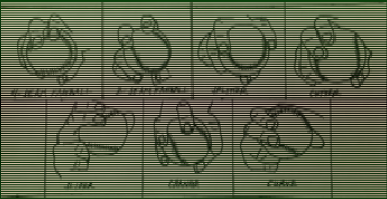




Elbow Anatomy
And Biomechanics



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**I (and/or my co-authors)
have something to
disclose.**

Detailed disclosure information is available via:

The course syllabus, or

AAOS Disclosure Program on the AAOS website at
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Scope of the Problem

- Affects athletes of any age engaged in overhand throwing sports.
- Since 2000 there has been a 5-fold increase in shoulder/elbow injuries in youth baseball players.
- Similar increase in the numbers of operative reconstructions required.

Professional Athlete

Elbow Anatomy and Biomechanics

- 1 in 3 MLB Pitchers have required surgery for elbow.
- Over 500 Million \$ in cumulative salaries miss time on the DL each year.

| Year of Surgery | Number of UCL Surgeries |
|-----------------|-------------------------|
| 1980 | 0 |
| 1985 | 1 |
| 1990 | 2 |
| 1995 | 3 |
| 2000 | 12 |
| 2005 | 14 |
| 2010 | 16 |
| 2015 | 32 |

Overhead Throwing Motion

Elbow Anatomy and Biomechanics

Medial Elbow

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- Where the action is....

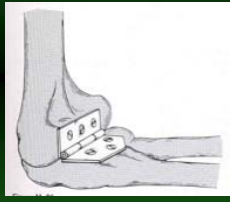
- UCL
- Ulnar Nerve
- Flexor-Pronator Mass
- Posteromedial Olecranon

Diagnostic Dilemma....

Elbow Joint

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- Hinge or ginglymus joint (single axis of rotation)
- Constrained by definition (50% intrinsic stability)



Range of Motion


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- Normal
 - 0 to 140 to 150 degrees passive elbow flexion
 - 75 degrees pronation, 85 degrees supination
- Functional
 - 30 to 130 degrees elbow flexion
 - 100 degrees of rotation equally divided between pronation and supination



Bony Anatomy

Elbow Anatomy and Biomechanics



- Three articulations
 - Trochlea and semilunar notch of the ulna
 - Flexion and extension
 - Capitulum and depression in the proximal radial head
 - Radial head and lesser sigmoid notch of the proximal ulna
 - Axial rotation and pivoting


Netter's Atlas of Human Anatomy

Carrying Angle

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- Male
 - 11 to 14 degrees
- Female
 - 13 to 16 degrees

Increased Carrying Angle may predispose to medial elbow pain, injury or cubital tunnel syndrome....




The illustration shows a female torso from the waist up, wearing a yellow bikini. Her right arm is extended downwards, and a green arrow points to the angle between the upper arm (humerus) and the forearm (ulna/radius) at the elbow, which is the carrying angle.

Proximal Ulna

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- Responsible for the inherent stability
- Coronoid process
 - Insertion of the brachialis (and on ulnar tuberosity)
 - Medial aspect, attachment site of MCL
- Olecranon
 - Insertion of the triceps tendon
- Sublime Tubercle
 - Insertion of UCL on Ulna




The anatomical diagrams show the proximal ulna from two perspectives. The top diagram is a superior view of the ulna with a '2' label. The middle diagram is a medial view of the ulna showing the coronoid process and olecranon. The bottom diagram is an anterior view of the ulna with a '6' label.

ELBOW STABILITY

Elbow Anatomy and Biomechanics

- Joint Congruity
- Ligaments
- Muscles



The anatomical diagrams show the elbow joint from two perspectives. The left diagram is a medial view of the elbow joint showing the ulna and humerus. The right diagram is an anterior view of the elbow joint showing the humerus and ulna.

