anterior-inferior glenoid labrum from the glenoid rim.

Boney Bankart Lesions

Superior Labrum Anterior-Posterior (SLAP)

- Fall on an outstretched abducted arm or sudden contraction of biceps tendon or repetitive stress. Or, repetitive injury related to eccentric deceleration “peel back”
Pathomechanics: Peel Back Mechanism in Throwing Athletes

- High eccentric activity of the biceps during arm deceleration.
- Torsional peel back force detaching labral anchor.

Pathomechanics: SLAP

- Type I/Fraying
- Type II/Biceps & Labrum are becoming detached
- Type III/Biceps & Labrum are stable on glenoid, but a flap hangs down
- Type IV/Bucket handle tear extending into the biceps

Special Tests for Superior Labrum Anterior Posterior (SLAP)

Active Compression & Passive Distraction Sensitivity .70, Specificity .90 (Hegedus et al 2012)
Etiology: Atraumatic Shoulder Multidirectional Instabilities

- Instability from micro-trauma from repetitive motions in one direction or multi-directional
  
  > Voluntary: Individual subluxes or dislocates volitionally
  > AMBRI: atraumatic, multidirectional, bilateral, rehabilitation, inferior shift
  
  > Involuntary: Subluxes or dislocates involuntary
Poll Question

Is the posterior inferior direction the most common dislocation of the shoulder?

a. Yes
b. No

PROTECTIVE PHASE REHABILITATION

- Glenohumeral joint is reduced and the arm is placed in a sling.
- Current evidence does not support ER to avoid recurrent shoulder dislocation (Vavken et al. 2014)
- Duration of immobilization (Paterno et al. 2014)
- ER with ABD may reduce the rate of recurrent dislocation/3 wk
**Important Considerations with Surgical Procedures**

**PROTECT HEALING STRUCTURES**

**Arthroscopic Repair / Bankart**
- Remain in sling except for table slides and passive flexion to 90°.
- Gradual external rotation during reparative phase (passive ER gradual stress at 3 to 4 wks post-op).
- No combined ER and ABD during reparative phase.
- Gradual progression of ROM and light strengthening during remodeling (no forceful stretching).
- Progress strengthening during maturation phase.

*Sperber et al 2001*

Image retrieved from: [http://www.theshoulderdoc.com/content/assets/bankart_layout.gif](http://www.theshoulderdoc.com/content/assets/bankart_layout.gif)

**Arthroscopic Repair / SLAP Type II**

Protect repair (10:00-2:00)
- Slow ER progressions limiting passive ER to 40° in scapular plane during reparative phase.
- Avoid extension and horizontal abduction for ~4 wks PO, remain in sling.
- Avoid resistance to elbow (extension and supination).


**REHABILITATION of Shoulder Dislocations: Reparative Phase**

- Continue immobilization.
- Maintain elbow and forearm motion.
- Maintain grip strength.
- Active assist to 90° in flexion and 60° scaption.
- Begin isometrics when sling is removed for external rotators.
- Avoid motions of abduction and external rotation.
FUNCTIONAL EXERCISES REMODELING TO MATURE PHASE

Core Stability

- Lumbopelvic region (inferiorly)
- Abdominals (anteriorly)
  - Transversus abdominis (TA)
  - Internal & external obliques
  - Rectus abdominus
- Diaphragm (superiorly)
- Paraspinals and gluteals (posteriorly)

TA is the first muscle that activates when lifting arm overhead

Secrets to Stabilization Part 1

Core Stability

  - Core strengthening resulted in 62% reduction of lost time and 42% reduction of injuries.
- Behm, Drinkwater, Willardson & Cowley (2011)
  - Stabilization exercises prevent low back dysfunction
- Emery, De Serres, McMillan & Cote (2009)
  - Core training improved thoracic posture, abdominal strength and stabilized core posture with shoulder flexion
  - Core strengthening improved upper extremity function
- Nagai et al 2012
  - Trunk rotation improves scapula kinematics
SHOULDER STABILIZERS

DYNAMIC
- Muscles
  - Scapular Stabilizers
  - Rotator Cuff Muscles
  - Long head of the biceps

Dynamic Stability
- Muscle contraction
- Joint position
- Signals agonist to relax

Motor Control
- Muscle Spindles

Golgi Tendon
- Joint movement
- Positions sense
- Reflex muscle contraction

Proprioception
Conscious Sensations
- Gnostic Position/Movement
- Tension or Force
- Sense of Balance
- Sense of Effort

Neuromuscular Control/Unconscious Stability
- Force couples of glenohumeral joint provide information on compression
  - Muscle spindles provide information on position sense and reflexive muscle contraction
  - Golgi tendons are tension sensitive and signal agonist to relax
    - Compliment input from capsuligamentous input to extreme motions (Ruffini) and compressive (Pacinian)
Neuromuscular Control/Unconscious Stability

