Elbow Impingement and Stress Fractures in Throwers

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I, John Conway MD, have relevant financial relationships to be discussed, directly or indirectly, referred to or illustrated with or without recognition within the presentation as follows:

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My full disclosure is in the AOSSM Final Program Book and in the AAOS Database

Elbow Impingement

1. Posterior-Lateral
   1. RC Plica
   2. Lateral Gutter Plica
   3. Proximal Lateral Band
2. Posterior
   Tip Spur / Fragmentation
   Fossa Spur, LB, Fibrosis
3. Posterior-Medial / VEO
   PM Tip Spur / Fragmentation
   PM Trochlea OCL, LB
Posterior-Lateral Impingement

1. Radius-capitellar Plica (Meniscus)
   - Anterior / Posterior
   - RH Chondromalacia

2. Lateral Gutter Plica
   - Proximal / Distal
   - Lateral Ulna / Trochlea
   - Chondromalacia

Passive Flexion
- Pronation Test (>25-50%)
- Active Flex-Pron Test
- Active Flex-Sup Test
- MRA: 3mm, irregular, edema

Palpation
- Ant & Post RC margins
- Distal lateral gutter
- Proximal lateral gutter

Radius-Capitellum Plica

Pain, Snapping, Catching, Locking
Findings
- Hypertrophy
- Frayed margins
- Inflammation
- Lateral capitellum and radial head chondromalacia

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Lateral Gutter Plica

Pain, Snapping, Catching, Locking
Findings
- Hypertrophy
- Frayed margins
- Inflammation
- Lateral ulna and trochlea chondromalacia

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MUCL Insufficiency Effect

The impact of ulnar collateral ligament tear and reconstruction on contact pressures in the lateral compartment of the elbow

John P. Duggan Jr., MD; Uche C. Okechukwu, MD; Jerry W. Alexander, MD; Phillip C. Nation, MD; Todd R. Limbar, MD

MUCL insufficiency that increased valgus laxity increased the radiocapitellar contact pressures and reduced the resistance of the elbow to valgus loading. This may contribute to the symptomatic entrapment of the plica.

Duggan JP et al JSES 2011
Arthroscopic Resection

Preserve the acononeus muscle fascia
Mini-Shavers (3mm)
Removes less fascia
Allows better access to the UH joint, the RC joint and the lateral margin of the radial head

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Allows better access to the UH joint, the RC joint and the lateral margin of the radial head

PL Impingement Outcomes

Clark 1988 Arthroscopy
Commandre et al JSMPF 1988
Akagi et al JSES 1998
Antuna et al Arthroscopy 2001
Awaya et al AJR 2001
Ruch et al JSES 2006
Kim et al AJSM
### PL Impingement Outcomes

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Flex Pron Test</th>
<th>Chondromalacia</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antuna et al Arthroscopy 2001</td>
<td>14 Patients</td>
<td>50%</td>
<td>93%</td>
<td>86% Excellent</td>
</tr>
<tr>
<td>Kim et al AJSM 2006</td>
<td>12 Patients</td>
<td>25%</td>
<td>58%</td>
<td>92% Excellent</td>
</tr>
<tr>
<td>Rajeev et al JOS 2015</td>
<td>600 Patients with lateral pain</td>
<td></td>
<td></td>
<td>40% RT Comp Sport</td>
</tr>
</tbody>
</table>

### Proximal Lateral Band

- **Band-like structure**: Running from the deep lateral triceps surface to the lateral margin of the trochlea rim.
- **Proximal lateral gutter**: Tender, sometimes snaps.
- **Often painful on:**
  - Deep flexion press
  - Full extension press

Gymnasts, golfers and boxers
Proximal Lateral Band

- **Band-like structure**
  - Running from the deep lateral triceps surface to the lateral margin of the olecranon fossa rim

- **Proximal lateral gutter**
  - Tender, sometimes snaps
  - Often painful on:
    - Deep flexion press
    - Full extension press
  - Gymnasts, golfers and boxers

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Posterior Impingement

- **Hyperextension mechanism**
  - Pain on extension
  - Sometimes locking and catching

- **2D / 3D thin section CT imaging**

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Posterior-Medial Impingement

- "...exfoliation of cartilage ... loose bodies ...”
  - GE Bennett Am J Surg 1959

- **Overload**
  - Medial Tension
  - Lateral Compression
  - Valgus Extension
  - Don Steiner AJSM 1978

- **VEO in the Pitching Elbow**
  - "...wedging effect of the olecranon into the olecranon fossa."
  - FD Wilson, JR Andrews AJSM 1983
MUCL Insufficiency Effect

**Elbow Medial Ulnar Collateral Ligament Insufficiency Alters PosteroMedial Olecranon Contact**

MUCL insufficiency that increased valgus laxity alters both the contact pressure and area on the PM olecranon & partially explains the development of PM olecranon osteophytes.

