Elbow Instability

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2/20/2019
Elbow Instability

- Introduction
- Anatomy
- Patterns of instability
  - PLRI
  - Valgus
  - PMRI
- Summary
Objectives

• Review elbow anatomy with emphasis on functional anatomy
• Identify common mechanisms of injury to the elbow
• Correlate typical injury patterns with imaging findings
  • What does the surgeon want to know?
  • Newly discussed associations (PMRI)
• Explore current and emerging treatment options
Elbow Instability History

• 1881 - First described by Albert E Lehrbuh
• 1940’s – Attempt to restore elbow stability with coronoid augmentation by Reichenheim and Wainwright (separately)
• 1960’s – Osborn and Cotterill recognized contribution of ligamentous insufficiency
• 1991 – Posterolateral rotatory instability first described by O’Driscoll ... helped clarify biomechanics of elbow instability
• 2000’s – Exponential growth in instability research
Elbow Basics

• Trochoginglymoid joint = hinge + pivot
  • 30° to 130° flexion/extension
  • 50° supination/pronation

• Normal valgus carrying angle
  • 5-10° for males
  • 10-15° for females

• In extension
  • 40% axial load transmitted through ulnohumeral joint
  • 60% axial load transmitted through radiocapitellar joint
Elbow Osseous Anatomy

- Humerus
- Medial epicondyle
- Lateral epicondyle
- Head
- Neck
- Tuberosity
- Radius
- Ulna
- Medial supracondylar ridge
- Lateral supracondylar ridge
- Radial fossa
- Coronoid fossa
- Coronoid process
- Trochlea
- Olecranon fossa
- Olecranon
- Head
- Neck
- Tuberosity
- Radius
- Ulna
- Groove for ulnar nerve
Elbow Osseous Anatomy - Capitellum
Elbow Osseous Anatomy – Ulna

Coronoid Process
Sublime Tubercle
Supinator Crest
Radiocapitellar Joint

• Capitellum – radial head
• Allows hinge and pivot motion
• Congruency of radial head within capitellum key
  • Radial head 2\textsuperscript{nd} most important restraint against valgus stress
  • Normal radius length maintains tension on LCL
Ulnohumeral Joint

• Trochlea of humerus – trochlear notch of ulna
• Hinge Joint
• Provides medial-lateral stability between 0° - 30° flexion
Proximal Radioulnar Joint

- Radial head – lesser sigmoid notch of ulna
- Pivot joint

Capsuloligamentous anatomy
Lateral Collateral Ligament Complex

Lateral Ulnar Collateral Ligament

- Common origin with RCL from humerus
  - Deep and distal to common extensor tendon
- Blends indistinguishably with RCL proximal to annular ligament
  - RCL runs slightly anterior
- Passes posterolateral to radial head -> supinatoe crest insertion
Lateral Ulnar Collateral Ligament

Origin: Lateral humeral epicondyle

Insertion: Supinator crest of the ulna
Radial Collateral Ligament

• Common origin with LUCL from humerus
• Blends indistinguishably with LUCL proximal to annular ligament
• Fans out distally to inset on annular ligament and supinator muscle
Annular Ligament

- Attaches to the anterior and posterior margins of the lesser sigmoid notch of the ulna
- Stabilizes the radial head
Annular Ligament

Origin/insertion: Anterior and posterior margins ulnar lesser sigmoid notch

Stabilizes: Proximal radioulnar joint

Accessory Lateral Collateral Ligament

• Originates from annular ligament
• Inserts on supinator crest
• Stabilizes the annular ligament during varus stress
Medial Collateral Ligament

- 3 – anterior bundle
  - Anterior and posterior bands
- 5 – posterior bundle
- 4 – transverse bundle

J Hand Surg Am. 2014 Feb;39:199-205
Anterior Bundle MCL

• Primary restraint in valgus stress
• Inferior medial epicondyle to sublime tubercle
• Anterior band
  • Taut 0-60 degrees
  • Resistance to varus and valgus stress in extension
  • Role diminishes at 90 degrees flexion
• Posterior band
  • Taut 90-120 degrees
  • Questionable increasing role in stability

J Hand Surg Am. 2014 Feb;39:199-205
• Reciprocal bands
• Bands may injured separately
• Injury will depend on degree of flexion – anterior band more vulnerable in extension
• Injury to posterior bundle unlikely in absence of complete anterior bundle injury
Posterior Bundle MCL