- SCAPULA
- POSTERIOR
- ANTERIOR

Shoulder Dynamic Stabilizers

Local Stabilizers
- Deep/close to axis of movement
- Constantly modulating
- Constantly modulates force output
- Highly proprioceptive
- Type I

Global Stabilizers
- Deep or superficial
- Controls inner and outer range
- Controls eccentric motions
- Highly proprioceptive
- Type IIa

Global Mobilizer
- Superficial
- Force w/length changes
- Primarily concentric
- Recruited with high load & high speed in open kinetic chain

Local Stabilizers
- Rotator cuff
- Long head of the biceps
- Lower and middle trapezius

Global Stabilizers
- Teres major, deltoids, coraco-brachialis, upper & middle trapezius, serratus anterior

Global Mobilizer
- Rhomboids
- Pectoralis minor
- Levator scapula
- Latissimus dorsi
- Pectoralis major
- Short head of biceps
- Long head of triceps
- Latissimus dorsi

Abnormal movement
- Reflex inhibition
- Poor response to load
- Poor movement patterns at segment

Reflect inhibition
- Overactive & tight muscles
- Spasms
- Results in decreased movement patterns at several joints
Early isometrics of external rotators

Isometric contraction side-lying (pushing down in table)

REHABILITATION of Shoulder Dislocations: Remodeling Phase

- Gradual motion and strengthening to 90°/90° (ER/ABD)
- Progress positions as pain decreases
- Proprioception training

Progress Position
• SERAPE EFFECT
  – Transfers stored energy into potential energy.
  – Transverse abdominus will activate before the initiation of movement to brace the body before the core generates power.

Hodges & Richardson, 1996

Decreased scapular upward rotation and increased scapular internal rotation in subjects with shoulder instabilities

Struyf, Nijs, Baeyens, Mottaram & Meeusen, 2011
Gradually Add Increased Challenges

Mature Phase: Work towards functional strengthening for return to previous activity level

Proprioception
Poll Question

1. Is limiting passive external rotation appropriate after a SLAP or Bankart surgery?
   
a. Yes
b. No
ELBOW STABILIZERS

- **STATIC**
  - Boney Congruency
  - Capsule
  - Medial Collateral Ligament
  - Lateral Collateral Ligament Complex

- **DYNAMIC**
  - Biceps
  - Brachialis
  - Brachioradialis
  - ECRL
  - Triceps
  - Anconeus

Other Stabilizers: Elbow Capsule

- Small contributor as a passive soft tissue stabilizer (questionable)
- Most lax at 80 degrees of flexion (consider this extensible meaning the capsule is not restraining)
- Position of comfort after injury
- Risk of flexion contracture
Static Stabilizers

- Medial collateral ligament (MCL)
- Lateral collateral ligament (LCL)
- Humeroulnar Joint

Anterior Capsule (taut with elbow ext)

Medial Collateral Ligaments

- Elbow extension stability to valgus stress
  - MCL contributes 30%
  - Anterior capsule 30%
  - Bony Articulation 40%

- Elbow at 90 degree flexion stability to valgus stress
  - MCL contributes 55%
  - Anterior capsule 10%
  - Bony articulation 35%

Lateral Collateral Ligaments

- Annular ligament

- Radial collateral ligament

- Lateral ulnar collateral ligament (LUCL)
  - Provides stability to posterolateral rotation

- Accessory lateral collateral ligament

Lateral Collateral Ligaments

- Elbow extension stability to varus stress
  - LCL contributes 15%
  - Anterior capsule 30%
  - Bony Articulation 55%

- Elbow at 90 degree flexion stability to varus stress
  - LCL contributes 10%
  - Anterior capsule 15%
  - Bony articulation 75%

Retrieved on 12/07/10 from:
ELBOW STABILIZERS

• DYNAMIC
  – Biceps
  – Brachialis
  – Pronators
  – Supinators
  – Brachioradialis
  – Wrist/digit extensors & flexors
  – Triceps
  – Anconeus

Elbow Dynamic Stabilizers

Local Stabilizers
  • Anconeus (deep fibers)
  • Pronator Quadratus (deep fibers)
  • Supinator (deep fibers)

Global Stabilizers
  • Brachialis
  • Brachioradialis
  • Triceps (medial & lateral heads)
  • Anconeus (superficial fibers)
  • Supinator (superficial fibers)
  • Pronator Quadratus (superficial fibers)
  • ECU (ulnar head)
  • FCU (ulnar head)
  • APL

Global Mobilizer
  Biceps Brachii (long & short heads)
  Triceps Brachii (long head)
  Wrist & Digit Extensors
  Pronator Teres
  Wrist & Digit Flexors

