Inspiration
Introduction to Instability

• Elbow instability increasingly recognized and stressed in literature
  – Pubmed search “elbow instability” years 2000-2010 = 663 entries
• Elbow “instability” should not be considered a single entity
  – Distinct clinical entities
  – Acute and chronic pathology
  – Presentation, findings, and treatment are unique
Fundamental Instability Concepts

1) Elbow instability relates to the interactions of underlying bony, capsuloligamentous, and myotendinous structures

2) Failure at specific joint stabilizers leads to common patterns of injury when stresses are applied

3) Instability is a clinical diagnosis, which may be supported or suggested by physical examination and imaging findings
Concept 1

Bony Structures

"Stability"

Capsuloligamentous Structures

Myotendinous Structures
Concept 2

Joint Congruence/Stability
- Primary Stabilizers
- Secondary Stabilizers

Trauma
- Acute Trauma
- Chronic/repetitive Trauma

Imaging Findings
- Fracture
- Dislocation
- Ligamentous disruption
- Hypertrophic Change
- Chondral disease

Instability Patterns
- Valgus
- PLRI
- (PMRI)
- (Varus)
Objectives

• Review the relevant anatomy of the elbow joint, with emphasis on imaging anatomy
  – Primary stabilizers of elbow
  – Secondary stabilizers of elbow
• Review the common injury patterns at the elbow
• Apply knowledge of functional anatomy and injury patterns to identify instability lesions
  – Valgus
  – PLRI
  – PMRI
• Highlight the importance of imaging in the diagnostic evaluation of patients with elbow trauma/pain
Anatomy - Stabilizers of the Elbow

• Primary Stabilizers
  – Ulnohumeral joint (coronoid process)
  – Medial collateral ligament (anterior band)
  – Lateral ulnar collateral ligament

• Secondary Stabilizers
  – Radiocapitellar joint (radial head)
  – Flexor-Pronator mass
  – Extensor mass

• Dynamic Constraints
  – Muscles which cross the ulnohumeral joint and tighten capsule
    • Anconeus
    • Triceps
    • Brachialis

• Damage to primary stabilizer will increase load on secondary stabilizers
Ulnohumeral Joint

Radiocapitellar Joint

Common Extensor

Flexor-pronator

aMCL

LUCL (RCL)
Primary Stabilizers

Humerus

Coronoid/Ulna

Medial Collateral
Primary and Secondary Stabilizers

- Lateral Collateral
- Medial Collateral
- Common Extensors
- Common Flexors
Valgus Injury

- Primary restraint is the medial collateral ligament, anterior bundle
- Radial head is secondary constraint
- Flexor-pronator mass acts as dynamic stabilizer
Valgus – Primary Stabilizer

• Medial Collateral Ligamentous Complex
  – Anterior band
  – Posterior band
  – Transverse band
Valgus – Primary Stabilizer

- Medial Collateral Ligamentous Complex
  - Anterior band
    - Primary valgus restraint
    - Proximal attachment to inferior medial epicondyle
    - Distal attachment to sublime tubercle of coronoid
  - Posterior band
  - Transverse band
Valgus – Primary Stabilizer

- Medial Collateral Ligamentous Complex
  - Anterior band
    - Fan like proximal attachment, often showing increased signal
    - Variable distal insertion, up to 3-4 mm distal to margin of articular cartilage
  - Posterior band
  - Transverse band
Valgus – Primary Stabilizer

• Medial Collateral Ligamentous Complex
  – Anterior band
    • Fan like proximal attachment, often showing increased signal
    • Variable distal insertion, up to 3-4 mm distal to margin of articular cartilage
  – Posterior band
  – Transverse band
Valgus – Secondary Stabilizers

- Radiocapitellar joint
  - Valgus stabilizer
Valgus – Secondary Stabilizers

- **Common Flexors**
  - Flexor carpi ulnaris
  - Palmaris Longus
  - Flexor carpi radialis
  - *Pronator Teres*
Valgus – Secondary Stabilizers

• Common Flexors
  – Origin at medial epicondyle
  – Proximal and medial to the medial collateral ligament
  – FDS fibers arise from anterior bundle medial collateral ligament
Valgus Injury

• Acute injury: hypervalgus stress
  – Trauma
    • Fall
    • Direct blow
  – Acute on chronic trauma
    • Medial epicondylitis steroid injection
    • Chronic degeneration