• Primary restraint to valgus stress in maximal elbow flexion
• Increasingly recognized role in stability
• Posterior aspect medial epicondyle to medial olecranon
• Forms floor of cubital tunnel
Transverse Bundle MCL

- No known direct contribution to stability
- Olecranon to coronoid process
- Horizontally spans the ulnar insertions of the anterior and posterior bundles
- Incompletely present

J Hand Surg Am. 2014 Feb;39:199-205
Joint Capsule

• Completely encases all 3 joints
• Posterior attachments
  • Humerus
  • Olecranon process
• Anterior attachments
  • Humerus
  • Coronoid process
  • Annular ligament
Muscular/Tendon anatomy

• Medial
  • Pronator teres
  • Palmaris
  • Common flexor tendon
    • Flexor carpi ulnaris
    • Flexor carpi radialis
    • Flexor digitorum superficialis
• Anterior
  • Biceps
  • Coracobrachialis
  • Brachialis

• Lateral
  • Common extensor tendon
    • Extensor carpi radialis brevis
    • Extensor digitorum
    • Extensor digiti minimi
    • Extensor carpi ulnaris
  • Supinator
  • Brachioradialis
  • Extensor carpi radialis longus

• Posterior
  • Triceps
  • Anconeus
Elbow stabilizers

- Static
  - Primary
  - Secondary
- Dynamic
Primary Static Stabilizers

- Anterior bundle of the MCL
  - Valgus restraint
- LCL complex
  - Varus restraint
- Coronoid process of ulna
  - Primary stabilizer of ulnohumeral joint
  - >50% loss = significant instability
  - Anteromedial aspect of coronoid process most important

Secondary Static Stabilizers

• Anterior joint capsule
  • Greatest contribution in elbow extension

• Radiocapitellar joint
  • Secondary valgus restraint
  • Greatest with 0-30° flexion/pronation

• CET and CFT

• Olecranon
  • Linear relationship absence: instability
  • Beyond 87.5% absent = gross instability

Dynamic Stabilizers

• Compressive or active stability
• Muscles that cross the joint and tighten the capsule, especially:
  • Anconeus
  • Brachialis
  • Triceps
  • Biceps
• Valgus stress: flexor-pronators
Elbow stabilizers

1° static stabilizers

2° static stabilizers

Dynamic stabilizers
Types of Instability

• Posterolateral Rotary Instability (PLRI)
• Valgus Instability
• Posteromedial Rotary Instability (PMRI)
Posterolateral Rotary Instability

Most common type of elbow instability

Rotatory subluxation of the ulna relative to trochlea

Posterolateral dislocation of radial head relative to capitellum

Stability of proximal radioulnar joint
Posterolateral Rotary Instability

- First described by O’Driscoll in 1991
- Classically associated by LUCL injury
- Increasing emphasis on role of entire LCL complex

- Isolated LUCL transection → Minor joint laxity
- LUCL + RCL transection → Posterolateral subluxation of ulnohumeral joint
Posterolateral Rotary Instability

- Isolated LUCL
- Isolated RCL
- Transect LUCL
- Transect RCL

Degree of internal-external rotation and maximal varus-valgus laxity

- internal-external rotation and varus-valgus laxity
Mechanism of Injury

- Traumatic dislocation
  - Most common
- Iatrogenic injury
  - Lateral arthroscopic approach or open procedures
- Chronic repetitive injury
- Recurrent steroid injections
- Chronic cubits varus deformity
Mechanism of Injury - dislocation

Ulna rotates on long axis

Distraction of radial aspect of ulnohumeral joint

Force transmitted through proximal RUJ to radius

Radius posteriorly displaces relative to capitellum

Surgical Treatment of Posterolateral Instability of the Elbow. Musculoskeletal Key.
Mechanism of Injury – Horii circle

• Stage I: LCL complex disrupted
• Stage II: Involvement of anterior and posterior capsule
  • Perched elbow
• Stage III: MCL disrupted
  • Frank dislocation
Biomechanics of elbow dislocation – O’Driscoll