I. Elbow Pathology Ligamentous
Lateral Collateral Ligament (LCL)

• Ligamentous
  – Lateral collateral ligament sprain or tear is also associated with trauma and often occurs with a fracture
  – Mechanism of injury
    • Fall on outstretched hand (FOOSH)
    • Forced twisting of the arm with varus (lateral) forces
Elbow pathology – ligamentous (LCL)

- Ligamentous stress tests
- Lateral Collateral Ligament (LCL) injury = Varus Stress Test
  - Elbow 20-30° flexion; forearm supinated
  - Examiner places one hand on medial elbow, the other on distal radial wrist
  - Apply medial force to wrist – this translates varus force to the elbow
  - Positive if painful or more lax than contralateral

Elbow pathology – ligamentous (LCL)

- Movement without stability is usually painful
- Elbow typically becomes more unstable as it moves into extension.
- Placing the elbow in 20-30 degrees of flexion unlocks the olecranon from the humerus.

  - Should be rehabilitated in pronation b/c the elbow is more stable from varus forces in pronation

Elbow pathology – ligamentous (LCL)

- Not all tears are repaired; sometimes they are left to heal on their own
- This can lead to chronic instability
- Ligament repair can occur if surgery is performed within 2-3 weeks of injury
- Ligament reconstruction is chosen if injury is more than 3 weeks old
- Palmaris longus is usually used for reconstruction

- If not repaired...
Posterolateral Rotatory Instability (PLRI)

Can result from a FOOSH with forearm supinated

I “snapping”
II varus instability
III Post. Dislocation
IV Complete instability

Leads to ulna (moving with radius due to annular ligament) externally rotating away from trochlea

(Picture resourced from Radsource: http://www.radsource.us/clinic/0901)

Special Tests: Lateral Elbow
Posterolateral Rotary Instability

Push-up and Stand-up tests
Sensitivity: 87.5%
Specificity: 100%

(Sayer et al 2006)

Rehab PLRI (LCL complex)
Elbow pathology - ligamentous

• General Post-op LCL Reconstruction Guidelines
  - Splint 90° flexion, pronated
  - AROM extension/flexion; extension limited to 60° initially and gradually increased
  - Forearm rotation from pronation to neutral only for 6 weeks
  - D/C splint at 6 weeks
  - Gradually resume supination

(Secrets to Stabilization Part 1)
Rehab PLRI (LCL complex)

- Flexion and pronation increase the contact between the radial head and capitellum.
- Studies have shown that the LCL deficient elbow is more stable in pronation.
- Shoulder AB and IR increase varus stress to the elbow—so avoid this position with exercises.
- If both medial and collateral ligaments have been repaired, elbow should be splinted in neutral rotation.

(Dynamic Stabilizers)

Dynamic Stabilizers Against Varus Stress

- Isometric strengthening EDC, ECRB & ECRU (An, Kaufman & Chao, 1989)

Elbow pathology - MCL

Medial collateral ligament injury

- May have spontaneous failure characterized by a “pop”
- Onset may be vague, characterized by failure to perform at less than normal ability:
  - Decreased accuracy
  - Decreased velocity
  - Decreased endurance
Elbow pathology - MCL

MCL Injury
- If no specific “pop” or rupture is noted, conservative management consisting of strengthening the muscles surrounding the joint, is pursued.
- If surgery is required, ligament repair may be possible in nonprofessional athletes
- Most professional athletes require ligament reconstruction, aka “Tommy John Procedure”.

Special Tests: Medial Elbow
Medial Collateral Ligament Instability

Valgus Stress Test:
- Sensitivity: 66%
- Specificity: 60%

Moving Valgus:
- Sensitivity: 100%
- Specificity: 75%
Elbow pathology - ligamentous

Conservative Management MCL Injury

- Protect – no overhead activity
- AROM - sagittal plane
- Strengthening - core, shoulder, elbow, and wrist
- Thrower’s Ten Program for shoulder, elbow, forearm, and wrist
- Evaluation of throwing technique
- Advanced Thrower’s Ten Program

Elbow pathology - ligamentous

- Post-operative management of MCL injury
  - Splint in neutral rotation, 90° flexion
  - Active elbow extension and flexion, with full extension limited initially
  - AROM digits and wrist; ok to grip
  - Isometric strengthening of shoulder. **No external rotation of shoulder as it creates valgus stress at elbow**
  - Splint D/C’d at 6 weeks
  - Progress through full ROM and into Thrower’s Ten
MCL Strengthening Considerations

CLINICAL PEARL!!
• Strengthen flexor carpi ulnaris, and flexor digitorum superficialis to increase stability
• Radial head contributes to stability
• Start exercises in supination and progress to pronated position.

Secrets to Stabilization Part 1 100
Intermediate Phase
Sub-Maximal Isometrics
Medial Collateral Ligament Rehab.

