Upper Extremity Injuries in the Skeletally Immature Athlete

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Introduction

Explosion in youth sports
- Younger ages
- Earlier specialization
- Multiple teams, year-round
- Social, financial, & parental pressures

Introduction

Unique considerations in children
- Skeletal immaturity
- Muscle strength, coordination
- Ligamentous laxity
- Poor technique, mechanics
- Overuse, high intensity

Objectives

Shoulder in overhead athlete
- Proximal humeral epiphyseolysis, instability

Thrower’s elbow
- Medial apophysitis, osteochondritis dissecans

Gymnast’s wrist
- Physeal arrest and TFCC tears

“Little League shoulder”

6 phases of throwing
- Acceleration: 40-50 msec, up to 600,000 deg/sec
- Deceleration: 50 msec, up to 500,000 deg/sec
**Epidemiology**


- 298 youth pitchers over 2 seasons
- 26% elbow pain
- 32% shoulder pain
- Risk factors for pain
  - Number of pitches
  - Arm fatigue during game

**Biomechanics of pitching**

Adults

- Elbow valgus stress ~ 65 Nm, highest during cocking
- Shoulder tensile stress ~ 1,100 Nm, highest during release

**Biomechanics of pitching**

What about children?

Sabick et al, *AJSM*, 2005

- 14 pitchers, fastballs
- 12.1 +/- 0.4 years
- ER torque 17.7 Nm
- Distraction 217.4 N

@ 5% vs 400% failure stress of physis

**“Little League shoulder”**

Proximal humeral epiphysiolysis

- Shoulder pain
- Throwing athlete
- Radiographic changes of proximal humeral physis

(Rotational) physeal stress fx

**“Little League shoulder”**


Pain, tenderness
Radiographic “widening” of proximal humeral physis +/- sclerosis and fragmentation

**“Little League shoulder”**

Treatment

- Rest (6 wks to 6 mo)
- Physical therapy for ROM, strengthening
- Interval throwing program
- Critical evaluation of pitching mechanics
“Little League shoulder”

Heyworth et al, unpublished

- 95 patients
- Symptom-free at 2.6 mo
- Return to play at 4.2 mo
- 7% recurred in 1 year
- GIRD with almost 3:1 odds ratio of recurrence

GIRD

Also, profound anatomic changes may occur due to excessive throwing in young athletes

Increased humeral retroversion
Loss of internal rotation

Internal rotation deficit

Internal rotation deficit

Edelson, JSES, 2000

- Analysis of 180 humeri
- Age 4 months to 19 years
- Infants: 65° retroversion
- Most derotation by 8 yrs
- Adults: 30° retroversion

Internal rotation deficit

GIRD due to capsular contractures...

...OR, persistent retroversion!

- Professional
- Collegiate
- Youth

Adaptive vs. maladaptive?
Internal rotation deficit

Treatment principles

• Accurate diagnosis
• Physical therapy
• Sleeper stretches for GIRD
• Periscapular & cuff strengthening
• Anterior stretching?

Internal rotation deficit

Improvements seen…but not all athletes will respond

• Intra-articular pathology?
• Bony changes?

Arthroscopic repair vs. release
• SLAP, cuff

Summary

High incidence of shoulder pain in throwers

Proximal humeral epiphysiolysis
GIRD → internal impingement

Prevention key
• USA baseball and LLBB guidelines
• Optimal mechanics, stretching & strengthening

Shoulder instability

Epidemiology

True incidence unknown

1: 10,000 athlete-exposures
• Owens et al, AJSM 2009

1.7: 1,000 per year in military
• Owens et al, JBJS 2009

Rising frequency in adolescents

Epidemiology

Zacchilli & Owens, JBJS 2010
• National Electronic Injury Surveillance System
• 2002-2006

• Overall, 23.9/ 100,000
  • Age 10-19, ~40/ 100,000
• 46.8% 15 – 29 years of age
• 48.3% during sports, recreation
Pathophysiology

Bankart lesion
MDI, ligamentous laxity
• Cameron et al, 2010
• Emery, 1994

Beware associated lesions
• Glenoid fractures
• ALPSA
• Hill-Sachs

The case for surgical treatment

High recurrence rate
↑ soft-tissue & bony injury
Surgery safe & effective

Natural history

Variable recurrence rates
Higher recurrence rates
• Younger patients
• Injury mechanisms
• Contact sports