• Chronic injury:
  – Repetitive motion/microtrauma
  – Originally reported with javelin throwers
  – Now commonly seen in throwing athletes
    • Late cocking/early acceleration
Valgus Injury - Instability

- Valgus injury does not lead to gross subluxation/dislocation
- Instability “symptoms” are not those of impending dislocation
- Rather, instability is manifest as pathology related to abnormal motion
  - Pain
  - OA
  - Ulnar neuritis
Valgus injury - Acute

- Flexor muscle strain
- Common flexor tendon tear
- MCL tear
- Combined injury
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High grade tear, common flexor tendon
Valgus injury - Acute

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

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

High grade tear MCL and flexor mass
Valgus injury - Chronic

- Repetitive valgus stress leads to spectrum of overuse injuries
- Injury pattern related with patient age
Valgus injury - Chronic

• In pediatric patient, chondro-osseous pathology predominates
  – Panner’s Disease
  – “Little leaguer’s elbow”
    • OCD
    • Medial epicondylitis (apophysitis)
Valgus injury - Chronic

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  - Panner’s Disease
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Valgus injury - Chronic

• In adult, ligamentous and hypertrophic bony changes predominate
  – Ligament degeneration
  – Chronic ligament tear
  – Valgus extension overload
  – Ulnar neuritis

• “Medial epicondylitis”
Valgus injury - Chronic

- Ligament Degeneration
- Chronic Tear
- Valgus extension overload
- Ulnar neuritis

Courtesy Dr. M Borso
Valgus injury - Chronic

- Ligament Degeneration
- Chronic MCL tear
- Valgus extension overload
- Ulnar neuritis

T-sign, partial thickness tear
Valgus injury - Chronic

- Ligament Degeneration
- Chronic MCL tear
- Valgus extension overload
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Courtesy Dr. Resnick
Valgus injury - Chronic

- Ligament Degeneration
- Chronic MCL tear
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Valgus injury - Chronic

• Ligament Degeneration
• Chronic MCL tear
• Valgus extension overload
• Ulnar neuritis
  – Thickened cubital retinaculum
  – Narrowed cubital tunnel related with medial excursion of capsule

Courtesy Dr. Resnick
Valgus injury - Chronic

- Ligament Degeneration
- Chronic MCL tear
- Valgus extension overload
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Ouellette 2007
Valgus Injury - Treatment

- Conservative management
- Primary repair
- Ligamentous Reconstruction
Valgus Injury - Treatment

- **Conservative management**
  - May be considered if no desire to return to competitive activity
  - Can lead to chronic valgus instability
    - Repetitive microtrauma/ligamentous insufficiency
    - Acute rupture on chronic tendinosis
  - Ulnar neuritis related with instability

- **Primary repair**
- **Ligamentous Reconstruction**
Valgus Injury - Treatment

- **Conservative management**

- **Primary repair**
  - Reserved for acute injuries
  - Native ligament/tendon reattachment
  - No ulnar nerve symptoms

- **Ligamentous Reconstruction**
Valgus Injury - Treatment

- Conservative management
- Primary repair
  - Reserved for acute injuries
  - Native ligament/tendon reattachment
- Ligamentous Reconstruction
  - Chronic Valgus Injury
  - Incompetent tissue
  - Autograft (palmaris tendon)
Valgus Injury - Treatment

- Conservative management
- Primary repair
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Valgus Injury - Summary

- Spectrum of pathology
  - aMCL
  - Flexor Mass
  - Radiocapitellar joint
  - Ulnar nerve
Switching Gears

Or downshifting, as it may be
Dislocation and the spectrum of posterolateral instability
Posterolateral rotatory instability

• Posterolateral rotatory instability (PLRI) originally described 1991
• “Elbow instability” and “PLRI” are used interchangeably in literature
  – Incorrect usage
  – Should always specify the “type” of instability
• PLRI in fact a clinico-pathologic entity on the spectrum of posterolateral subluxation-dislocation
Posterolateral rotatory instability (PLRI)