• Strengthen with forearm in supination. FCU & FDS and isometric pronation

Secrets to Stabilization Part 1 101
Advance to Mature Phase
Motor Control / Proprioception Training

Decreased joint position sense compared healthy elbows

Secrets to Stabilization
Elbow Trauma Dislocations & Fractures

Dislocation Classification

- **Simple**
  - Small osseous fractures not affecting joint stability
  - Described as posterior, anterior, medial, lateral
- **Complex**
  - Described as posterior, anterior, medial, lateral, or divergent
- **Acute** (less than 2 weeks)
- **Subacute** (2 to 4 weeks)
- **Chronic** (6 weeks or more)

Sheps et al 2004

![Normal](http://www.scripts.com/color/skeletal/normal_elbow.jpg)
![Posterior](http://www.scripts.com/color/skeletal/posterior_elbow.jpg)
![Medial](http://www.scripts.com/color/skeletal/medial_elbow.jpg)
![Lateral](http://www.scripts.com/color/skeletal/lateral_elbow.jpg)
![Divergent](http://www.scripts.com/color/skeletal/divergent_elbow.jpg)
Evidence for Early Motion in Simple Posterior Dislocations

- Loss of extension is the most frequent complication

- Ross et al protocol: Immediate active motion combined with modalities to reduce pain and swelling and UE strengthening. Results of nearly full ROM within 5 degrees of extension.

ELBOW TRAUMA

Radial Head Fractures in Elbow Trauma

- Terrible Triad
  - Posterior or posterolateral dislocation of ulnohumeral joint with fractures of the radial head and coronoid process. Avulsion of medial collateral ligament (MCL) and lateral collateral ligament (LCL)
  - Coronoid process provides stability
    - Buttress against posterior displacement of the ulna and contributes to varus stability

- Essex Lopresti: radial head fracture, rupture of the interosseous membrane (IOM) resulting in forearm instability and proximal migration of the radius
Radial Head Fractures
Internal Fixation or Radial Head Replacement

• Fragmentation of less than 3 fragments have improved results with fixation (Ring & Jupiter, 2001)
• Lateral collateral ligament protection may be required if ligament re-attached or involved, reattached after surgery (pronation) at 2 days post-op allow pro/sup with elbow flexed at 90°

Internal Fixation

• Phase I
  – Early mobilization 3 to 5 days post-op/PROM gentle
  – Posterior elbow orthosis 90° flexion with forearm neutral
  – Regain motion 1 to 3 wks post-op AAROM (flex/ext, pro/sup)
  – CPM
• Phase II (4 to 6 wks post-op)
  – Regain full motion and gradual strengthening
• Phase III (6 to 12 wks)
  – Advance strengthening and closed chain exercises
  – Joint mobilizations
  – End range strengthening

Radial Head Replacement

• Phase I (Week 1 to 3 post-op)
  – Early mobilization (orthosis CPM forearm pronated or neutral), AROM wrist and hand during 1st week
  – Hinged elbow orthosis worn at all times
  – Advance elbow and forearm motion exercises. Elbow AAROM with gravity assisted extension. Position elbow at 90° flexion during forearm exercises
  – Consider edema glove for hand
• Phase II (Week 3-6 post-op)
  – Begin AAROM pro/sup, PROM elbow stretching to tolerance, initiate orthosis to increase flex/ext if needed, advance to AROM forearm rotation and elbow motion
• Phase III (Week 6-8 post-op)
  – Discharge hinged orthosis, begin isometrics, continue mobilization orthosis
• Phase IV (Week 8-12 post-op)
  – Light resistance gradually upgrade strengthening
Distal Humerus Intra-articular Fractures

Fixation Plating (post-op 1 week):
• Edema control
• Long arm orthosis alternating between elbow flexion daily and elbow extension nightly
• Elbow, shoulder, forearm, wrist, hand AROM every 1 to 2 hours

Post-op 2 weeks:
• Initiate scar management
• Progress ROM each week
• Non-weight-bearing until fracture healed
• Strengthening when fractured healed

CHALLENGE

- Stability

- Mobility

Stability

- Know the safe arc of motion
- Closed pack position
  • Humeral head: neutral, Humeroradial 90° flex/30° sup

Mobility

- Maximize ROM, scar management, prevent contracture
- Exercise positioning and working dynamic stabilizers

Function

- Maintain ROM and strength to uninvolved structures

Warning

- Monitor ulnar nerve involvement
- Recognize symptoms of heterotrophic ossification
- Implement mobility orthosis when appropriate/avoid contracture
Customizing Therapy to Patient

Should I incorporate CPM?
• Indicated to prevent post-traumatic stiffness based on rationale:
  – Acute bleeding and edema result in swelling of peri-articular tissues limiting joint motion and ↑'ing pain
  – Moving the joint through its entire range can empirically prevent stiffness and edema
  – Subacute stage: deposition of extracellular matrix and granulation tissue; cpm used to accomplish full ROM (1 week to 4 weeks)

