

The Throwing Shoulder: Biomechanics; Injury Prevention and Treatment

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Disclosure

In Compliance with ACCME guidelines, I hereby declare:

I do not have financial or other relationships with the manufacture(s) of any commercial services discussed in this educational activity.

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Overview

- Introduction
- Phases of Throwing
- Physical Characteristics
- Specific Injuries



Introduction

- Overhead throwing is one of fastest human activities
- Angular velocity of $7,000^{\circ}/\text{sec}$
- Transfer of potential energy to kinetic energy of object



Introduction

- Repetitive overhead activities
 - Enormous stress on soft-tissues and bony structures of shoulder
- “Thrower’s Paradox”
 - “Lax enough to allow excessive external rotation, but stable enough to prevent symptomatic subluxations”



Introduction

- “Overhead Activities” often refers to pitching/throwing in baseball
- The phases of throwing are well studied and understood
- Other sports have similar motions



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Introduction

■ Tennis serve



Introduction

■ Volleyball



Introduction

■ Javelin

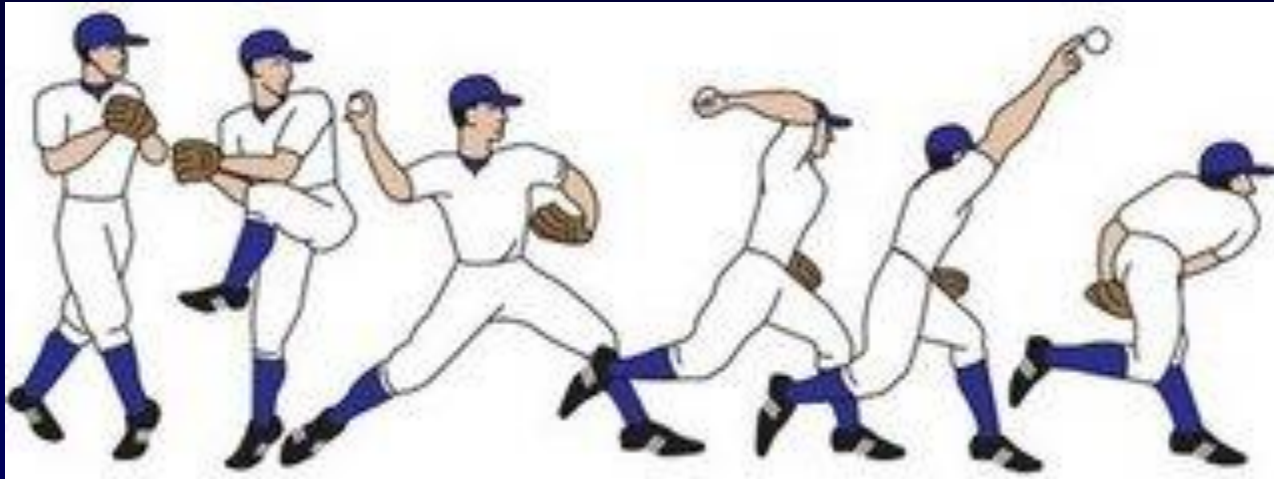


Introduction

■ Football



Phases of Throwing



Phases of Throwing

■ The Wind-Up

- Coiling phase: potential energy
- Center of gravity is raised
- Minimal stress on shoulder



Phases of Throwing

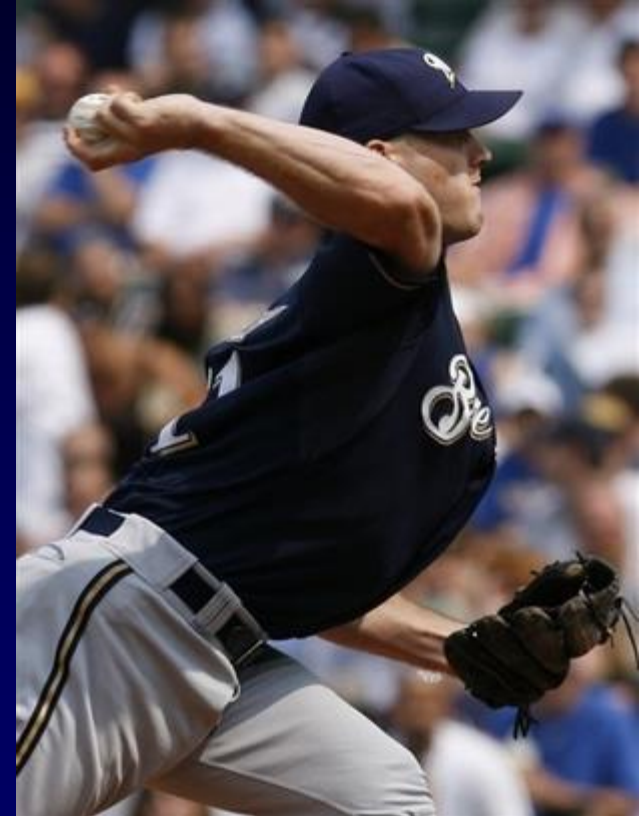
■ Early Cocking

- Arm Abducted to 90°
- ER initiated
- EMG shows early deltoid and later rotator cuff activation