## Staging of Posterolateral Rotatory Instability

<table>
<thead>
<tr>
<th>Stage</th>
<th>Degrees of Capsuloligamentous Disruption&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subluxation of the elbow in a posterolateral direction</td>
</tr>
<tr>
<td>2</td>
<td>Subluxation of the elbow joint with the coronoid perched underneath the trochlea</td>
</tr>
<tr>
<td>3</td>
<td>Complete dislocation with the coronoid resting behind the trochlea</td>
</tr>
<tr>
<td>3A</td>
<td>Includes the posterior band of the medial collateral ligament tear</td>
</tr>
<tr>
<td>3B</td>
<td>Includes the anterior and posterior bands of the medial collateral ligament tear</td>
</tr>
</tbody>
</table>

<sup>a</sup>
Alternative Theory

- Disruption begins medially
- Review of elbow dislocation youtube videos since Sept 2, 2011
  - 873 potential videos -> 77 high quality -> 62 deemed adequate
    - 97% shoulder abduction
    - 63% shoulder forward flexion
    - 92% elbow full extension
    - 68% forearm in pronation
    - 89% valgus stress
    - 90% axial compression
    - 94% body internal rotation
- 4 distinct patterns
- Most common pattern consistent with PLRI as described BUT
- Gross valgus deformity noted immediately after loading
  - AMCL most important restraint to valgus instability

### Table 2. Patterns of Elbow Dislocation Mechanism

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Shoulder Position</th>
<th>Elbow Position</th>
<th>Deforming Force</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Flexion-abduction</td>
<td>Pronation-extension</td>
<td>Axial/Valgus</td>
<td>33 (53)</td>
</tr>
<tr>
<td>II</td>
<td>Extension-abduction</td>
<td>Supination-extension</td>
<td>Axial/Valgus</td>
<td>16 (25)</td>
</tr>
<tr>
<td>III</td>
<td>Hyperflexion-abduction</td>
<td>Pronation-extension</td>
<td>Axial/Valgus</td>
<td>3 (5)</td>
</tr>
<tr>
<td>IV</td>
<td>Flexion-abduction</td>
<td>Flexion</td>
<td>Varus (extrinsic)</td>
<td>4 (6)</td>
</tr>
</tbody>
</table>

Alternative Theory

• Sojbjerg, Helmig and Kjaersgaard-Andersen in 1989
  • Cadaveric dislocation study showed AMCL tear (80%) > LUCL tear (20%)
• Josefsson, Johnell, Wendeberg in 1987
  • 31 pts examined under anesthesia after acute elbow dislocation
  • All patients unstable to valgus stress
  • Only 26% unstable to varus stress
  • No specific PLRI evaluation
• Rhyou IH, Kim YS in 2012
  • MRI study evaluating ligamentous injury & osseous contusion after dislocation
  • Medial-sided origin of instability for simple dislocation
Clinical Presentation

• Pain
• Clicking, snapping, clunking
• Catching with elbow extension (pushing off from chair)
• Symptoms occur in extension arc in supination
Most reliable of the clinical tests
Lateral pivot shift

- Supination
- Valgus
- Axial compression
Lateral pivot shift

Axial compression

Valgus

Supination

Subluxation
PLRI testing – Push up tests

## PLRI testing

<table>
<thead>
<tr>
<th>Test</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterolateral rotatory drawer test</td>
<td>Most sensitive examination maneuver</td>
<td>Not always performed or described accurately</td>
</tr>
<tr>
<td></td>
<td>Allows assessment of degree of instability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can be performed in the awake and anesthetized patient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Does not cause pain or discomfort for the patient</td>
<td></td>
</tr>
<tr>
<td>Lateral pivot-shift test</td>
<td>Highly specific test</td>
<td>May cause discomfort in some patients</td>
</tr>
<tr>
<td></td>
<td>Dramatic phenomenon when positive</td>
<td>Can be difficult to perform in the awake patient if not able to relax</td>
</tr>
<tr>
<td>Push-up tests</td>
<td>Allows the patient to control the speed and force of the examination</td>
<td>Can only be performed in the awake and cooperative patient</td>
</tr>
<tr>
<td>Radiograph</td>
<td>Evaluates bony structure and alignment</td>
<td>Does not assess the degree of instability</td>
</tr>
<tr>
<td>Computed tomography scan</td>
<td>Shows articular dysplasia, malunion and nonunion of fractures, impaction fractures</td>
<td>Generally unrevealing</td>
</tr>
<tr>
<td>Magnetic resonance imaging</td>
<td>Allows assessment of the lateral collateral ligament complex</td>
<td>Additional radiation</td>
</tr>
<tr>
<td></td>
<td>Allows assessment of articular surfaces</td>
<td></td>
</tr>
<tr>
<td>Dynamic fluoroscopy</td>
<td>Allows assessment of the degree of instability</td>
<td>Can miss lateral collateral ligament injuries</td>
</tr>
<tr>
<td></td>
<td>Can be performed in the awake and anesthetized patient</td>
<td>Does not permit dynamic assessment</td>
</tr>
<tr>
<td>Dynamic ultrasound</td>
<td>Allows assessment of the degree of instability</td>
<td>Radiation exposure for the patient and provider</td>
</tr>
<tr>
<td></td>
<td>Can be performed in the awake and anesthetized patient</td>
<td>Emerging technology in need of additional validation</td>
</tr>
<tr>
<td></td>
<td>No radiation exposure</td>
<td></td>
</tr>
</tbody>
</table>
Radiographs