Should I Incorporate CPM?
• Phase I
  – Prevent joint stiffness
  – Minimize edema
  – Minimize hydrostatic joint pressures

• Evidence Controversial
  – CPM vs no CPM post open contracture release (Lindenhovius et al. 2009)
  – CPM vs no CPM total knee arthroplasty (MacDonald et al. 2000)

How do I protect soft tissue structures?
• Lateral collateral ligament (LCL) protection may be required if ligament reattached or involved.
• Protect LCL with the patient supine and placing forearm in pronation during ROM
• May allow pro/sup with elbow flexed at 90 at 2 days post-op
• Avoid adduction and internal rotation of the shoulder limiting varus stress (Dunning et al. 2001)

Hand on forehead maintaining pronation
What muscles can I begin isometric strengthening for stability?

**Dynamic Stabilizers Against Varus Stress**
- Isometric strengthening EDC, ECRB & ECRU (An, Kaufman & Chao, 2008)

**Schickendantz, M (2002). Bindra & Bringer, 2010**

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How do I protect soft tissue structures?
- Medial collateral ligament (MCL)
  - Hinged orthosis with forearm in supination to block end range extension gradually add ~10° extension weekly
  - Elbow motion performed within safe arc and forearm supinated
  - Avoid external rotation and abducted positions of the shoulder during early phases of healing limiting valgus stress

**Park & Ahmad, 2004**

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What muscles can I begin isometric strengthening for stability?

**Dynamic Stabilizers Against Valgus Stress**
- Isometric strengthening flexor pronator mass, flexor carpi ulnaris, and flexor digitorum superficialis to increase stability (Park & Ahmad, 2004)

**Schickendantz, M (2002). Bindra & Bringer, 2010**
How should I position the forearm during elbow ROM?

- Protect LCL w/forearm pronated
- Protect MCL w/forearm supinated

### Poll Question

Which of the following shoulder motions will place the most stress on a healing medial collateral ligament?

- a. Adduction combined with internal rotation
- b. Abduction combined with external rotation
- c. Forward flexion
- d. Extension with internal rotation

### Customizing Therapy to Patient

What are the signs of heterotopic ossification?

- Risk Factors: > 1 reduction in head injuries, burns, operative care > 48 hours after injury, floating fractures
- Signs & Symptoms:
  - Decreased ROM
  - Increased pain
  - Localized edema
  - Increase in temperature
What are the symptoms of ulnar nerve involvement?

Clinical Presentation
• Paraesthesia at ring and small fingers
• Elbow pain
• Weakness in grip

Clinical Management
• Nerve gliding, elbow orthosis nocturnally, protect cubital tunnel

Customizing Therapy to Patient

• What type of orthosis should I use when contracture has developed, static progressive or dynamic?

Elbow Static Progressive vs. Dynamic Orthosis

• *Lindenhovius, A. et al 2012*
  
  **Results**
  
  - 3 months: No significant differences
  - 6 months: DASH scores significantly improved in static progressive group
  - 12 months: No significant difference between groups for ROM and DASH scores
  
  - 6 month results:
    - Dynamic orthosis: ROM improved 40°
    - Static progressive: ROM improved 39°
  
  - 12 month results:
    - Dynamic orthosis: ROM improved 47°
    - Static progressive: ROM improved 49°

-- Most gains are in the first 3 months
-- No statistical significant difference for elbow ROM between the static progressive and dynamic orthosis

-- Regaining elbow motion factors:
  - Comfort, optimism, confidence & self-efficacy to perform elbow stretching
  - Patients can continue to make ROM gains for 12 months
  - Patients with an elbow contracture uncommonly request surgery

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Customizing Therapy to Patient

- Custom or pre-fabricated?

**PROS**
- Custom fabrication allows for improved fit
- Easy to make adjustments for patient's comfort
- Easy don/doffing & cleaning
- Hinge placement can be modified

**CONS**
- Fabrication time between 30 and 60 minutes depending on experience level
- Elbow flexion and extension motion limited to length of hinge
**Customizing Therapy to Patient**

**Custom or pre-fabricated?**

**PROS**
- Pre-fab: short wearing time
- Light weight & easy fitting with measurements
- Easy don/doffing & cleaning
- Results can reach up to 170° of flexion and -10° of extension
- Patient can track progress on

**CONS**
- Could be limited by insurance authorization
- Modifications to orthosis could be more timely
- Can be high profile depending on order

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**Poll Question**

Is it safe to begin early ROM in a type one radial head fracture that is minimally displaced?

a. Yes
b. No
WRIST/HAND INSTABILITIES

Bony Anatomy

- 2 long bones
  - Radius & Ulna
- 8 carpal bones
  - Proximal & distal rows
- 14 phalanges
- 5 metacarpals

FUNCTIONAL MOTIONS

- FLEXION
- EXTENSION
- RADIAL DEVIATION
- ULNAR DEVIATION
- CIRCUMDUCTION
- DART THROW AXIS

Retrieved on 05/01/09 from: www.dkimages.com/.../Darts/ Darts-15.html
Carpal Row Movements during Flexion/Extension

- Distal carpal row follows the direction of movement of metacarpals #2,3.
- Proximal row moves with the distal row, but there is more motion between the individual bones.
- Flexion: Proximal row glides dorsally and capitate glides dorsally on lunate.
- Extension: Proximal row glides volarly and capitate glide volarly.