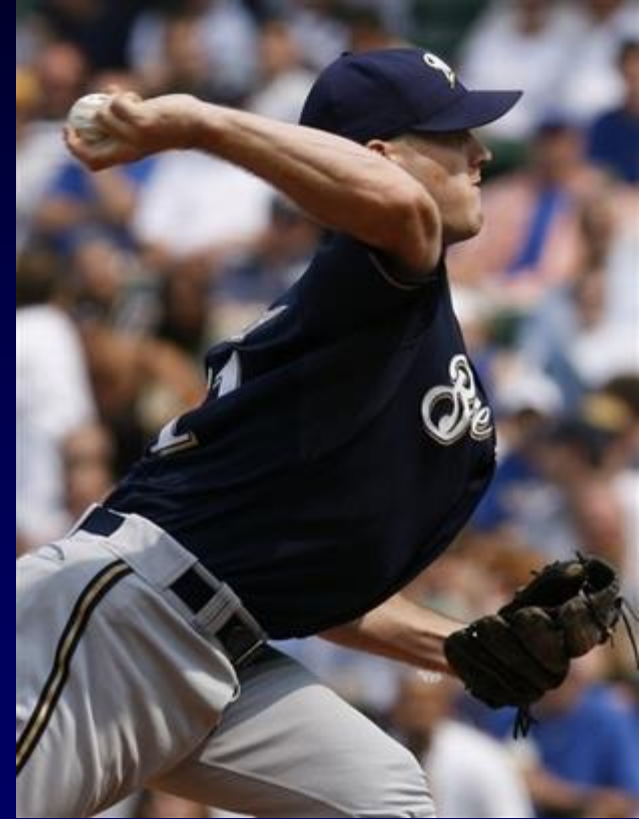
Phases of Throwing

- Late Cocking
 - Maximum ER of arm
 - Can reach 170°
 - Posterior translation of humeral head



Phases of Throwing

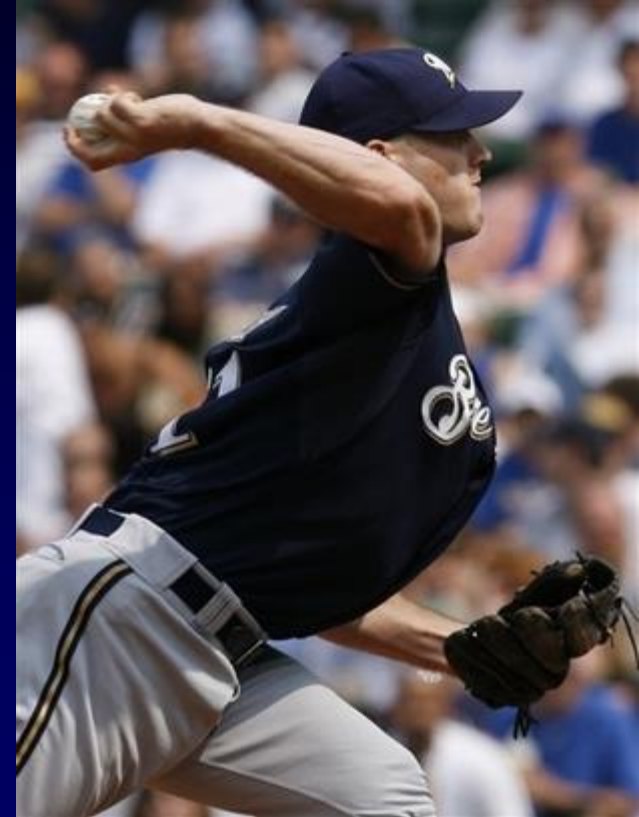
- Late Cocking
 - High RTC activity
 - Early SS/IS/TM
 - Late Subscap
 - Compressive forces up to 650 N



Phases of Throwing

■ Late Cocking

- Maximum stress on anterior restraints
- Anterior shear forces approach 400 N, or as high as $\frac{1}{2}$ Body Weight
- Pain = labral pathology > RCT or biceps