- Avulsion fracture of the LCL complex
- Varus malalignment of elbow
- Widening of radiocapetellar joint (LCL disruption)
- Stress radiographs = ulnohumeral widening and radial head subluxation
Radiographs

Drop sign = ulnohumeral distance > 4mm on lateral unstressed radiograph
Sonographic PLRI Stress Test

Assess for widening of the posterolateral ulnohumeral joint
Sonographic PLRI Stress Test

• A = at rest
• B = with stress
• Laxity = distance with stress – distance at rest
Sonographic PLRI Stress Test

- Group 1: Intact elbow
- Group 2: ECRB release
- Group 3: LCL release, + posterolateral drawer test
- Group 4: LCLC release with capsule release, + lateral pivot shift test

<table>
<thead>
<tr>
<th></th>
<th>Mean Values for All Sages</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>P Value*</td>
<td></td>
</tr>
<tr>
<td>Rest, mm</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>.58</td>
<td></td>
</tr>
<tr>
<td>Stress, mm</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>13</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>Laxity, mm</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>10</td>
<td>&lt; .001</td>
<td></td>
</tr>
</tbody>
</table>
Computed Tomography

- Often acquired in the acute setting to better assess for fractures
- Less of a role in chronic injury
- CT arthrogram can be helpful if MRI cannot be obtained
Quick Aside: Osborne-Cotterill Lesion

• 1966: “an osteochondral fracture of the posterolateral margin of the capitellum with or without a crater or shovel-like defect in the radial head”

• Bankart/Hill-Sachs equivalents

• 2008: Jeon et al deems this an “Osborne-Cotterill lesion”
  • Indicative of PLRI
  • Shear/depression fracture of capitellum and lateral condyle
Osborne-Cotterill Lesion
Osborne Cotterill Lesion

Capitellar defect ~ osseous Bankart lesion
Radial head fracture ~ Hill-Sachs deformity
Osborne-Cotterill Lesion
• 30-60° flexion: greater radial head displacement with OCL
• < 30° or > 60°: no difference OCL vs intact capsule
• OCL + LCL injury → markedly greater radial head displacement than OCL alone
• Conclusion = capsular attachment at site of OCL contributes to instability
• “Osborne-Cotterill ligament”
• Pitfalls of study
MRI findings

• LUCL usually avulses from the distal humerus
• +/- fracture/bone bruises
  • Radial head
  • Posterior capitellum
• Posterior subluxation of the radius in relation to capitellum

• Static evaluation = major disadvantage
• No consensus on sensitivity/specificity of MRI for PLRI
Radiocapitellar Incongruity

Technique:
• Sagittal view center radial head
• Rotational center of capitulum (CAP)
• Longitudinal axis of radius (R)
• Distance between CAP and R

If > 1.2 mm,
• Sensitivity: 67%
• Specificity: 70%

Positive predictive value of 100% if >3.4 mm

J Hand Surg Am. 2015;40(7):1428e1433.
Sagittal Ulnohumeral Incongruity

Technique:
- Sagittal view coronoid process tip
- Best fit circle trochlea (TR) and olecranon (OL)
- B1 = TR center to olecranon tip
- B2 = TR center to middle point
- B3 = TR center to coronoid tip
- Greatest difference between B1, B2 and B3