Retrieved on 05/01/09 from: http://www.andysleigh.com/WristAndForearm/tutorial/wrist/page5a.html

Carpal Row Movements during Radial/Ulnar Deviation

Reciprocal Motion

- Ulnar Deviation: Distal row moves ulnarly and the proximal row extends and translate radially.
- Radial deviation: Distal row moves radially and the proximal row flexes and translate ulnarly.

Retrieved on 05/01/09 from: www.davidnelson.edu/Lichtman_talk.htm

Osseous Morphology & Kinematics

Radius & Ulna

- Distal radius articulates with proximal row at scaphoid fossa and lunate fossa.
- Ulna does not articulate with the carpus. Triangular disc articulates with carpus at distal ulna.

Retrieved on 05/01/09
From: www.answers.com/topic/ulna
Retrieved on 5/3/09
From: www.hughston.com/hha/a_13_3_1.htm
WRIST ARTICULATIONS

Consists of:
- Radiocarpal Joint
- Midcarpal Joint
- Distal Radioulnar Joint
- Interosseous Joints

Wrist Ligaments

- **Intrinsic** ligaments exist between carpal bones in capsule
- **Extrinsic** ligaments oblique orientation b-w peripheral of wrist to carpal bone & superficial to capsule
- **Radioulnar** ligament

Important Stabilizers

**Intrinsic**
- Scaphoid-lunate
- Lunotriquetral

**Extrinsic**
- Volar: Radioscaphocapitate, radiolunotriquetral, short radiolunate ligaments
- Dorsal: dorsal radiocarpal ligament
Examining the Wrist Column Concept

Radial Wrist
- Radial Wrist
  - THUMB CMC OA

Dorsal Central
- Scaphoid-Lunate Tear

Ulnar Wrist
- Lunotriquetral Tear (Dissociative)
- Triangular Fibrocartilage Complex Tear (TFCC)

THUMB CARPAL METACARPAL OSTEOARTHRITIS
(THUMB CMC OA, BASAL JOINT OA, DEGENERATIVE JOINT DISEASE)
DEFORMITY PATTERNS

- **Zig Zag** (most common)
  - MP hyper-extension, IP hyper-flexion resulting in CMC instability

- **Reverse Zig Zag**
  - MP hyper-flexion, IP hyperextension resulting in CMC instability

**Static Thumb Stabilizers**

- **Anterior Oblique/dAOL (Beak Ligament)**
  - Posterior Oblique/POL
  - Intermetacarpal/IML
  - Dorsal Intermetacarpal/DIML
  - Dorsal radiocarpal/DRL


Photo retrieve from: http://www.eatonhand.com/mus/thumbmus.gif

Thumb Adduction

- MP Hyper-ext
  - MP volar plate stretched
  - dAOL lax
  - Thumb Adduction
  - MP Hyper-ext
  - Diminished Proprioception TM Joint

FPL Primary Flexor
CMC Grind Test
1. Stabilize the trapezium with one hand.
2. Grasp the first metacarpal.
3. Compress the metacarpal base to the trapezium while applying an axial load to the metacarpal.
4. Pain is a positive test.

Conservative Treatment
- Soft Tissue Release of Adductor
- Mobilize CMC joint – Gentle Distraction
  Arm behind back. Hold involved thumb while the weight of arms provides distraction

Technique from: O’Brien V, Albrecht J. Fine Tuning the Care of the Painful Thumb. ASHT Instructional Course Webinar, 2012.
Conservative Management

• Neuromuscular re-education and strengthening for thumb stabilizers
• Strengthen thumb intrinsics
• Strengthen thumb and wrist extensors
• Teach Functional Pinch

Poll Question

Which of the following exercises is most appropriate to strengthen for individuals with thumb CMC osteoarthritis?

a. Flexor pollicis longus
b. Adductor pollicis
c. Adductor digiti minimi
d. Extensor pollicis brevis, opponens pollicis, abductor pollicis brevis, 1st dorsal interossei

Radial Wrist

• THUMB CMC OA

Ulnar Wrist

• Lunotriquetral Tear (Dissociative)
• Triangular Fibrocartilage Complex Tear (TFCC)

Dorsal Central

• Scaphoid-Lunate Tear
Tendencies of the Scaphoid and Lunate

- Scaphoid flexes
- Without ligament support it will tilt volar
- Dorsal intercalated instability (DISI)

Dorsal Central Wrist
Scaphoid-Lunate Dissociative

- History & Clinical presentation:
  - Hyper-ext/UD injury
  - Radial sided pain
  - Click and/or clunk
  - Weakness of grip
  - Limited wrist ROM
  - Positive Watson’s test
  - Ring sign on AP view

Scapholunate Dissociation
Dorsiflexion Intercalated Segment Instability (DISI)
Watson’s test: Provocative test for scaphoid instability.