Phases of Throwing

- Acceleration
 - Rapid IR up to $7,000^{\circ}/\text{sec}$
 - Humeral head returns to neutral position, and capsule uncoils
 - Minimal load to glenohumeral joint



Phases of Throwing

■ Deceleration

- Most violent phase
- From ball release to 0°
- Maximal posterior capsule stress
- Posterior shear stresses of 400 N



Phases of Throwing

■ Deceleration

- Marked eccentric contraction of rotator cuff
- Distraction forces equal to Body Weight
- Pain=rotator cuff injury



Phases of Throwing

- Follow through
 - Rebalancing of muscles
 - Posterior capsule still under stress
- Entire cycle: Approx. 2 seconds

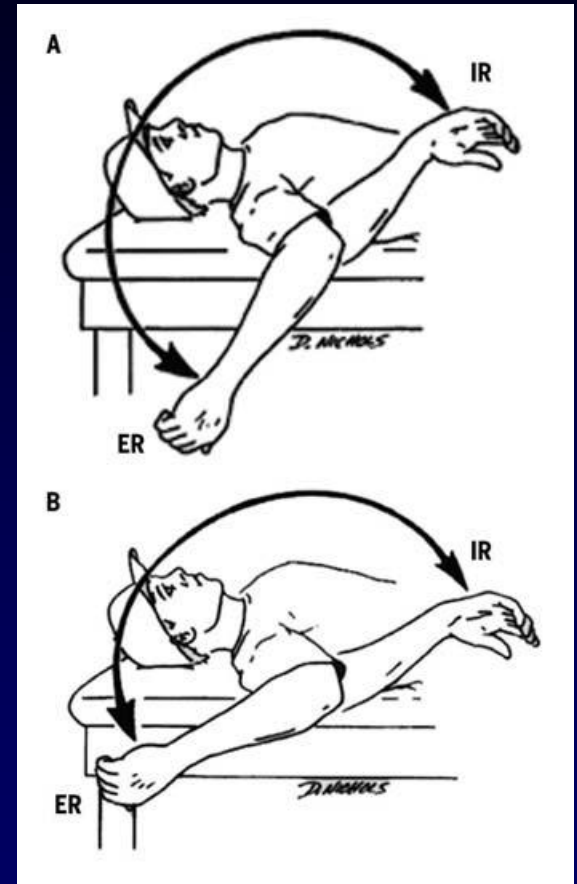


Physical Characteristics



Physical Characteristics

- Range of Motion
 - Increased ER, compensatory loss of IR (Wilk, AJSM 2008)
 - ER: $+9^{\circ}$, IR -8.5° compared to non-throwing arm in pitchers
 - Total Motion (ER to IR) often preserved (180°)



Wilk, JOSPT 2009

Physical Characteristics

■ Laxity

- Increased laxity allows increased ROM
- Maybe acquired or congenital
 - Anterior structures stretch out over time?
- Not present in all throwers



Physical Characteristics

- **Osseous Adaptations**
 - Increased retroversion of humeral head in throwers
- Retroversion greatest in younger athletes
 - Remodeling with open growth plates



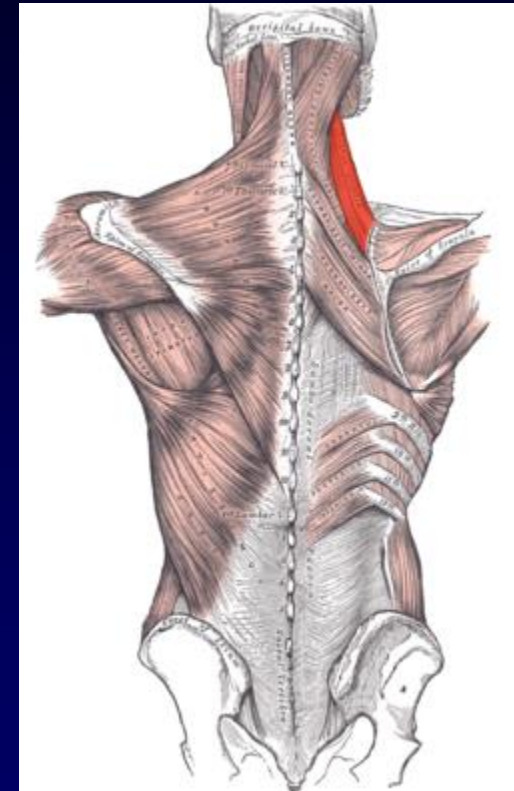
Physical Characteristics

- **Muscle Strength**
 - Decreased strength in ER
 - Increased strength in IR
 - Important that ER strength should be at least 65% of IR strength (Wilk, JOSPT 2009)
 - Provides dynamic stabilization