O'Driscoll et al. - 2000
Significance of PLRI

• Elbow instability was originally recognized by isolated or recurrent dislocation
  – Patient presenting with dislocation has “proven instability”
  – Hyperextension injury was presumed mechanism (lever of olecranon)
  – Rational treatment regimens were not available
• “PLRI” provides anatomic and mechanistic basis for the *majority* of elbow dislocations
  – Primary and secondary stabilizer injury, either acute or chronic
Acute versus Chronic

- Acutely unstable elbow often not a diagnostic dilemma
  - Patient presents with dislocation or fracture/dislocation
  - Imaging useful to identify extent of injury
- Chronic instability more insidious
  - Patient presentation
    - Pain
    - Clicking
    - Snapping
    - Clunking
    - Locking
  - Physical exam often unremarkable
    - Exam under anesthesia may be needed to elicit positive instability test
  - Imaging findings useful to support/suggest diagnosis of instability
PLRI – Stabilizers

• Primary
  – Lateral Collateral Ligamentous complex
  – Coronoid process
  – MCL

• Secondary
  – Radiocapitellar Joint
  – Capsule
PLRI – Primary Stabilizers

• Lateral Collateral Ligamentous complex
  – LUCL
  – RCL
  – Annular ligament
PLRI – Primary Stabilizers

- Lateral Collateral Ligamentous complex
  - LUCL
  - RCL
  - Annular ligament
PLRI – Primary Stabilizers

• Lateral Collateral Ligamentous complex
  – LUCL
    • Classically described as the primary ligamentous restraint to posterolateral stress
    • Variably seen
  – RCL
  – Annular ligament
PLRI – Primary Stabilizers

- Lateral Collateral Ligamentous complex
  - LUCL
    - Extends from lateral epicondyle to tubercle of supinator crest
    - “sling” for radial head
  - RCL
  - Annular ligament
PLRI – Primary Stabilizers

- Lateral Collateral Ligamentous complex
  - LUCL
    - Proximally, distinction from RCL difficult on MR
    - Also difficult on surgical exposure
    - Anterior ½ - RCL
    - Posterior ½ - LUCL
  - RCL
  - Annular ligament
Anatomy – Primary Stabilizers

- Lateral Collateral Ligamentous complex
  - LUCL
  - RCL
    - Contiguous with annular ligament
    - Varus stability and annular ligament stabilizer
  - Annular ligament
Anatomy – Primary Stabilizers

- Lateral Collateral Ligamentous complex
  - LUCL
  - RCL
  - Annular ligament
    - Anterior and posterior attachments onto ulna
    - Ligamentous restraint of PRUJ
PLRI – Primary Stabilizers

• “Lateral Collateral Ligamentous complex”
• LUCL and RCL/annular recently shown to both function in varus/PLRI
  – No instability until both lesions sectioned
• Implication on imaging:
  – “Complete disruption” lateral ligamentous structures when both ligaments disrupted
  – “Partial (high grade)” if intact fibers from the other ligament
PLRI – Primary Stabilizers

- Lateral Collateral Ligamentous complex
  - Valgus posterolateral rotatory stabilizer
PLRI – Primary Stabilizers

• Coronoid Process
  – Valgus (posterolateral rotatory) stabilizer
PLRI – Secondary Stabilizers

• Radiocapitellar joint
  – Posterolateral rotatory stabilizer
Acute posterolateral subluxation/dislocation

- Acute trauma results in a subluxation/dislocation
  - Most often FOOSH
- Sequential pattern of injury
  - Circle of Horii

O'Driscoll et al. - 2000
Acute posterolateral subluxation/dislocation

• Acute trauma results in a subluxation/dislocation
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  1. LCL rupture (PLRI)
  2. Disruption of capsule (perched)
  3. a. MCL (except anterior band)
     b. entire mcl.
     c. complete soft tissue injury

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Courtesy Dr. Pathria
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Courtesy Drs. Pathria/Chung
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    c. complete soft tissue injury

Courtesy Dr. Pathria
Acute posterolateral dislocation
Dislocation

• Simple Dislocation
  – Pure ligamentous injury

• Complex dislocation
  – Ligamentous and bone injury
  – Radial Head Fracture
  – Coronoid Process Fracture
  – Terrible Triad
  – Posterior Monteggia
  – Anterior trans-olecranon fracture dislocation
Complex Dislocation - Significance