Procedure:
• Ulnar deviate the wrist with extension
• Pressure to palmar aspect of distal scaphoid
• Then, radial deviate the wrist with flexion

Positive Test: Proximal pole of scaphoid shifts or jumps dorsally within the scaphoid fossa.

Ballotment Test for S-L Instability

• Stabilize the lunate b/w the thumb and index finger of one hand
• Stabilize the scaphoid between the thumb and index finger of the other hand.
• Push the scaphoid in a volar to dorsal direction

Positive Test: Discomfort may suggest injury to S-L ligament.
Rehabilitation of S-L Instability

Grade I Sprain:
• Follow the stages of soft tissue healing
• Inflammatory to proliferation: Immobilize in thumb spica with light AROM (dart throwers) & neuro-muscular re-ed
• Proliferation/Remodeling: AROM, PROM with emphasis on dart thrower’s position
• Mature: Strengthening with emphasis on dart thrower muscles

Poll Question

A dorsal inter-calcated instability (DISI) is described as:

a. Lunate and triquetrum tilts dorsally
b. Scaphoid and lunate tilt dorsally
c. Scaphoid and trapezium tilts dorsally
d. Hook of the hamate tilts dorsally

Radial Wrist
• DE QUERVAINS
• THUMB CMC OA
• SCAPHOID FRACTURE
• DISTAL RADIUS FRACTURE

Ulnar Wrist
• Lunotriquetral Tear (Dissociative)
• Triangular Fibrocartilage Complex Tear (TFCC)

Dorsal Central
• Scaphoid-Lunate Tear
Ulnar Wrist
Lunotriquetral *Dissociation*

Clinical presentation:
- Pain with ulnar and supination of the fa
- Tender at L-T joint
- Patient c/o weakness and giving away
- Unable to lift heavy items
- Positive ballotment of lunotriquetral

Dissociative Lunate-Triquetrum VISI Volar Intercalated Instability

Mechanism of Injury
- Fall on outstretched hand
- Shoulder ER, forearm supinated and wrist extended and radial deviated

Lunotriquetral ballottement test (Regan Shuck):
- Procedure: Stabilize the lunate with the thumb and index fingers of one hand while the other hand attempts to displace the pisotriquetral unit volarly then dorsally.
- Positive result: Laxity, pain, or crepitus.
Rehabilitation of LT Instability

Grade I Sprain:
- Follow the stages of soft tissue healing
- Inflammatory to proliferation: Immobilize in wrist orthosis, light AROM & neuro-muscular re-ed
- Proliferation/Remodeling: AROM, PROM with emphasis on dart thrower’s position
- Mature: Strengthening with emphasis on dart thrower muscles
*Consider taping for neuromuscular re-ed

Ulnar Sided Wrist Pain
Clinical Presentation of TFCC Tear
- Ulnar sided wrist pain
- Pain with palpation in region of TFCC
- Pain with active ulnar deviation
- Positive TFCC load test
- Pain with forearm rotation
- Audible click with rotation
- Pain with pronated grip

Retrieved from: www.hughston.com/hha/a_13_3_1.htm
• Normal axial load of radius is 80% and ulna is 20%
• The TFCC functions to transmit 20% of the axially applied load from the ulnar carpus to the distal ulna. It is a major stabilizer of the distal radial ulnar joint.

Stabilizers of the Ulnar Wrist

Static Stabilizers
– Sigmoid Notch
– Dorsal/Volar radioulnar ligaments
– TFCC

Dynamic Stabilizers
– Pronator Quadratus
– ECU
– FCU

Triangular Fibrocartilage Complex (TFCC)

• Palpate for tenderness

Fovea sign: Tenderness b/w FCU tendon and ulnar styloid process
TFCC or Ulnocarpal Abutment Testing

- Axial load compression with wrist in ulnar deviation. Glide volar and dorsally.

Positive Test:
Reproduction of pain, clicking or crepitus

Poll Question

Which is the following best describes the triangular fibro-cartilage complex?

a. Redistributes force from the ulna to the radius
b. Is highly vascular in the central portion
c. Re-distributes 20% of the force from the ulnar carpus to the distal ulna and is contributor to the stability of the distal radioulnar joint
d. Clinically presents as radial wrist pain
Rehabilitation for Ulnar Wrist Pain

- Follow the stages of soft tissue healing
- Inflammatory to proliferation: Immobilize in wrist orthosis, light arom & neuro-muscular re-ed
- Proliferation/Remodeling: AROM, PROM
- Mature: Strengthening with emphasis on dynamic stabilizers
*Consider taping for neuromuscular re-ed

Isometric contraction of pronator quadratus in supination for DRUJ stability

Phase I (~6 wks): Long arm removeable orthotic with forearm and wrist in neutral. Gentle AROM.