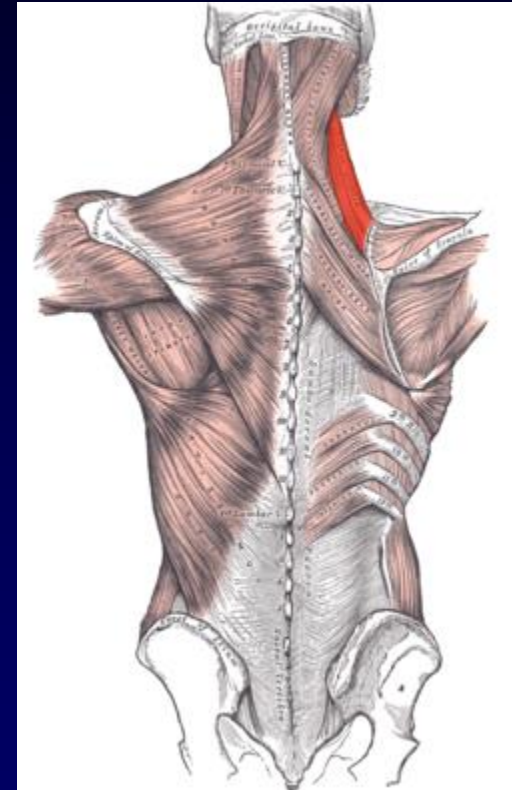
Physical Characteristics

- **Muscle Strength**
 - Significantly stronger scapular protractors and elevators
 - Significantly stronger depressor muscles
 - Maintained ratio of elevators/depressors important (Wilk. JOSPT 2009)



Physical Characteristics

- **Posture and Scapular Postion**
 - **Scapula: protracted and anteriorly tilted at rest compared to non-throwing arm**
 - **Anterior tilt increased with Abd/ER and with fatigue**
 - **+ anterior tilt → loss of IR**



Pathologic Conditions



Pathologic Conditions

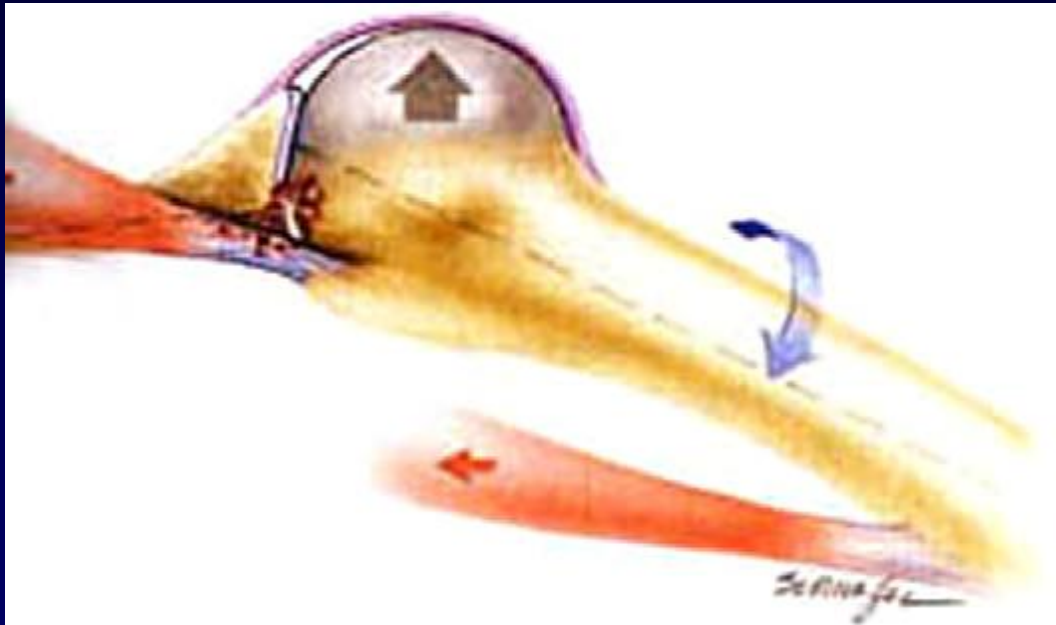
■ Internal Impingement

- Contact of articular surface of posterior RTC and greater tuberosity with posterior/superior glenoid and labrum
- Excessive anterior translation of humerus
 - tight posterior capsule/lax anterior restraints
 - increased external rotation