**MUCL Insufficiency Effect**

**Unihumeral Chondral and Ligamentous Overload**

Biomechanical Correlation for PosteroMedial Chondromalacia of the Elbow in Throwing Athletes

And pitchers with concomitant UCLO "may have a lower rate for return" following MUCL reconstruction

Oshbar et al, CORR 2012

Posterior-Medial Impingement

**Most common diagnosis (78%) requiring surgical treatment in baseball players**

Andrews, Timmerman, AJSM 1995

**Most common diagnosis (51%) requiring arthroscopic treatment in athletes**

Reedy et al, Arthroscopy 2000
Posterior-Medial Impingement

1. Posterior-medial Gutter Synovitis / Plica
   - May occur without other PI pathology
   - Usually resolves without surgery
   - May respond to injection
   - Rarely treat with synovectomy

Posterior-Medial Impingement

2. Olecranon
   - Stress Reaction
   - Stress Fracture
     - Posterior-medial Tip
     - Proximal-transverse Process
   - Exostosis Formation
   - Fragmentation (LB)

Incidence

Incidence 24%
135 Asymptomatic Pros

- 18-21 yo 12%
- 22-25 yo 19%
- 26-29 yo 36%
- 30-35 yo 50%

Conway AOSSM 2000
3. Posterior-medial Trochlea

- Chondromalacia
- Subchondral edema / insufficiency fracture
- Osteochondral collapse
- Marginal exostoses

Posterior-Medial Impingement
3. Posterior-medial Trochlea
- Chondromalacia
- Subchondral edema / insufficiency fracture
- Osteochondral collapse
- Marginal exostoses

MRI
MRI Scan
- Moderate to high signal in the PM trochlea hyaline cartilage and for some, the subchondral bone
- Focal OC defects in a few

Cohen SB, et al Arthroscopy 2011

Resect What?
Old School thought said remove the entire olecranon tip
New School says don’t remove any of the normal olecranon margin
Extent of Resection

Kamineni JBJS 2003
Kinematic Study
3mm increments:
Stepwise incr. valgus angulation
Challenges rationale for removal of any normal bone

Kamineni JBJS 2004
Biomechanical Study
3mm increments:
≥ 6 mm resection incr. MUCL strain
Concluded resection > 3mm may jeopardize MUCL function

Olecranon Fragmentation

The Goal of treatment is the restoration of the normal contour of the posterior medial olecranon

Trochlea Chondromalacia
### Outcomes - Return to Play

**Arthroscopic Resection**
- Rossenwasser AANA 91 83%
- Jordan AOSSM 92 74%
- Ward JHSurg 93 78%
- Andrews AJSM 95 73%
- Fideler JSES 97 74%
- Hepler Arthroscopy 98 95%
- Reedy Arthroscopy 00 85%
- Cohen Arthroscopy 11 78%

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### Second Surgery @ 2 years

**All Procedures**
- Fideler JSES 97 26%
- Andrews AJSM 95 41%
- Bartz AOSSM 99 17%

**UCL Reconstruction**
- Fideler JSES 97 10%
- Andrews AJSM 95 25%
- Bartz AOSSM 99 8%

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### Rehabilitation Considerations

- Full extension splint for 24 hours
- Higher rate of post MUCL reconstruction stiffness with scope
- Irrigate and fully extend elbow to evacuate hemarthrosis before final ligament fixation.

**Don’t shorten MUCL immobilization period unless micro-fracture performed – then limit motion or CPM to 10-50° (or 40-100°) for 10 days**

**Make motion recovery the first priority but don’t be aggressive.**

*Bernas et al. AJSM 2009*
Pearls

Safety First!
Experience / Knowledge
Reasonable expectations
Strategic preoperative planning
Supine position BEST
See well / Use retractors
Extension Splint

Elbow Stress Fractures

ME Apophysis
PM Trochlea
Capitellum Rim
Lateral Column
Sublute
Tubercle
Olecranon
Apophysis
St Reaction
Oblique Mid
Trans
Proximal
Tips
Adaptionist’s Paradigm

Form is related to function

Bones adapt to their mechanical environment over time leading to a predictable relationship between structure and function.