Collateral Ligaments

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- Ligaments
 - Medial (Ulnar) Complex
 - Anterior Bundle Medial Collateral
 - Primary Restraint to Valgus and distraction with elbow in Flexion
 - Posterior Bundle Medial Collateral
 - Transverse Oblique
 - Lateral (Radial) Complex
 - LUCL (PLRI)
 - RCL
 - Annular
 - Accessory radial collateral

Anterior Bundle UCL

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- Primary Restraint to Valgus and distraction with elbow in Flexion
- Origin
 - Anterior inferior medial epicondyle
 - Central 67%
 - O' Driscoll, et al. *J Hand Surg*, 1992
- Insertion
 - Sublime Tubercle
 - Medial proximal ulna/coronoid
- By far, most important of MCL complex (strength, stability)

From Morrey BH. *Anatomy of the Elbow Joint*. In: Morrey BH. *The elbow and its disorders*. 3rd Ed.

Posterior Bundle

Elbow Anatomy and Biomechanics

- Posterior Bundle
 - Functionally insignificant
 - Fan-shaped in appearance
 - Origin
 - distal to anterior bundle
 - Insertion
 - medial semilunar notch
 - Thinner and weaker than anterior band
 - Secondary stabilizer at flexion > 90
- Transverse Bundle
 - Does not cross elbow joint
 - Expansion of inferior- medial capsule

From Morrey BH. *Anatomy of the Elbow Joint*. In: Morrey BH. *The elbow and its disorders*. 3rd Ed.

Medial Cadaveric Section

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- No gross or radiographic ulnohumeral increase with divisions of
 - Posterior bundle
 - Transverse ligament
- Gross and radiographic increase with division of the Anterior bundle

UCL Adaptation

Elbow Anatomy and Biomechanics

Evaluation of the thickness of the medial ulnar collateral ligament in junior high and high school baseball players

Hideaki Nagamoto · Nobuyuki Yamamoto · Daisuke Kurokawa · Hiroyuki Takahashi · Takayuki Muraki · Minoru Tanaka · Yoichi Koike · Hirotsuka Sano · Eiji Itoi

| Group | Throwing arm (mm) | Non-throwing arm (mm) |
|--------------------|-------------------|-----------------------|
| High School | ~5.5 | ~4.5 |
| Junior High School | ~4.8 | ~4.5 |
| Overall | ~5.2 | ~4.5 |

■ Throwing arm □ Non-throwing arm * p<0.01

Muscles Medial Epicondyle

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- Pronator teres
 - Median Nerve
 - Two heads
 - ME and Coronoid
- Common flexor tendon
 - Flexor carpi radialis
 - Median nerve
 - Palmaris longus
 - Median nerve
 - Flexor carpi ulnaris
 - Ulnar nerve
- Flexor Digitorum Superficialis

Elbow Anatomy and Biomechanics

DYNAMIC CONTRIBUTIONS OF THE FLEXOR-PRONATOR MASS TO ELBOW VALGUS STABILITY

BY MAXWELL C. PARK, MD, AND CHRISTOPHER S. AUMANO, MD
 Investigation performed at the Center for Shoulder, Elbow and Sports Medicine, Department of Orthopaedic Surgery, Columbia University Medical Center, New York, NY

(A) 30 Degrees Elbow Flexion

| Dynamic Muscle Condition | Valgus Angle in Degrees |
|--------------------------|-------------------------|
| Normal | 6.5 |
| IMR | 5.5 |
| PFD | 1.5 |
| PFD+PDS | 1.5 |
| PDS | 4.5 |
| PT | 5.5 |

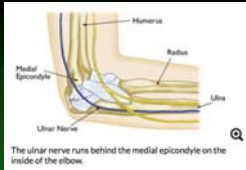
(B) 90 Degrees Elbow Flexion

| Dynamic Muscle Condition | Valgus Angle in Degrees |
|--------------------------|-------------------------|
| Normal | 4.5 |
| IMR | 3.5 |
| PFD | 1.5 |
| PFD+PDS | 1.5 |
| PDS | 2.5 |
| PT | 3.5 |