Pathologic Conditions

■ Internal Impingement



Jobe Oper Tech 1996

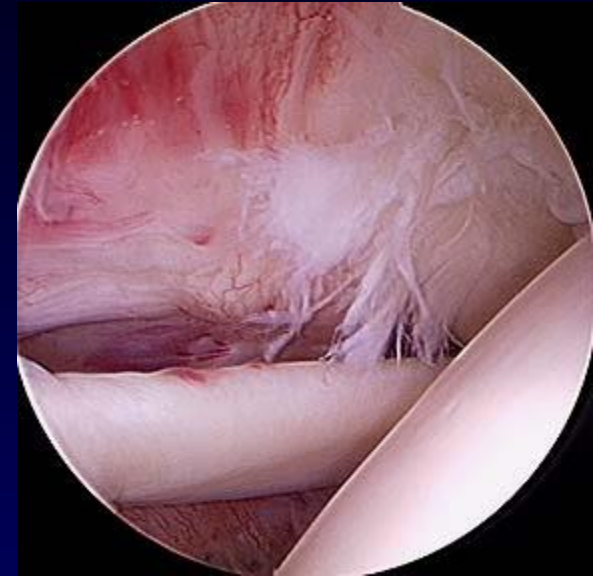


Conway Orthop Clin 2001

Pathologic Conditions

■ Internal Impingement

- Articular sided rotator cuff tears (~80%)
- Posterior and SLAP (IIB)
- Humeral head cysts
 - Rotator cuff insertion



Pathologic Conditions

■ Internal Impingement

- Insidious onset of pain
 - Increases during season
- Pain posterior during late cocking
 - Anterior pain often
- Increased ER most common finding on physical exam



Pathologic Conditions

■ Internal Impingement

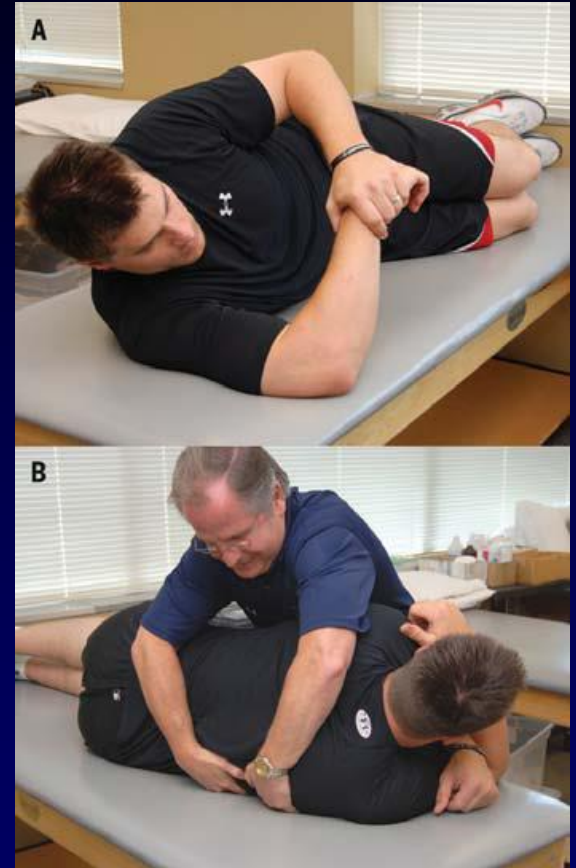
■ Treatment

■ Increase IR

- Posterior capsule stretching
- Sleeper stretch

■ Rotator Cuff Program

■ Scapular stabilization



Wilk JOSPT 2009

Pathologic Conditions

■ Internal Impingement

■ Surgery last resort (~80% return to play)

■ Debridement of RTC vs. Repair

■ Labral debridement vs. Repair

■ Anterior capsular plication?

■ Posterior capsular release

■ Posterior band in IGHL



Pathologic Conditions

■ GIRD

- Loss of $> 25^\circ$ of IR compared to contralateral arm
- Due to posterior capsular contracture
 - Repetitive shear/deceleration?