Phase II (~6 to 8 wks): Removable wrist splint with periodic gentle ROM
YOSHIAKI et al 2004 (cuff vs ulnar gutter) Progressive ROM and gentle strengthening

Phase III (~12 weeks): Gradual return to sport or work as pain is decreased

Injuries to the central region are not amenable to repair due to avascularity

Trial Ulnar Wrist Support

1. Cut 3-4” piece of velcro.
2. Cut hole and 2 tails.
3. Apply hook to each tail.
Procedures for Distal Radial Ulnar Joint (DRUJ) Instability

- Soft tissue reconstruction
- Suave Kapandje
- Darrah
- Hemiresection-Interposition Arthroplasty (HIT)
- Implant arthroplasty

General Progression Concepts with Stabilization

Proliferation/Regeneration Phases
- Gradual return to AROM and gentle PROM at wrist and forearm (gradual progression to end range pro/sup)

Maturation Phase (6 to 12 weeks)
- Gentle strengthening and activity as tolerated
- Full activity as tolerated

GENERAL REHAB CONSIDERATIONS

- Which orthotic limits forearm rotation best?
  - Muenster
  - Sugartong
  - Antipronation

Slaughter et al 2010

Retrieved on 11/27/11 from; http://www.orthoteers.org
Conclusion

• Sugartong restricts pronation significantly better than all other orthotics
• Anti-pronation demonstrated significantly better results limiting forearm pronation as compared to the wrist orthotic
• Anti-pronation splint may be uncomfortable due to placement on ulnar styloid
• Neither Muenster or Sugartong completely immobilized rotation
• 3 subjects reported Sugartong most comfortable and 2 reported Muenster most comfortable

Poll Question

Should forearm rotation strength and ROM be phased in gradually as the patient gains strength following a surgical reconstruction of the distal radial ulnar joint?

a. Yes
b. No

General Concepts for Wrist Rehabilitation
Proprioception Training
Conscious Rehabilitation

Phase I: Conscious joint control

Phase II: Sense joint motion without audiovisual cues

Phase III: Strengthening specific muscles to enhance joint stability

Phase IV: Unconscious Rehabilitation

Hagert, E. (2010)

Conscious Rehabilitation
Phase I

- Edema Control
- Pain Control (visual analog scale)
- Promote Safe Motion

Diagram retrieved on 7/15/11 from: http://0.tqn.com/d/ergonomics/1/0/IC/-/-/-/painscale.jpg

Conscious Rehabilitation
Phase II & III

Conscious joint control

- Mirror therapy
- Active reproduction of joint angle; accuracy of joint re-positioning

Hagert, E. (2010)
Conscious Rehabilitation
Phase IV

Sense Joint Motion without Audiovisual Cues
• Motion detection (detection of passive motion)
  – Degree of joint angle at which motion is detected

Hagert, E. (2010)

Conscious Rehabilitation
Phase V

Strengthen specific muscles to enhance joint stability
• Eccentric training
• Co-activation training

Hagert, E. (2010)

Phase VI
UNCONSCIOUS NEUROMUSCULAR REHABILITATION

Reactive muscle activation

Hagert, E. (2010)
Phase VI
UNCONSCIOUS NEUROMUSCULAR
REHABILITATION  Hagert, E. (2010)

Reactive muscle activation

Sensorimotor Retraining

1. Use chopsticks to pickup varying items and separate items
2. Finding dry beans in putty
3. Molding specific shapes
4. Card turning
5. Rhythmic stabilization

Research pediatric sensorimotor activities for more ideas.


**Patient Function and Goals**

- **Patient’s functional activity**
  - Validated outcome assessments for shoulder instabilities include:
    - Oxford shoulder instability questionnaire
    - Shoulder instability questionnaire
    - Western Ontario shoulder instability index
    - The American Shoulder and Elbow Surgeons subjective scale
    - Disability of the arm, shoulder and hand (DASH)
    - Constant Murley shoulder assessment
    - Shoulder pain and disability index
Elbow Joints Kinesiology

**Humeroulnar Joint:**
- Hinge-joint that flexes and extends
  - Open Pack: 70° flex/10° supination
  - Closed Pack: ext/supination

**Humeroradial Joint:**
- Hinge-joint that flexes and extends
  - Open Pack: ext/sup.
  - Closed Pack: 90° flex/5° sup.

**Proximal Radioulnar Joint:**
- Pronation and supination
  - Open Pack: 70° flex/35° Sup.
  - Closed Pack: 5° sup/ext