Robinson 2002 Elbaum 1994
Sachs 2007 Marans 1992
Rhee 2009 Vermeiren 1993
Milano 2011 Wagner 1983

Non-operative treatment

Sling immobilization
• Paterson et al, JBJS 2010
ER immobilization?
• Itoi et al, JBJS 1999
• Itoi et al, JBJS 2007
• Seybold et al, AOTS, 2009
• Finestone et al, JBJSB 2007
• Limpisvasali AJSM 2008
• Llaava et al, JBJS 2011

Physical therapy
The in-season athlete


- 26 of 30 athletes able to complete season
- 10 athletes with recurrent instability
- 16 athletes elected off-season surgery

Owens et al, JAOS 2012

The case for surgical treatment

Recurrence → additional soft-tissue & bony injury

More extensive labral injury
  • Kim et al, AJSM 2010

Progressive capsulolabral degeneration
  • Habermeyer et al, JSES 1999

Owens et al, JAAOS 2012 © COSF 2015

The case for surgical treatment

18% vs. 40% arthropathy with recurrent dislocations
  • Hovellius et al, JSES 2009

19.7% arthropathy, higher with recurrence, surgical delay
  • Buscayret et al, AJSM 2004

Kim et al, AJSM 2010

The case for surgical treatment

Primary stabilization safe and effective!

Recurrence 7-20%

Bottoni et al, AJSM 2002
Robinson et al, JBJS 2008
Kirkley et al, Arthroscopy 2005
Jones et al, JPO 2007

Handoll & Al-Maiyah, Cochrane Review, 2010
  • 4 RCT’s
  • 163 patients, primary traumatic dislocations

“Limited evidence supports primary surgery for young adults, usually male, engaged in highly demanding physical activities who have sustained their first acute traumatic shoulder dislocation…”

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But…

Risks of primary surgery
  • Unnecessary surgery
  • Loss of motion
  • Recurrent instability

Shared-decision making & individualized treatment!
  • Patient buy-in!
**Case presentation**

15yo RHD athlete with primary dislocation

**Conclusions**

Traumatic shoulder dislocation

- High recurrence rate
- Additional soft-tissue, bony injury
- Safe and effective

Individualized treatment, shared decision-making

**Medial epicondyle apophysitis**

Tensile forces medially
Compression forces laterally

**Biomechanics of pitching**

**Adults: UCL tears**

**Kids: Medial epicondyle**

10 years
1 year
4.5 years
4.5 years
Consequences

Pain!
Difficulty throwing
Avulsion fractures

Treatment

Accurate diagnosis
Rest
Physical therapy
• Address IR deficit!
Interval throwing program
Pitching mechanics

ORIF

Safe & effective
• Bony union
• Valgus stability

Louahem et al, AOTS 2010
• 139 pts
• Good-excellent results
• Stable
• 130/139 nl ROM

ORIF for medial epicondyle fracture

Kamath et al, JCO 2009
• 498 patients in 14 studies
• No difference in pain
• Valgus not measured
• ORIF: 9.3x higher union
• No difference in ulnar nerve symptoms
Summary

Medial epicondyle apophysitis
- Valgus forces on elbow
- Rest, PT, mechanics

Avulsion fractures
- ORIF for displaced injuries in athletes

Osteochondritis Dessicans (OCD) of the Elbow

Repetitive loading, Limited blood supply
  + Inability to heal after microtrauma
  - Subchondral fracture, Articular cartilage failure
  - Loose body formation

Biomechanics of pitching

Tensile forces medially
Compression forces laterally

Clinical presentation

Adolescent throwing athletes
- Lateral elbow pain (90%)
- Stiffness (55%)
- Catching, locking (<20%)
Not “tennis elbow!”