Wolff’s Law

1) Bone is deposited and reabsorbed to achieve optimum balance between strength and weight.
2) Trabecular bone is formed during growth and development in orientations that line up with the direction of the principle mechanical stresses that act on the bone.
3) Both phenomena occur through self-regulating mechanisms that respond to mechanical forces acting on bone tissue.

Wolff J, 1892
Pearson OM, YrBk Phys Anthrop 2004

Olecranon Stress Fractures

Osbahr DC, Bedi A, Conway JE
Sports Medicine of Baseball, Chapter 23
Excessive Stress in Bone

**Stress Reaction**
Peri-trabecular and periosteal inflammation and edema
with or w/o periosteal new bone formation

**Stress Fracture**
Tabecular and cortical fracture lines

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Stress Fracture / Reaction

**Insufficiency Fracture**
Normal stress on abnormal bone

**Fatigue Fracture**
Abnormal stress on normal bone

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Presentation

**Must consider it to look for it**

Bone pain means bone stress

**Change in activity**
Gradual onset
Vaguely localized
Late presentation
Progressive complaints
Pop on onset rare
Pain at rest rare
Presentation

Must consider it to look for it

Bone pain means bone stress

Pain on palpation
  well localized

Pain on bone stress
  valgus, extension, torsion

Pain on percussion

Pain on vibration

Differential Diagnosis

Tumor
Infection
Inflammatory Arthritis
Peripheral neuropathy
  median & radial n.
Proximal neuropathy
  radiculitis & TOS

Must consider other causes for vague pain – or risk missing the real problem

Plain Radiographs

Often normal
Beam projection dependant
Digital windowing revealing

Enthesopathy
Periosteal new bone
Endosteal thickening
Cortical radiolucency
Linear sclerosis
Fracture line
Marginal fragmentation
Adaptive Changes

Cortical and trabecular hypertrophy
Canal and fossa narrowing
Traction and degenerative exostosis formation

Plain Radiographs

3 Phase Bone Scan

Positive early
All 3 phases positive with fracture
Findings resolve in order with healing
4 Stage Zwas Grading Scale
MR Imaging
False negative or Delayed positive, especially for olecranon tip and sublime tubercle stress fractures
Sequence dependant
Marrow / periosteal edema
Fracture line
4 Stage Grading Scale

Bone Stress Injury in the Elbow
Ulna
Sublime tubercle
Ulna metaphysis
Olecranon process mid and proximal
Olecranon apophysis
Olecranon tip

Bone Stress Injury in the Elbow
Humerus
Capitellum margin
Capitellum body
Post-med Trochlea
Medial epicondyle
Mid and Distal Humerus

Periostitis
Humeral Shin Splints
TPBS & MRI
diagnostic

2 Fx Groups
Under 30 years old
Over 30 years old
4 risk factors

Mid and Distal Humerus

Under age 30
No prodromal sx
Single hard throw
Change in activity?
Spiral, bfly fragment
Consider pathological fracture

Mid and Distal Humerus

Over age 30
Prolonged time from pitching
Lack of regular exercise
Prodromal symptoms
Medial epicondyle

- Primarily seen in adolescents
- Stress reaction and fracture seen in ME following UCLR
- Bone tunnels
- Interference Screw

Capitellum

- Central Stress Reaction
  - MRI shows central edema
  - Associated with UCL insufficiency (VO)

- Rim Stress Fracture
  - Described in 1980 (Gore)
  - Lateral column loss
  - Treat with rest or excision

Posterior-medial Trochlea

- Posterior Impingement
  - Compression / Shear
  - Chondromalacia

- Stress reaction - Edema
  - Subchondral insufficiency fracture
  - Focal Osteo-necrosis (SON)
Sublime Tubercle

**Enthesopathic**

New bone formation

Sublime tubercle changes are very common and seen in up to 75% of pitchers

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Sublime Tubercle

**Stress reaction** is common in HS and college

**Fracture** more common in young throwers

Av Age < 17 years old

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Sublime Tubercle

**Most fail to heal** or have associated UCL insufficiency

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Poor Prognostic Indicators

- Older age
- Prolonged or recurrent symptoms
- Sclerotic margins
- Fracture displacement
- MUCL abnormal on MRI
- Contrast w/in fracture