• Fracture implies loss of stabilizer support
  – Increasing instability with associated fractures
• Seemingly trivial fracture can have significant implications with regards to instability
  – Radial head fracture
  – Coronoid tip fracture
• “Terrible triad” injury associated with complicated outcomes
Complex Dislocation - Significance
Brief aside regarding radial head and coronoid fractures
Radial Head Fractures

- Mason classification (Modified)
  - Type 1: <2mm articular surface displacement
    - Conservative treatment
  - Type 2: >2mm, >30% articular surface
  - Type 3: comminuted fracture
  - Type 4: any fracture pattern following dislocation
Radial Head Fractures

- Mason classification (Modified)
  - Type 1: <2mm articular surface displacement
  - Type 2: > 2mm, >30% articular surface
    - Debated treatment
  - Type 3: comminuted fracture
  - Type 4: any fracture pattern following dislocation
Radial Head Fractures

• Mason classification (Modified)
  – Type 1: <2mm articular surface displacement
  – Type 2: >2mm, >30% articular surface
  – Type 3: comminuted fracture
    • Resection versus ORIF/arthroplasty
  – Type 4: any fracture pattern following dislocation
Radial Head Fractures

- Mason classification (Modified)
  - Type 1: <2mm articular surface displacement
  - Type 2: > 2mm, >30% articular surface
  - Type 3: comminuted fracture
  - Type 4: any fracture pattern following dislocation
    - Stabilizer recruitment
    - Strongly consider ORIF/arthroplasty
Radial head fracture - Treatment

- Excision
- ORIF
- Arthroplasty
Radial head fracture - Treatment

- Excision
- ORIF
- Arthroplasty
Radial head fracture - Treatment

- Excision
- ORIF
  - Miniplate
  - Herbert Screw
- Arthroplasty
Radial head fracture - Treatment

- Excision
- ORIF
- Arthroplasty
Radial head fracture - Treatment

- Excision
- ORIF
- Arthroplasty
  - Essex Lopresti fx
Coronoid Fracture

- Regan Morrey classification
  - Type 1 - tip “avulsion”
  - Type 2 - <50% of process
  - Type 3 - >50%

- Inconsistent treatment based on fracture type

- Treatment originally advocated for Type 3

- Instability more important

Doornberg 2006
Coronoid Fracture

- O’Driscoll classification
  - Based on fracture patterns
  - Associated with mechanism
  - Difficult to evaluate (CT required)
Coronoid Fracture

- O’Driscoll classification
  - Based on fracture patterns
    - Type 1 – transverse tip
      - Posterolateral dislocation/Terrible triad injury
      - Treatment via sutures
    - Type 2 – anteromedial facet
    - Type 3 – base

Doornberg 2006
Coronoid Fracture

- O’Driscoll classification
  - Based on fracture patterns
    - Type 1 – transverse tip
    - Type 2 – anteromedial facet
      - Varus posteromedial instability
      - Treatment via anteromedial plate and screw
    - Type 3 – base

Doornberg 2006
Coronoid Fracture

- O’Driscoll classification
  - Based on fracture patterns
    - Type 1 – transverse tip
    - Type 2 – anteromedial facet
    - Type 3 – Base
      - Olecranon fracture/dislocations
      - Medial plate/screw

Doornberg 2006
Terrible triad injury

- Posterolateral dislocation
- Radial head fracture
- Coronoid fracture
Terrible triad injury

- Poor outcomes
- Damage to multiple supporting structures
- Unstable, even in splint/cast
- Complex treatment algorithms
  - Surgeons will be aggressive

Matthew 2009
Terrible triad injury

- Posterolateral dislocation
- Radial head fracture
- Coronoid fracture
Terrible triad injury

Suspected “terrible triad”
Imaging of PLRI

- Radiologist may not have history of subluxation/dislocation
- Instability will be suggested based on damage to primary and secondary stabilizers
  - LUCL/RCL
  - Radial head
  - Coronoid Process
  - MCL
Acute PLRI

Define injuries
Acute avulsion RCL/LUCL from humeral attachment

Capsular injury

Stage 2
Stage 3a PLRI

Courtesy Dr. Pathria
Stage 3b PLRI with coronoid tip fracture

Courtesy Dr. Pathria
Courtesy Dr. Pathria
Chronic PLRI

Suggest instability
Chronic PLRI

• Post traumatic
  – Inadequate healing
• Iatrogenic
• Chronic soft tissue overload
• Connective tissue disorders
Chronic PLRI

