Shoulder & Elbow in the Skeletally Immature Athlete
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Outline
Common injuries in athletes:
Shoulder
• Rotator cuff tendonitis
• AC separation
Elbow
• Medial ulnar collateral ligament (MUCL) tear
• Lateral epicondylitis (tennis elbow)

Disclosures
John Faust, M.D., has no financial relationships to disclose

Shoulder injuries in skeletally immature athletes

Objectives (20 minutes)
Shoulder injuries in skeletally immature athletes:
• Relevant anatomy
• Unique injuries
• Mimic injuries seen in skeletally mature athletes

Elbow injuries in skeletally immature athletes
• Same

Mimicker #1
12 yo male with a “sore rotator cuff”
• History:
  • All-star pitcher
  • Playing every week for the last 12 months
  • Lateral shoulder soreness
• Exam:
  • Full rotator cuff strength with pain
  • Tender over lateral shoulder
  • Obligate abduction

Diagnosis:
rotator cuff tendonitis?
Proximal humerus epiphysiolysis

**Diagnosis:** proximal humerus epiphysiolysis (little leaguer’s shoulder)

**Proximal humerus epiphysiolysis** (Little leaguer’s shoulder)

- Often misdiagnosed as rotator cuff tendinitis (seen in skeletally mature athletes)
- Rotator cuff tears almost non-existent in teenagers, partial thickness tears exist but rarely the whole story and rarely isolated
- Highest incidence in male baseball pitchers ages 11-16
- Peak incidence around puberty at age 14
- Significant shear stress from the high torque in the late cocking/early acceleration phase of throwing
- Fastest recorded human motion

**Mechanism of physeal stress injuries**

Some recent studies define the mechanism of physeal stress injury as:
- Begins in the metaphysis with disruption of the normal metaphyseal blood supply
- Absent blood flow disrupts endochondral bone formation
- Long columns of hypertrophic cartilage cells from the physis extend into the metaphysis
- Cartilage signal intensity of apparent physeal widening seen on MRI
- These areas of physeal widening differ from blebs injuries
- No erosion of the epiphysis fluid through the cartilage
- No fluid seen on the MRI
- Neither physeal nor apophyseal displacements seen
- Pohanka S, Radiology 1998; 203: 121-129
- Laor T, AJR American Journal of Roentgenology, 2006; 186: 1039-1042
- The newly formed metaphyseal bone is fragile and unable to resist compressive, shear or tensile forces making the chondro-osseous junction (COJ) susceptible to injury
- The newly formed physeal cartilage (primary spongiosa) has only a few mineralized cartilage spines to resist weight bearing
- The peripheral metaphyseal cortex is thicker compared to the cortical thickness of the diaphysis

**Shoulder Anatomy**

**Proximal humeral physis**
- Closure begins around 14 yo and finishes by 17 yo
- Estimate for complete closure:
  - 16 yo for females
  - 18 yo for males

**Growth plate (physis) anatomy**

Endochondral bone growth
- Epiphyseal cartilage turns into mineralized osseous matrix
- Chondrocytes align in columns and progress through defined zones:
  - Resting
  - Proliﬁerative
  - Hypertrophic
- Chondrocytes becoming separated by increasing bands of mineralized cartilage matrix starting in the proliferative zone and increasing in density towards the chondro-osseous junction (COJ)
- These mineralized cartilaginous struts are the substrate of the metaphysis on which mineral deposition occurs, produce, and mineralize the extracellular matrix of bone

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Proximal humerus epiphysiolysis

Diagnosis
- History and exam
- Radiographs (AP of the bilateral shoulders in external rotation)
- MRI rarely needed

Treatment
- Rest and structured PT: 2-3 months
- Throwing program: light tossing then increase distance and velocity
- Education – pitch counts

Natural history
- 91% return to sports and remain asymptomatic with structured PT
- Long-term consequences rare due to remodeling potential of the proximal humerus
- Half of the growth of the humerus is proximal
- Complications rare:
  - Premature physeal closure → length discrepancy, angular deformity
  - Physeal fracture

Pitch Counts

USA Baseball: web.usabaseball.com
- Pitch counts are found in the article “Youth Baseball Pitching Injuries” near the bottom of the Medical Safety Reports page at web.usabaseball.com/about/medical_safety_reports.jsp

USA Baseball and MLB’s Pitch Smart website notes:
- “Ultimately, it is the responsibility of the parent and the athlete to ensure that the player follows the guidelines for his age group over the course of the year - given that he will oftentimes play in multiple leagues with different affiliations covering different times of the year.”