No statistically significant difference between PLRI and stable elbows

Coronal Ulnohumeral Incongruity

Technique:
- Rotational center distal humerus
- Distance between trochlea and olecranon measured at ulnar edge (C1), radial edge (C4) and two points in between (C2, C3)
- Greatest difference between C1, C2, C3 and C4

No statistically significant difference between PLRI and stable elbows

J Hand Surg Am. 2015;40(7):1428e1433.
Axial Ulnohumeral Incongruity

Technique:
• Motion axis of distal humerus
• Distance between trochlea and olecranon measured at ulnar edge (D1), radial edge (D4) and two points in between (D2, D3)
• Greatest difference between D1, D2, D3 and D4

If > 0.7 mm,
• Sensitivity: 63%
• Specificity: 70%
PLRI Case #1

PLRI Case #2

- 7/27/2018
- 64 yo F post fall
PLRI Case #2

- 2/7/2019
- Persistent pain, instability and decreased ROM
- **Green arrow**: anterior bundle MCL stripping with edema
- **Yellow arrow**: thickening/irregularity of RCL and LUCL at humeral attachment
- Radiocapitellar subluxation
PLRI Case #3

- 41 yo F with decreased ROM and pain after bike injury 4 months prior
- Complete RCL and LUCL tears at humeral attachment
- Widening and subluxation of radiocapitellar joint
- Anterior and posterior MCL bundle tear
- Osborne-Cotterill lesion
PLRI Case #4

- 28 yo F with recent fall and pain
- Complete RCL, LUCL & CET tear
- Complete AB/PB MCL & CFT tear
- Osborne-Cotterill lesion
- Radiocapitellar subluxation
Non-operative Treatment

• Only for acute injuries/dislocations
• Immobilize in 90° flexion for 1 week
  • LCL disrupted but MCL intact -> pronate
  • LCL and MCL disrupted -> neutral
• Early active ROM after splint removal
Surgical Treatment Indications

• Complex dislocation
  • Fixation of LCL if coronoid fragment > 2.5 mm
  • Increasing incidence of coronoid fracture fixation
  • Sublime tubercle injury -> must fix

• Osteochondral fragment

• Soft tissue entrapment

• Chronic PLRI
Surgical Treatment Technique

• Mainstay of treatment = restore LCL complex function
• Graft with palmaris longus, gracilis or triceps fascia
  • Docking technique currently most utilized
• Graft covers > 25% radial head to create sling
• Coronoid fractures
  • Fix large fragments
  • Remove small fragments
• Recurrent instability in 3-8%
Graft Repair of LCL

Point of isometry (axis of rotation)

3mm Ø 1cm

Docking Technique

Docking Technique

• Advantages
  • Reduced bone removal
  • Creation of an isometric construct
  • Historically high rate of restoration of joint stability

• Disadvantages
  • Precise anatomic knowledge and technical precision is required
Take a break!
Valgus Instability

• Second most common type of instability
• Injury or rupture to the medial collateral ligament
• Overhead athletes (pitchers)
• Uncommon in skeletally immature athletes
  • Medial epicondyle avulsions = little leaguers elbow
Mechanism of Action

• Dislocation

• Overuse
  • Repetitive valgus stress -> rupture anterior band MCL
  • Late cocking/early acceleration phase of throwing
  • Valgus load greatest in acceleration phase

• Iatrogenic
  • Excessive olecranon resection

Oper Tech Sports Med. 2016 Sept; 24(3): 156-161
Spectrum of Acute Valgus Injury

- Flexor muscle strain
- Common flexor tendon tear
- MCL tear
- Combined injury

Stable

Unstable
Spectrum - Flexor Muscle Strain
Spectrum – Common Flexor Tendon Tear
Spectrum – MCL Tear
Spectrum – Combined Tendon & Muscle Injury
Acute Presentation

- Acute injury may present as pain with “pop”
- Does NOT cause subluxation/dislocation
- Decreased throwing performance
  - Velocity
  - Accuracy
- Pain of MCL origin
Chronic Presentation

- MCL degeneration/thickening
- Valgus extension overload
- Ulnar neuritis
- Medial epicondylitis
Valgus Stress Test

- Flex elbow 20-30°
- Forearm is supinated
- Externally rotate humerus
- Apply valgus stress
- Positive = MCL pain
- 50% sensitive
Milking maneuver

• Forearm supinated
• Elbow flexed at 90°
• Pull on patient’s thumb
• Positive = apprehension, instability or pain
Modified milking maneuver