Sublime Tubercle Case #1

16yo HS junior, draftable, playing
Sore all summer, WU difficult
Tender over ST, MVST +
X-rays ST stress fracture
  < 0.5 mm RL
MRI
Bone Growth Stim. 2 months

Sublime Tubercle Case #2

17 yo HS junior
Ache 2 months then
Sudden pain
X-rays ST stress fracture
  < 0.5 mm RL
MRI
ORIF with bone graft
Sublime Tubercle Case #3

19 yo college soph
6 months vague pain then
Sudden pain
X-rays ST stress fracture
1.5 mm RL
MRI UCL chronic tear
UCLR with DANE TJ

UCL and ST Insufficiency

Options
- Really wide tunnels
- Distal Docking
- Interference Screw
- Button (Endo, Biceps)
- Combined

Olecranon Process

Adolescent
- Apophyseal delayed closure
- Apophyseal nonunion
- Apopyseal avulsion

Adult
- Four types
Adolescent Persistent Olecranon Physis

16 published reports:
- Athletes between 13 – 16/17 years
- 53 individual cases
- Largest series: 16 baseball players

Sports:
- Gymnastics, Baseball, Javelin, Tennis,
- Badminton, Diving, Wrestling

Treatment recommendations

Rest

Surgery
- Tension band / Pins
- Tension band / Screws
- Screws

Most recommend autogenous bone graft
None recommend bone growth stim.
Materials

Over 12 years
31 athletes with olecranon injuries
(Age 9 – 20 years)

Oblq. Stress Fx in mature skeleton 7
Displ. Avulsion Fx thru physis 2
Delayed closure of physis 22

Materials

All males
Sport Baseball 21
Gymnastics 1

Group 1 Surgery
Group 2 No Surgery

Group 1- Surgery

16 Athletes (15 baseball, 1 gymnast)
Av Age Onset 15+2 years (15+4)
(12+10 – 16+10)
Av Age Surg 15+10 years
(14+6 – 16+11)
Av Duration 8 months
(11 months <15 YO)
Group 2- No Surgery

6 Athletes (all baseball players)
Av Age Onset 14+7 years (13+0 to 15+6)
Av Duration 2 months

Methods

History and Examination
Comparison X-rays
Algorithm (age at first visit)
< 14+0 (n=2) No surgery
14+0 – 15+11 Discussion
>16+0 (n=8) Surgery

Discussion

Duration of symptoms
Response to conservative care
Comparative radiographic appearance
Sequential radiographic changes
Review of literature and experience
Risk / benefit
Family / Patient preference
Contra-lateral Physis

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av.</td>
<td>Av.</td>
</tr>
<tr>
<td>94%</td>
<td>62%</td>
</tr>
<tr>
<td>Closed</td>
<td>Closed</td>
</tr>
<tr>
<td>Range</td>
<td>Range</td>
</tr>
<tr>
<td>50 – 100%</td>
<td>20 – 100%</td>
</tr>
</tbody>
</table>

Group 1 - Treatment

- Internal fixation
  - Single 6.5 mm screw: 15 (baseball)
  - Double 4.0 mm screws: 1 (gymnastics)
- Graft: Local autogenous graft (First 6 only)
- Hardware removal: 50% patients
- Av Post-op: 20 weeks
Group 1 - Treatment

LHP
15+1 years

Pre-op
1 week
16 weeks

Radiographic Follow-up

Post-operative studies at:
0, 1, 6 weeks then every 6 weeks until bony union documented

1 week
6 weeks
12 weeks

Group 2 - Treatment

16 weeks
### Results - Time to Closure

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Av. 9 Weeks (~2 Mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7/15 Closed at 6 weeks</td>
</tr>
<tr>
<td></td>
<td>15/16 Closed at 12 weeks</td>
</tr>
<tr>
<td></td>
<td>1/16 Unknown</td>
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</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Av. 25 Weeks (~6 Mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4/6 Closed at 10 months</td>
</tr>
<tr>
<td></td>
<td>2/6 Unknown</td>
</tr>
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</table>