Radiographic evaluation

Plain radiographs
- AP, lateral
- Contralateral views
- 45° flexion oblique
Radiographic evaluation

MRI
- Assessment of cartilage surface
- Loose body
- Healing

Treatment: Stable lesions

Rest
Physical therapy
Serial examinations
- Clinical
- Radiographic
Interval throwing program, pitching mechanics

Surgical treatment

Surgical indications
- Symptomatic OCD
- Fragment instability
- Loose body
- Failed non-operative treatment

Unstable lesion
- Debridement
- Internal fixation
- Loose body excision

Internal fixation
- Unstable in situ
- Fragment elevation, curettage, fixation
- Best if ≤ 8 mm?
**Surgical treatment**

OATS

- Replacement with hyaline cartilage
- Better for large, uncontained lesions

**Results of treatment**

*Return to sports?*

- Mean 3.9 year f/u
- 4/10 returned to organized baseball

Takahara et al, JBJS, 2007
- Mean 7.2 years
- Open physis: 7/18
- Closed physis: 31/88

~ 40%

**Surgical treatment**

19 baseball players
- Mean age 14.2 yrs
- Ave f/u 45 mo
- 18/19 pain free
- 17/19 return to sports
- Excellent functional scores

**Surgical treatment**

18 baseball players
- Mean age 13.6 yrs
- Ave f/u 3.5 yrs
- High healing rate, return to sports
Surgical treatment

Ingall & Bae, ASSH 2015
Mean age 15.1 years
Mean f/u 22.5 months
>90% pain free
100% return to sports
92% return to primary sport
Improved Timmerman, DASH scores

Surgical treatment

11 males
OATS from LFC
Ave 26mo f/u
Excellent Lysholm, IKDC scores
6/9 50-100% fill
4/9 normal cartilage

Summary

OCD
• Lateral pain, stiffness, & mechanical symptoms
Stable lesions → rest

Unstable lesions
• Surgical treatment options
• OATS promising

Gymnast’s wrist

Distal radius physeal injury
• Sport-specific demands
• Wrist as weight-bearing joint
• ~ 2 per 100 gymnast-seasons

“Gymnast’s wrist”

Distal radius physeal arrest
• Repetitive compressive and tensile loading
• Distal radial physeal arrest
• Abnormal biomechanics
“Gymnast’s wrist”

Axial loads at wrist

- Neutral variance
  - 80% radiocarpal
  - 20% ulnocarpal

- 2mm ulnar positive variance
  - 42% ulnocarpal load

Early clinical presentation: wrist pain

Characteristic radiographic progression

Early clinical presentation: wrist pain

Characteristic radiographic progression

Preventative measures:

- Training techniques
  - Gradual advances during rapid growth
  - Alternate loading activities
  - Cyclical progressive training

- Appropriate response to pain
- Individualized care

Treatment of early stage(s)

- “Rest” x 6 weeks
- Clinical reassessment +/- radiographs
- Gradual resumption of training
- Serial clinical & radiographic follow-up

No evidence to support notion that wrist braces reduce the risk of physeal injury in skeletally immature gymnasts

“Tiger Paws allow gymnasts to train longer without pain.”
**Distal radial physeal injury**

Consequences:
- Abnormal wrist mechanics
- Ulnocarpal impaction
- TFCC tears
- DRUJ instability

Pain, functional limitations

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**Distal radial physeal injury**

Treatment
- Wrist arthroscopy
- TFCC repair
- Ulnar shortening osteotomy

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**TFCC**

Bae et al, ASSH 2008
- 54 patients
- Mean age 15.8 yrs
- 58% prior fracture
- Majority sports-related
- MMWS

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**TFCC**

Surgical treatment
Palmer 1A: debridement
Palmer 1B: repaired
- Ulnar debridement
- Percutaneous suture passage
- Horizontal mattress repair

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**TFCC**

Palmer 1D: repair
- Radial debridement
- Transradial drill holes
- Suture passage
- Horizontal mattress repair

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**TFCC**

Ulnar procedures common
- 84% return to sports without limitations
  MMWS 83 → 96
TFCC

Fishman et al, 2013
- 23 patients
- Mean age 14.6 years
- TFCC tears without prior fracture
- 90% return to sports
- PODCI 91
- Excellent subscores

Summary

Gymnast’s wrist
- Repetitive compression injury
- Pain → physeal arrest, ulnocarpal impaction
- Rest, PT, activity modification
- Surgery to correct ulnar variance and TFCC

Thank You

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