Tyler AJSM 2010

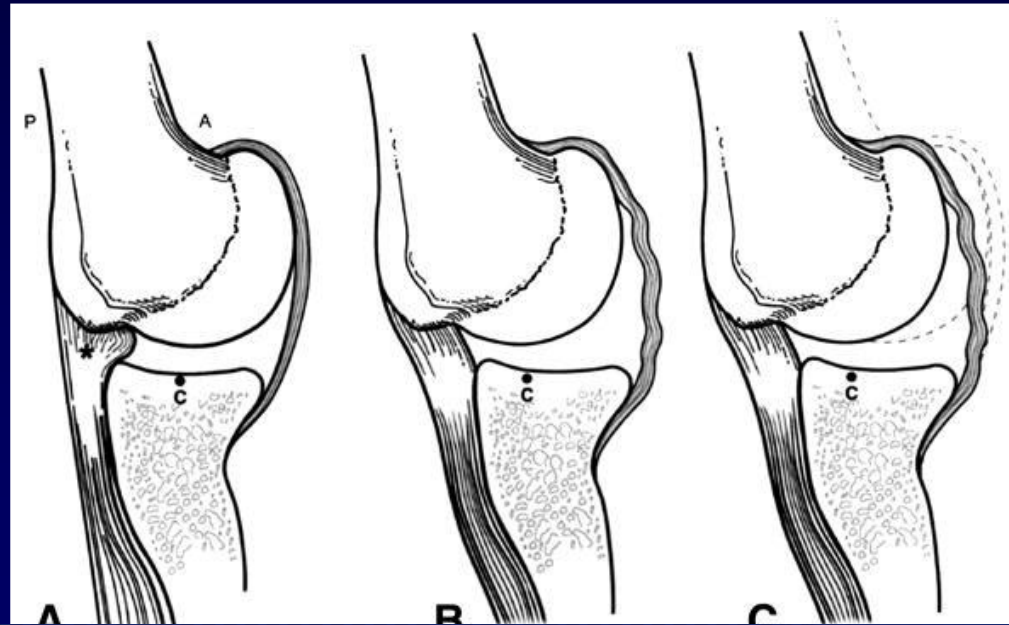
Pathologic Conditions

■ GIRD

- Causes posterior-superior shift in contact point

- Leads to increased ER

Burkart Arthroscopy 2003



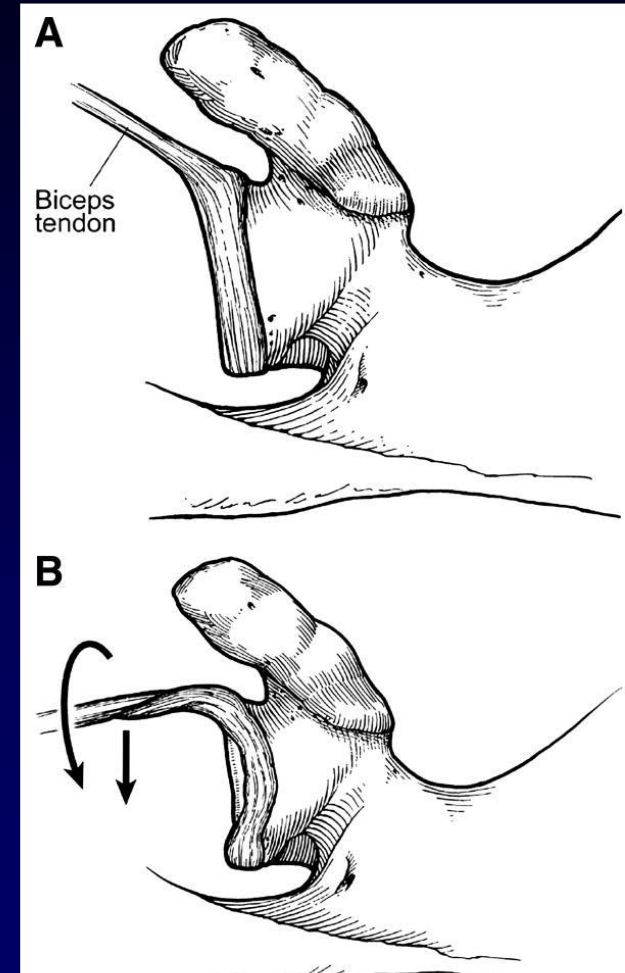
Pathologic Conditions

■ GIRD

■ Increased ER

- increases in shear and Peel-back forces
- SLAP/posterior labral injury

Burkart Arthroscopy 2003



Pathologic Conditions

■ GIRD

■ Posterior capsular stretching

- Sleeper stretch
- ~90% successful Burkhardt



Pathologic Conditions

■ GIRD

- Posterior capsular release as last resort
 - 70% return to pre-injury level
 - 100% if no other lesions