Elbow Anatomy and Biomechanics

Ulnar Nerve

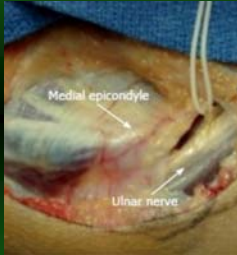
- Crosses the Medial Elbow at the Cubital Tunnel
 - Roof Aponeurosis of Flexor Carpi Ulnaris
 - Floor is the UCL
- 10% Anatomic Variant Subluxation
 - No Correlation to Symptoms



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Ulnar Nerve

- Ulnar Nerve Irritation can occur do to:
 - repetitive motion
 - Tension During Valgus Moment
 - Underlying UCL Injury



Cocking: Early and Late

Elbow Anatomy and Biomechanics

- Ends as front foot hits ground
- **Valgus Load at the Elbow**
- Flexion at elbow

Biomechanics

Elbow Anatomy and Biomechanics

- Late Cocking/Early Acceleration
 - Elbow increases angle of flexion 63-74 degrees
 - Intensity of primary flexor muscle action is low
 - Lateral epicondylar muscle mass has strongest level of muscle action

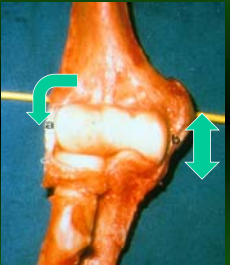
MEDIAL INSUFFICIENCY

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- Tensile Force
- Angular Velocity (2300-5000 deg/sec)
- Valgus Moment (32Nm)
- Ultimate Failure Load UCL (33Nm)

Valgus Load

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- Repetitive near-tensile failure loads
 - Microtrauma to anterior band
 - Ligament attenuation or failure
- Throwing generates large valgus and extension forces
 - Compressive forces of 500N at lateral radiocapitellar articulation

Valgus Extension Overload Syndrome

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- **Tensile stress along medial compartment restraints**
 - UCL, flexor-pronator mass, medial epicondyle apophysis, and ulnar nerve
- **Shear stress in the posterior compartment**
 - Posteromedial tip of the olecranon and trochlea / olecranon fossa
- **Compression stress laterally**
 - Radial head and capitellum



Deceleration Phase

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- Ball Release thru maximum IR of shoulder
- Elbow achieves forceful terminal extension
- **Posteromedial Olecranon Contact with Trochlea**
 - Compression and Shear stress
 - Common Pattern of Posterior Impingement



Posteromedial Osteophyte

PARTIAL POSTEROMEDIAL OLECRANON RESECTION: A KINEMATIC STUDY
 BY S. KAMATH, MD, H. HIRAYAMA, MD, A. PRASADHARISH, MD, P. L. NAGAI, MD, S.W. O'DONOGHUE, PhD, M.D., R. BARTSCHKE, MD, R. B. AN, PhD, AND R.E. AMADIO, MD
 Investigation performed in the Biomechanics Laboratory, Division of Orthopaedic Research, Mayo Clinic, Rochester, Minnesota

MEDIAL COLLATERAL LIGAMENT STRAIN WITH PARTIAL POSTEROMEDIAL OLECRANON RESECTION
 A BIOMECHANICAL STUDY
 BY SUDHAKAR KAMATH, MD, FRACS (ORTHOP), NAGAI P, BARTSCHKE, MD, BARTSCHKE, M, O'DONOGHUE, MD, PHD, CHANDRASEKHAR S, AMADIO, MD, HIRAYAMA, HIRAYAMA, MD, PRASADHARISH, MD, AND NAGAI, AN, PHD, AND BARTSCHKE S, AMADIO, MD

Elbow Summary

- Valgus Stress during the late cocking/acceleration phase of throwing leads to a predictable pattern of pathology
 - Flexor-Pronator Strain
 - Posteromedial Olecranon Impingement
 - UCL injury
 - Ulnar Nerve Involvement

Thank You

Chicago