Mimicker #2

His radiograph

Diagnosis: distal clavicle fracture

Red: acromion
Orange: coracoid
Light green: distal clavicle fragment
Green: proximal clavicle fragment

12 yo male “separated his shoulder”
- Tackled playing football, landed on his shoulder
- Exam:
  - Prominent and tender distal clavicle

Distal clavicle fracture

- Distal clavicle ruptures through the periosteum
- Significant remodeling potential

Periosteum torn
Periosteal sleeve where the bone will remodel

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Distal clavicle fractures

Treatment:
- Initial treatment: sling
- Ortho follow-up in 1 week
- Definitive treatment: sling vs. ORIF
- Age (under/over 13 yo)
- Displacement
- Fracture pattern:
  - Types I-III: usually sling
  - Types IV-VI: sling vs. ORIF

Mimicker #1

Radiographs from the 12 yo pitcher

Diagnosis: medial epicondyle apophysitis

Elbow injuries in skeletally immature athletes

Mimicker #1

12 yo male baseball player
- Best pitcher on the team
- Plays on multiple teams year round
- Medial elbow pain after pitching

11 yo female gymnast
- Level 10
- Medial elbow pain after floor routines

Diagnosis: medial ulnar collateral ligament tear?

Medial Epicondyle Apophysitis

His MRI

Elbow Anatomy

Medial ulnar collateral ligament (MUCL)
- Proximal attachment to the inferior surface of the medial epicondyle apophysis

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Elbow Anatomy

Medial ulnar collateral ligament (MUCL)
- Proximal attachment to the inferior surface of the medial epicondyle apophysis
- Distal attachment to the sublime tubercle of the ulna and the medial ulnar crest

Mechanics of Pitching Injuries

Pitching mechanics
- Late cocking/early acceleration: elbow flexing/extending under valgus stress →
  - Tensile force distracts the ulnar side
  - Compressive forces on the radial side
  - Abutment/shear of the olecranon on the trochlea
    = Valgus extension overload

Elbow Anatomy

Ossification centers (age when appears)
- Capitellum (1 yo)
- Radial head (3 yo)
- Medial epicondyle (5 yo)
  - Appears as late as age 7 in males
  - Fuses around age 15 in males
- Trochlea (7 yo)
- Olecranon (9 yo)
- Lateral epicondyle (12-14 yo)

Mechanics of Pitching Injuries

Shared mechanism of injury / spectrum of injury:

<table>
<thead>
<tr>
<th>Skeletally immature</th>
<th>Skeletally mature</th>
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<tbody>
<tr>
<td>Ulnar tension force</td>
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<tr>
<td>1. Medial epicondyle apophysis</td>
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<td>2. Medial epicondyle avulsion fx</td>
<td>2. Medial ulnar collateral ligament (MUCL) tear</td>
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<td>Partial</td>
<td>Complete</td>
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<th>Radial compression force</th>
<th>Capitellar OCD</th>
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<td>1. Capitellar OCD</td>
<td>Radiocapitellar arthritis</td>
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<td>2. OCD loose body</td>
<td>Olecranon stress fracture</td>
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<th>Olecranon abutment and shear</th>
<th>Olecranon arthritis and osteophytes</th>
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Mechanics of Pitching Injuries

All together: valgus overload syndrome

Little Leaguer’s Elbow

Valgus extension overload (VEO) stresses the medial epicondyle apophysis

• MUCCL attaches to the medial epicondyle
  • \(\Rightarrow\) range of injuries referred to as Little Leaguer’s elbow:
    • Medial epicondylar apophysitis (most common use)
    • Accelerated apophyseal growth with delayed closure
    • Medial epicondyle avulsion fracture (initial description)
      • Complete avulsions - true Salter-Harris I physeal fracture
      • Partial avulsions

Medial Epicondyle Avulsion Fracture

Presentation

• Ages 7-15 yo
• 3 mechanisms
  • Avulsion
  • Pop and pain
  • Elbow buckles while tumbling
  • Throwing a fastball
  • Dislocation
  • Direct trauma

10-20% of pediatric elbow fracture
50-60% associated with elbow dislocations

• Watch for fragment incarcerated in the elbow joint
• Watch for ulnar nerve symptoms

Medial Epicondyle Apophysitis

Dorsal injury

Presentation

• Patients 5-15 yo (unfused medial epicondyle), but usually under 10 yo
• Medial or acute-onset medial elbow pain
• During pitching or handstands
• Decreased throwing distance

Imaging:

• Radiographic widening of the medial epicondylar apophysis on radiographs
• MRI not usually necessary

Exam:

• Medial epicondyle tender

Treatment:

• Rest, ice, anti-inflammatories
• Activity modification – no valgus elbow stress
• Nonthrowing, batting, etc. for pain
• No handstands, freestyle, etc.
• Physical therapy – throwing program, pitching mechanics
• Gradual return to sports, pitch counts

Medial epicondyle avulsion fracture

Fracture displacement

• Displaces anterior to the origin on the medial epicondyle
• In line with the pull of the flexor-pronator muscle mass
• Hard to measure on radiographs

• Internal oblique view best
  • [Image of internal oblique view]
  • 45° internal oblique, multiply measurement by 1.4 for best estimate
  • [Image of measurement]

• Exact number needed to indicate surgery not known

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Medial epicondyle avulsion fracture

Treatment:
• Non-operative:
  • Brief immobilization for pain then mobilize to avoid stiffness
  • Stiffness is the most common complication
  • Fragment heals anterior → MUIE tight in extension → loss of elbow extension
• Indications:
  • Minimal displacement
  • Non-athletic types
• Open reduction internal fixation
  • Secure fixation allows safe and early ROM to avoid stiffness
  • Incarcerated fragment
  • Open fracture
  • Throwing athlete, gymnast, upper extremity athlete
  • Significant displacement (≥ 7 mm or cm)
  • Valgus instability
  • Elbow dislocation?
  • Ulnar nerve symptoms?