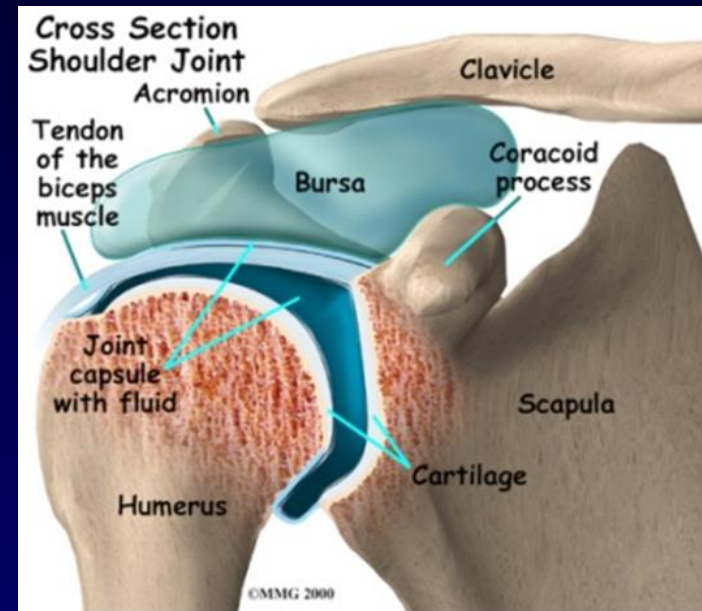
Yoneda 2006



Pathologic Conditions

■ Rotator Cuff Tendinitis/Bursitis

- Pain during late cocking or at deceleration
- Weakness noted 2° to pain
- Early in season (poor conditioning) or late as an overuse syndrome



Pathologic Conditions

■ Rotator Cuff Tendinitis/Bursitis

■ Treatment:

- NSAIDs
- Rest
- Rotor Cuff program
- Corticosteroid injection



Pathologic Conditions

- Rotator Cuff Tendinitis/Bursitis
 - Surgery only after conservative trx. fails
 - Bursectomy
 - Subacromial (bone) decompression rarely needed
 - R/O underlying causes
 - MDI
 - GIRD



Pathologic Conditions

■ Rotator Cuff Tears

- Pain in acceleration or deceleration
- Full-thickness tears rare
- Articular sided partial thickness tears more common



Pathologic Conditions

■ Rotator Cuff Tears Treatment

- Full-thickness tears
 - Surgical repair in athletes
- Partial thickness
 - Rest / NSAIDs
 - Rotator Cuff program
 - Posterior capsular stretching

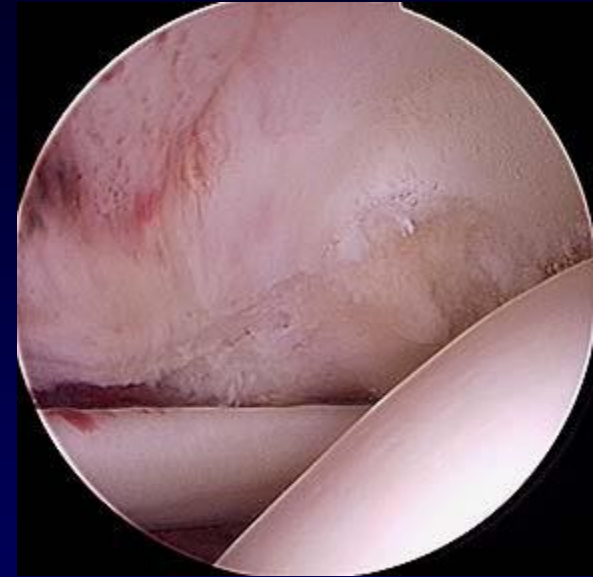


Pathologic Conditions

■ Rotator Cuff Tears

■ Partial thickness

- Surgery only after failure of conservative trx
- Debridement vs. repair
 - Repair if $> 50\%$
- Anterior capsule plication?
- Posterior capsule release?



Pathologic Conditions

■ Rotator Cuff Tears

- Return to play unpredictable after surgery
 - Becoming more predictable with arthroscopic techniques
 - 10-80% return to play in pitchers