• Humerus adducted, externally rotated
• Valgus stress through thumb
• Flex elbow to 70°
• Positive = apprehension, instability or pain

Moving Valgus Stress Test

- Abduct, externally rotate shoulder
- Extend elbow from full flexion to 30° flexion
- Apply valgus force throughout
- Positive = apprehension, instability or pain between 70-120°
- 100% sensitive, 75% specific

Radiographs

• Gravity or manual stress may show widening of medial joint line >3 mm
• Posteromedial osteophyte may suggest overuse
CT arthrography

• Can better demonstrate partial thickness MCL tears
• 91% specific
• 71-86% sensitive
MRI

• **Noncontrast**
  • MCL injury – acute v chronic
  • 57-79% sensitive
  • 100% specific

• **MR arthrogram**
  • T-sign
  • 97% sensitive
  • 100% specific
Dynamic Ultrasound

Can evaluate laxity with valgus stress
Nonoperative Treatment

• First line
• 6 weeks rest from throwing
• Physical therapy for flexor-pronator strengthening
• 42% return to preinjury level in ~24 weeks
Surgical Treatment

• Indications
  • High-level throwers
  • Failed conservative treatment

• Tommy John Surgery

• Outcomes
  • 90% return to preinjury throwing
Surgical Techniques

• Reconstruction > direct repair
• Autograft > allograft
• Palmaris longus > gracilis

• Modified Jobe Technique
• Docking Technique
• Hybrid Interference-Screw Technique
• Cortical Suspensory Fixation
Modified Jobe Technique

- Figure of 8 reconstruction
- 2 tunnels in humerus
- Single tunnel in ulnar sublime tubercle
Docking Technique

- Single humeral docking tunnel
- 2 punctures medial epicondyle
- Best outcomes and lowest complications

https://www.arthrex.com/elbow/docking-technique
Hybrid Interference-Screw Technique (DANE TJ)

- Docking fixation in humerus
- Interference screw in ulna
Cortical Suspensory Fixation

- Docking in humerus
- Endobutton in ulna
- Strongest technique

https://emedicine.medscape.com/article/1230902-treatment#d10
OUT OF ORDER!
Posteromedial Rotatory Instability

• First described by O’Driscoll in 2003
• Characterized by:
  • Anteromedial fracture of coronoid
  • Disruption of the LCL
  • +/- injury to the MCL
• Varus elbow stabilizers
  • Osseous articulation
  • LCL
  • Capsule
Coronoid Process

- Anteromedial “facet”
- Region between coronoid tip and sublime tubercle
- 60% coronoid unsupported by ulnar metaphysis = prone to fracture
- Resists posterior ulnar subluxation and posteromedial/lateral rotatory forces
Accompanying Injuries

• LCL humeral avulsion – common
• Posterior bundle MCL
• +/- anterior bundle MCL
• Olecranon fracture
  • LCL may be preserved
• Coronoid base fracture
• Radial head fracture - rare
Mechanism of Injury

- Compression + internal rotation + varus force
- Varus overload + LCL rupture + convex coronoid fx
- Pronation + varus + axial force
- Pronation + valgus overload + LCL rupture + concave coronoid fx
Varus Posteromedial Rotatory Instability

Fracture-subluxation or fracture-dislocation

Courtesy of Dr. Eric Chang
Varus Posteromedial Rotatory Instability

Fracture-subluxation or fracture-dislocation

- Axial loading

Courtesy of Dr. Eric Chang
Varus Posteromedial Rotatory Instability

Fracture-subluxation or fracture-dislocation

- Axial loading
- Varus force
Varus Posteromedial Rotatory Instability

Fracture-subluxation or fracture-dislocation

- Axial loading
- Varus force
- Internal rotation of the forearm with shearing and fracture of the anteromedial facet of the coronoid process

Courtesy of Dr. Eric Chang
Varus Posteromedial Rotatory Instability

Fracture-subluxation or fracture-dislocation

Courtesy of Dr. Eric Chang
Varus Posteromedial Rotatory Instability

Fracture-subluxation or fracture-dislocation

Courtesy of Dr. Eric Chang
Coronoid Fractures – Regan and Morrey

• Original classification system

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>“Avulsion” of the coronoid tip</td>
</tr>
<tr>
<td>Type II</td>
<td>Single or comminuted fracture involving ≤50% coronoid</td>
</tr>
<tr>
<td>Type III</td>
<td>Single or comminuted fracture involving &gt;50% coronoid</td>
</tr>
</tbody>
</table>