Osteochondritis Dissecans (OCD) of the capitellum

Localized disorder of subchondral bone causing separation and fragmentation of the articular surface
• Chronic compressive forces at the radiocapitellar articulation
• Avascular necrosis of subchondral bone
• Same possible mechanism of injury as physeal stress injuries:
  • Disruption of blood flow to the secondary epiphysis "metaphyseal equivalent".
  

Osteochondritis Dissecans (OCD) of the capitellum

Presentation:
• Overuse injury in gymnasts and throwers
  • Dull pain, worse with activity
  • Popping or locking
• Elbow tender laterally
• Asymmetric extension

Mimicker #2

13 yo male baseball player
• Pitcher and catcher
• Lateral elbow sore after every game
• No injury

Diagnosis:
lateral epicondylitis (tennis elbow)?

12 yo female gymnast
• Elbow hurts after practice and recently started locking
• No injury

Diagnosis: Osteochondritis Dissecans (OCD) of the capitellum

Osteochondritis Dissecans (OCD) of the capitellum

10y 5m gymnast

Diagnosis: Osteochondritis Dissecans (OCD) of the capitellum

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Osteochondritis Dissecans (OCD) of the capitellum

Treatment:
- Observation if asymptomatic
- Non-operative: stable lesions
  - Activity and weight bearing restrictions
  - Immobilization
- Surgery:
  - Symptomatic despite immobilization, weight bearing restrictions, or activity
  - Loose body

Surgical options:
- Arthroscopy
- Observation
- Osteochondral grafting
- Osteochondral autograft
- Osteochondral allograft
- Mosaicplasty
- Osteochondral autograft transfer system (OATS)
- Best for large, deep, and unstable lesions

Shi, J Pediatr Orthop 2012
Iwasaki ASJM 2006

Osteochondritis Dissecans (OCD) of the capitellum

Treatment
- Location important
  - Contained lesions – surrounded by normal cartilage
  - Better outcome with marrow stimulation
  - Uncontained lesions
  - Osteochondral grafting
  - Worse outcomes:
    - >50% of the articular surface
    - >1 cm diameter
    - Uncontained lateral margin
  - Return to sports: 25-86%
    - Depends on the study and the sport

Mimicker #3

10 yo female gymnast
- Lateral elbow pain
- Sore during practice
- No mechanical symptoms

Diagnosis:
lateral epicondylitis (tennis elbow)?

Mimicker #3

Diagnosis:
Posterolateral Synovial Impingement

Panner’s Disease

AVN of the capitellum ossific nucleus
- “Perthes disease of the elbow”
- Etiology unclear
  - Likely due to lateral compression across the radiocapitellar joint
- 4-8 yo
- Difference from OCD
  - <10 yo
  - NOT an overuse injury
  - Benign natural history

Natural history:
- Self-limited
  - Initial period of fragmentation then normal growth resumes
  - Late sequelae rare

Treatment:
- Rest then rehabilitation

Posterolateral Synovial Impingement

Synovial Impingement of the Posterolateral Elbow (SIPEL)
- Plica of the elbow
- Often recall an injury
- Exam:
  - Negative for epicondylitis provocative findings
  - Tender at posterolateral aspect of the radiocapitellar joint

Treatment:
- Rest, rest, rest
- Physical therapy and mechanics
- Arthroscopic resection (occasionally)
Injuries shared with skeletally mature athletes

Subluxating ulnar nerve
Snapping triceps tendon
Posterolateral rotatory instability (PLRI) (as approaching maturity)
Ulnar collateral ligament (UCL) tear (as approaching maturity)

- Ulnar physeal widening
- UCL instability
- Ulnar collateral ligament avulsion
- Ulnar nerve palsy
- Ulnar collateral ligament tear
- Ulnar collateral ligament attenuation

Flexor-pronator tendonitis (as approaching maturity)

Summary

Shoulder
- Rotator cuff tendinitis
- Proximal humerus epiphysiolysis (Little Leaguer’s shoulder)
- AC separation
- Distal clavicle fracture

Elbow
- UCL
- Little Leaguer’s elbow (Medial epicondylo apophysitis or Medial epicondylo fracture)
- Tendon elbow
- OCD of capitellar or Synovial impingement (SIPLE)

References

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