- Post traumatic
- Iatrogenic
  - Surgical violation of lateral supporting structures
    - Lateral epicondyle release
    - Access to lateral compartment
  - Radial head resection
  - Steroid use
- Chronic soft tissue overload
- Connective tissue disorders
Chronic PLRI

- Post traumatic
- Iatrogenic
- Chronic soft tissue overload
  - Cubitus Varus deformity
  - Cructhes
- Connective tissue disorders

Abe, 1997
Chronic PLRI

- Post traumatic
- Iatrogenic
- Chronic soft tissue overload
- Connective tissue disorders
  - Ehlers Danlos
PLRI – additional findings
Posterior Capitellar Impaction

- Osteochondral impaction fracture of posterior capitellum
- “Hill-Sachs” equivalent
Posterior Capitellar Impaction

AJR 2008; 190:435–441
Posterior Capitellar Impaction

Courtesy Dr. Pathria
Posterior Capitellar Impaction

AJR 2008; 190:435–441
Pitfall - Pseudodefect of Capitellum

• Junction of lateral epicondyle with posterior capitellar chondral surface
• Trough-like indentation a normal finding on sag and coronal images
• Lack of marrow edema helpful
Pitfall- Pseudodefect of Capitellum

- Junction of lateral epicondyle with posterior capitellar chondral surface
- Trough-like indentation a normal finding on sag and coronal images
- Lack of marrow edema helpful

AJR 2008; 190:435–441
Osborne-Cotterill

- First described 1966
- Recurrent dislocations
- “an osteochondral fracture in the posterolateral margin of the capitellum with or without a crater or shovel-like defect in the radial head”
- No description of ligamentous pathology

AJR 2008; 191:727–729
Osborne-Cotterill

- Recently described in patients with PLRI
- Shear fracture from posterolateral capitellum
- Poor coverage of radial head in extension
- *Probably on spectrum of posterior capitellar impaction fracture*

*AJR 2008; 191:727–729*
Osborne-Cotterill? Posterior Impaction?
“Drop” Sign

- Lateral view
- Measure ulnohumeral distance
- Greater than 4 mm associated with instability in small series
PLRI - treatment

• Acute simple
  – Conservative treatment based on stage of soft tissue injury

• Acute complex
  – Fracture fixation
  – Primary ligament repair or reconstruction (LUCL)

• Chronic
  – Ligament Reconstruction (LUCL)

Sanchez-Sotelo, 2003
Terrible triad injury: Unstable fracture dislocation of elbow

Closed reduction EUA

Stable (subtle P/L instability?)

Hinged elbow brace (stable in pronation or supination)

Unstable open reduction Global posterior approach

MUCL common flexors

LUCL common extensors

Radial head fracture

Stable reconstruction possible

ORIF

Approach coronoid medially after ORIF

Stable reconstruction NOT possible

Radial head replacement arthroplasty

Approach coronoid laterally before replacement

NO radial head fracture

Check LUCL EUA for P/L stability

Approach coronoid medially
• Balance between maintaining ROM and congruency
  – Avoid contractures
  – Allow for anatomic healing
• Focused on key stabilizers
• Treatment likely aggressive in terrible triad injury
Varus Injury Patterns

• Pure varus injury
  – Isolated varus instability rare

• Varus posteromedial rotatory instability (PMRI)
  – Recently described in association with anteromedial coronoid fracture
  – LCL injury
  – +/- MCL injury
PMRI – Primary Stabilizers

• Lateral Collateral Ligamentous complex
  – Varus stabilizer
PMRI – Primary Stabilizers

• Coronoid Process
  – Varus (posteromedial rotatory) stabilizer
PMRI

- Anteromedial coronoid fracture
  - O’Driscoll type 2
  - Look for involvement of sublime tubercle (MCL)
  - ORIF
PMRI

Doornberg, 2006
Concept 2

Joint Congruence/Stability
- Primary Stabilizers
- Secondary Stabilizers

Trauma
- Acute Trauma
- Chronic/repetitive Trauma

Imaging Findings
- Fracture
- Dislocation
- Ligamentous disruption
- Hypertrophic Change
- Chondral disease

Instability Patterns
- Valgus
- PLRI
- (PMRI)
- (Varus)
Thank you
Refs