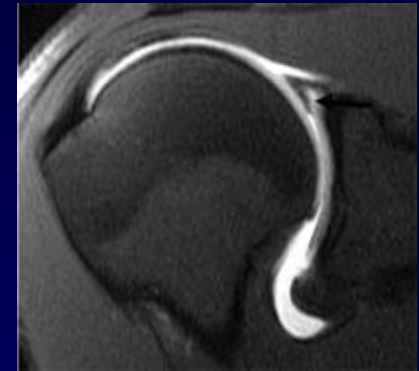
Pathologic Conditions

- SLAP tears

- Tears of superior labrum at biceps anchor

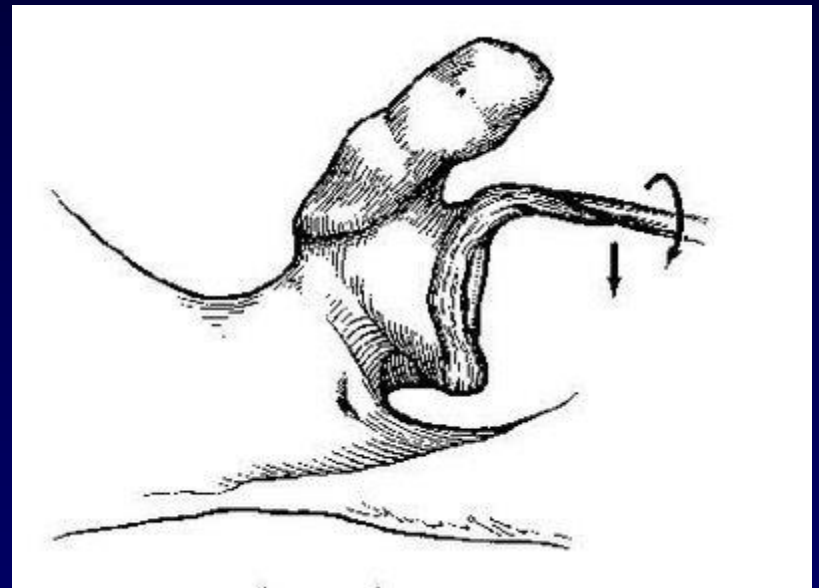
- 10 “types”

- Type 2B most common in throwers



Pathologic Conditions

- SLAP tears
 - “Peel back mechanism”



Burkhart Arthroscopy 2003

Pathologic Conditions

- SLAP tears
 - Vague pain in late cocking
 - Physical exam has poor predictive value
 - MRI/Arthrogram and arthroscopy are gold standard



Pathologic Conditions

- SLAP tears

- Treatment

- Trial of NSAIDs / Rest
 - Cuff/scapular stabilizers

- Surgical Repair if symptoms persist

- Outcomes good

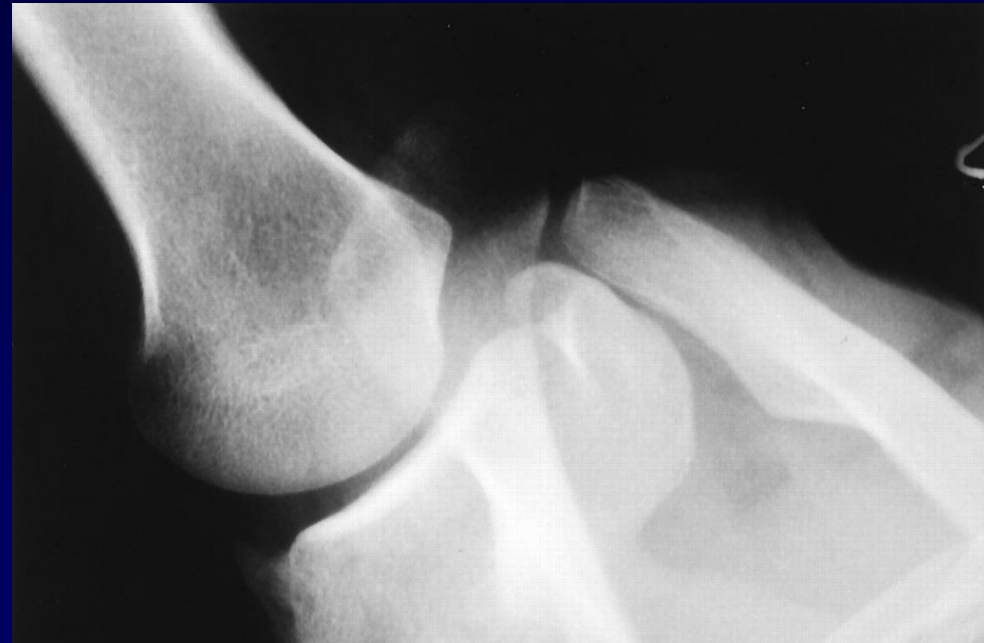
- ~75-87% return to preinjury activity



Pathologic Conditions

- **Bennett's lesion**
 - **Bony overgrowth on posteroinferior glenoid**
 - **Insertion of posterior inferior glenohumeral ligament**
 - **Repetitive traction during throwing**

Meister AJSM 1999



Pathologic Conditions

- **Bennett's lesion**
 - Posterior pain during release
 - Most do not develop symptoms
 - Treated with posterior capsulotomy and burring down



Meister AJSM 1999

Conclusions

- Throwing places enormous stress on the shoulder
- There are adaptive changes to the stress that may lead to pathologic processes
- It is important to understand the biomechanics of throwing to diagnose, treat, and ensure return to play
- Surgery should be reserved to players who have failed conservative treatment



Thank You