• Doesn’t address location of fracture
### Coronoid Fractures – O’Driscoll

<table>
<thead>
<tr>
<th>Type</th>
<th>Subtype I</th>
<th>Subtype II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tip</td>
<td>≤2 mm coronoid height</td>
<td>&gt; 2 mm coronoid height</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anteromedial</td>
<td>Anteromedial rim</td>
<td>Anteromedial rim and tip</td>
</tr>
<tr>
<td>Base</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coronoid body and base</td>
<td>Trans-olecranon coronoid base</td>
</tr>
</tbody>
</table>
Coronoid Fractures – O’Driscoll

**Type 1** – transverse fractures of the tip

**Type 2** – involves the anteromedial facet of the coronoid process

**Type 3** – all fractures at the base of the coronoid
Coronoid Fractures – O’Driscoll

Type 1  Type 2  Type 3

AM facet subtypes

Type 2  Type 3

### Coronoid Fractures – Doornberg and Ring

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Injury Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Anterior (25%) dislocation Posterior (75%) dislocation</td>
</tr>
<tr>
<td>Small transverse</td>
<td>Terrible triad</td>
</tr>
<tr>
<td>Anteromedial ‘facet’</td>
<td>Posteromedial Rotatory Instability</td>
</tr>
</tbody>
</table>
Role of the Posterior Bundle of MCL

• Classically PMRI was attributed to the coronoid fracture and LCL
• Increasing evidence that posterior band MCL plays role in stability
• Persistent instability post coronoid fixation + LCL and anterior bundle MCL repair

pMCL = posterior bundle MCL and aMCL = anterior bundle MCL
Role of the pMCL – Pollock 2009

• First paper to recognize role of posterior bundle MCL
• Cadaveric study
• Isolated pMCL transection ->
  • Increased elbow rotation
  • Increased varus/valgus motion
Role of the pMCL – Morrey 2012

• Professional pitcher
• Persistent medial instability despite multiple traditional aMCL reconstructions
• Isolated pMCL reconstruction -> return to competition
• Olecranon deficient
Role of the pMCL – Golan 2016

• Isolated sectioning of the pMCL
  • Increased gapping of the anterior aspect of the ulnohumeral joint
  • Increased ulnohumeral torsion at 60° and 90°
  • Despite integrity of aMCL
• Greatest gaps occurred at 60° flexion
• Conclusion: isolated pMCL injury can cause instability in the absence of AMC fracture or aMCL injury....
Role of the pMCL – Sard 2017

• Cadaveric study – 16 elbows
  • Intact MCL
  • Transected aMCL
  • Transected aMCL + pMCL
• Dislocation only with transected aMCL + pMCL
• Reconstruction aMCL and pMCL
  • Complete recovery elbow stability
  • Re-establish elbow ROM
MCL repair - Sard
Role of the pMCL – Hwang 2018

• Supports Sard’s findings, different conclusion
• pMCL necessary for subluxation to occur
• Increased ulnohumeral contact pressure can occur with intact pMCL
• Conclusion: post-traumatic arthritis can occur in absence of pMCL injury
Role of the pMCL – Gluck 2018

• pMCL greatest contribution to stability at 90° flexion
• Post pMCL repair
  • Joint gapping decreased at the higher degrees of flexion
• Isolated pMCL reconstruction
  • Stability can improve but not perfect
  • Recommend concurrent coronoid fracture fixation
• Conclusion: PMRI can occur with pMCL + coronoid fracture, in the absence of an LCL injury.
MCL repair - Gluck
Clinical Presentation

- Elbow subluxation versus frank dislocation
- Clicking, popping, slipping
- Pain
- Nonspecific, subtle symptoms
- Paucity of clinical tests
Gravity-assisted Varus Stress Test

- Shoulder abduced to 90°
- Forearm in neutral rotation
- Elbow moved from extension to flexion
- Positive = instability, pain, crepitation
- Most sensitive, specific

Hyperpronation Test

- Elbow in 90° flexion
- Examiner passively hyperpronates patient’s forearm
- Examiner palpates for ulnohumeral subluxation
Radiographs