### Results - Return to Sport

<table>
<thead>
<tr>
<th>Group 1</th>
<th>94% 15 / 16 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14 / 15 Baseball</td>
</tr>
<tr>
<td></td>
<td>9 / 15 College</td>
</tr>
<tr>
<td></td>
<td>2 / 15 Drafted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>80% (4 / 5 Total)</th>
</tr>
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<tr>
<td></td>
<td>One lost to Follow-up</td>
</tr>
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</table>

### Results - Return to Sport

<table>
<thead>
<tr>
<th>1 Gymnast</th>
<th>6 weeks (age 15+1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full activity 5 weeks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Jr. Olympic Nat'l Championships (4 mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Bar Gold</td>
</tr>
<tr>
<td>Still Rings Bronze</td>
</tr>
<tr>
<td>All Around Bronze</td>
</tr>
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</table>

One lost to Follow-up
Effect of Graft / HW Removal

None

Conclusions

Non-operative Treatment is effective for younger adolescent athletes with persistence of the olecranon physis.

Operative Treatment without bone graft is recommended for the older adolescent athlete with a persistent olecranon physis.

Adult - Classification

4 Adult Types

1. Metaphyseal Str. Reaction
2. Oblique Mid-olecranon Fx
3. Transverse proximal olecranon Fx
4. Olecranon Tip Fx

Nakaj Knee Surg STA 2006; Schickendantz AJSM 2002
1. Proximal Ulna Str Reaction

**Cause** Valgus and Torsion

**X-rays** Normal

**MRI** Diffuse edema

**Non-operative care**
- Complete rest 6 wks or Relative rest
- Budget throwing, change positions, BGS

2. Mid-oblique Str Fracture

**Cause** Valgus and Torsion

**X-rays** Normal or fracture

**MRI** Edema Varies

**Location** Mid-olecranon

**Fracture line** runs proximal-medial to distal-lateral
2. Mid-oblique Str Fracture

Non-operative care
- Short duration sx
- No fx line or sclerosis
- Play based on symptoms
- Higher recurrence rate
- Follow: X-ray and MRI
- Sx resolve with x-rays

Operative care
- Chronic condition
- Failed non-operative
- X-ray Fx line / sclerosis

Fixation Methods
- Screws
- T-bands, Plates

Screw Fixation Options
- Longitudinal
  - Single vs Paired
  - With T-band wire
- Oblique and ⊥ to the fx line
  - Paired 4.0mm screws
  - Probably more failures with longitudinal screw fixation placement
Screw Fixation – Case 1

**Longitudinal Fixation**
- Fracture persisted

**Oblique Fixation**
- Fracture healed
  - Paired 4.0mm screws
  - Perpendicular to fx line

Follow with 2mm, 3 plane CT Pre and Post-op

Minor League Pitcher
ORIF with Axial screw
Failed union

Screw Fixation – Case 2

**Conservative care**
- Fracture persisted

**Oblique Fixation**
- Fracture healed
  - Paired 4.0mm screws
  - Perpendicular to fx line

Exchange for fully threaded screws
Direction: From Proximal, Lat, and Dorsal To Distal, Med, and Volar

Very close to the subchondral plate
3. Transverse Prox Str Fracture

**Cause**
- Torsion, VEO
- UCL insufficiency

**X-rays**
- Normal or fracture

**MRI**
- Edema Varies

**Location**
- Prox olecranon

**Fracture line**
- runs Transverse

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3. Transverse Prox Str Fracture

- Single screw
- Screw and T-band
- Paired screws
  - Ante grade
  - Smaller fragment
  - Retro grade
  - Larger fragment

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Transverse Prox Stress Fracture
Transverse Prox Stress Fracture

Failed Fixation

3 Months Postop
4. Post-Med Tip Str Fracture

**Cause**
- VEO, Posterior Imp
- UCL insufficiency

**X-rays**
- Normal, Exostosis, Fracture, Loose Bodies

**MRI**
- Edema Varies, Often False Negative

**Location**
- PM Tip

**Fracture line**
- runs Transverse or Oblique

Radial Head Stress Fracture

**Salter Harris Type 3**
- Rare
- Not an Os RH
- Often unrecognized
- > 90% Gymnasts
- Age 8 – 11
- Best followed with fluoroscopy
Salter Harris Type 3
Rare
Not an Os RH
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Radial Head Stress Fracture
N=19 gymnasts
Age 8 – 11
Level 8 to elite
6 required ORIF
All healed and 5/6 returned to sport

Summary – Stress Fractures
Overall
10 different types
Humerus 4
Ulna 6
Olecranon 5
Thank You