- Anteromedial coronoid fractures – may need obliques
- +/- lateral epicondyle avulsion fractures
- Subtle decrease medial ulnohumeral space
- +/- widened radiocapitellar joint if complete LCL disruption
Radiographs – Double Crescent Sign

• Described by Sanchez-Sotelo
• Pathognomonic for anteromedial coronoid fractures
• Displaced anteromedial coronoid fragment
  • Double subchondral density
  • Loss of parallelism between medial coronoid and opposing distal humeral articular surface
Radiographs – Stress Images

- Gold Standard
- Varus stress under anesthesia
- Widening of the radiocapitellar joint
Computed Tomography

• Always recommended in acute setting to better characterize the coronoid process fractures
• 3D reconstructions popular for surgical planning
MRI

• Can demonstrate degree of LCL and MCL injury
• Increasingly important to determine degree of injury of pMCL
PRMI Case #1

• 30 yo M post fall
• Oblique radiograph best demonstrates fracture of the anteromedial coronoid facet.
PRMI Case #1

Courtesy of Dr. Eric Chang
PRMI Case #2

- 46 yo M fall
- Varus angulation
- LUCL, RCL, CET tear
- Coronoid fx

Courtesy of Dr. Eric Chang
PRMI Case #3

• Young patient post elbow injury
• Elbow joint effusion
• Fracture difficult to appreciate by radiograph
PRMI Case #3

- Minimally displaced fracture of the coronoid process
- Increased signal and irregularity of proximal MCL
PRMI Case #4
Nonoperative treatment

- No clear guidelines
- Indications:
  - No recurrent subluxation/dislocation
  - Small coronoid fragment
  - Compliant patient
  - Absence of concurrent muscle injury
- Cast in 90° flexion with neutral rotation
- Avoid shoulder abduction (varus stress at elbow)
- Limited outcome studies
Surgical Treatment

• Indications
  • Nonconcentric elbow
  • Displaced anteromedial coronoid fracture
  • Trapped fracture fragment or soft tissue
  • “Larger” coronoid fragments

• Approach is controversial
# Treatment Based on O’Driscoll Classification

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Treatment Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated tip fracture</td>
<td>Fix if fragment &gt; 10% coronoid height</td>
</tr>
<tr>
<td></td>
<td>Repair MCL if fracture &lt; 10% height</td>
</tr>
<tr>
<td>Anteromedial ‘facet’ fracture</td>
<td>ORIF coronoid process fracture</td>
</tr>
<tr>
<td></td>
<td>Bone graft reconstruction</td>
</tr>
<tr>
<td>Base fracture</td>
<td>Type I: ORIF with contoured plate</td>
</tr>
<tr>
<td></td>
<td>Type II: Two plate technique</td>
</tr>
</tbody>
</table>
| **Pollock et al** | Small subtype I with intact MCL: nonoperative LCL  
Large subtype I or subtype II/III: fixation and LCL recon |
|------------------|--------------------------------------------------|
| **Rhyou et al**  | Fragment > 6 mm: ORIF  
Fragment ≤ 5 mm: LCL reconstruction alone |
| **Park et al**   | Subtype I: LCL repair/reconstruction only  
Subtype II/III: ORIF + LCL +/- MCL |
| **Chen et al**   | Non-comminuted fx: Fix fracture, rehab LCL  
Comminuted fx: LCL repair + external fixator |
| **Rameriz et al**| Buttressing/plate fixation preferred  
Severe comminution: anterior capsule reattachment |
O’Driscoll Type II-II fixation
O’Driscoll Type II-III fixation
Screw Fixation
Comminuted Coronoid Fracture

Outcomes

• Primary concern = rapidly progressive OA
• Limited outcome studies
• Doornberg and Ring 2006 (18 pts)
  • 22% repeat surgery
  • 33% post-traumatic OA
• Park et al 2015 (11 pts)
  • 9% persistent joint incongruity
  • 18% ulnar neuropathy
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• Beingessner DM, Whitcomb Pollock J, King GJW. Introduction to posteromedial rotatory instability (PMRI) of the elbow 1304-Rockwood. 2014, Chapter 12.


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• Malagelada, Francesc & Dalmau-Pastor, Miki & Vega, Jordi & Golano, Pau. (2014). Elbow Anatomy. 10.1007/978-3-642-36801-1_38-1.


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