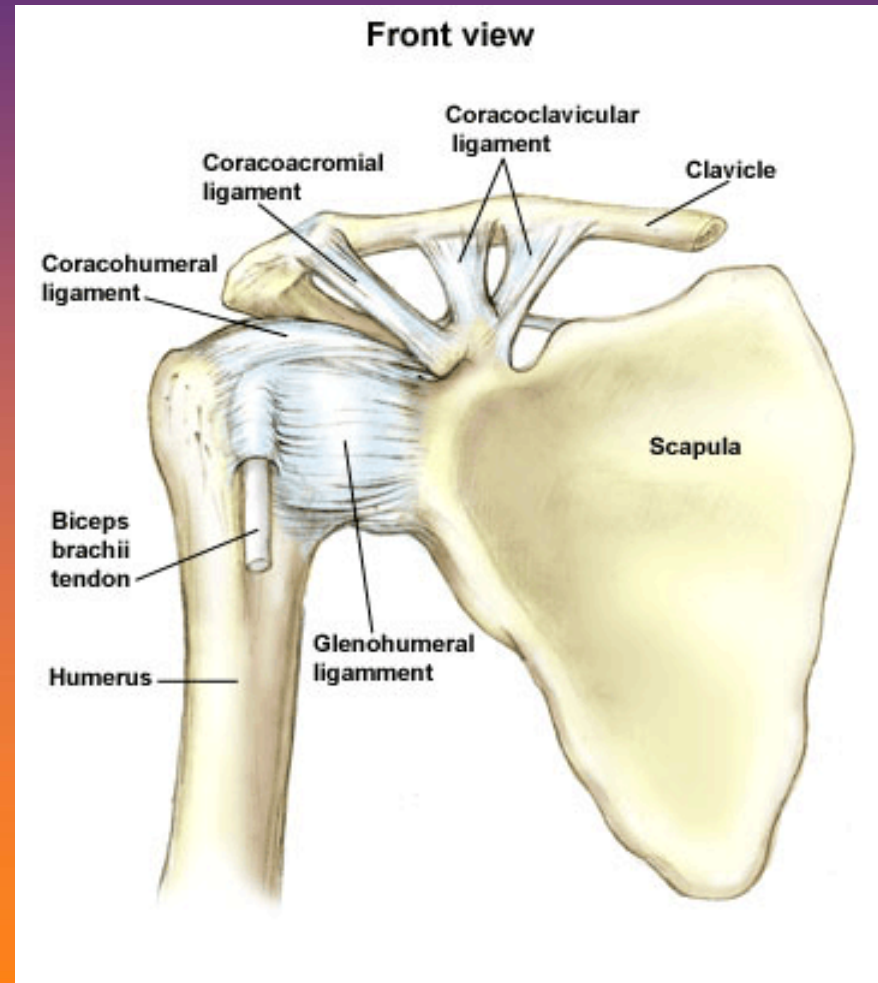


Biomechanics of the Shoulder and Throwing

Shoulder Anatomy

- Most mobile joint in the body
 - Ball-and-socket joint
- 3 bones connected by muscles, ligaments & tendons
 - Clavicle
 - Humerus
 - Scapula

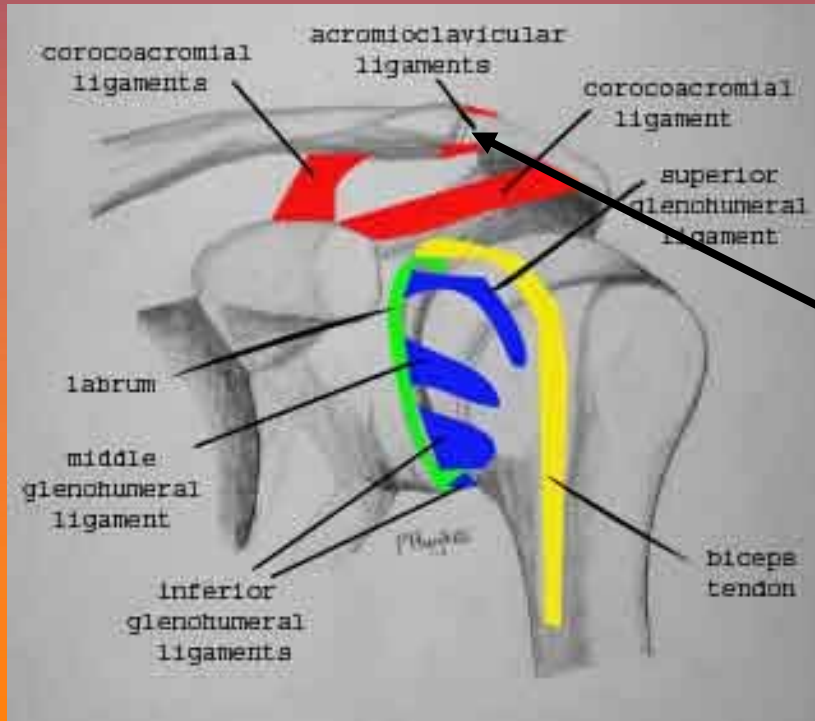
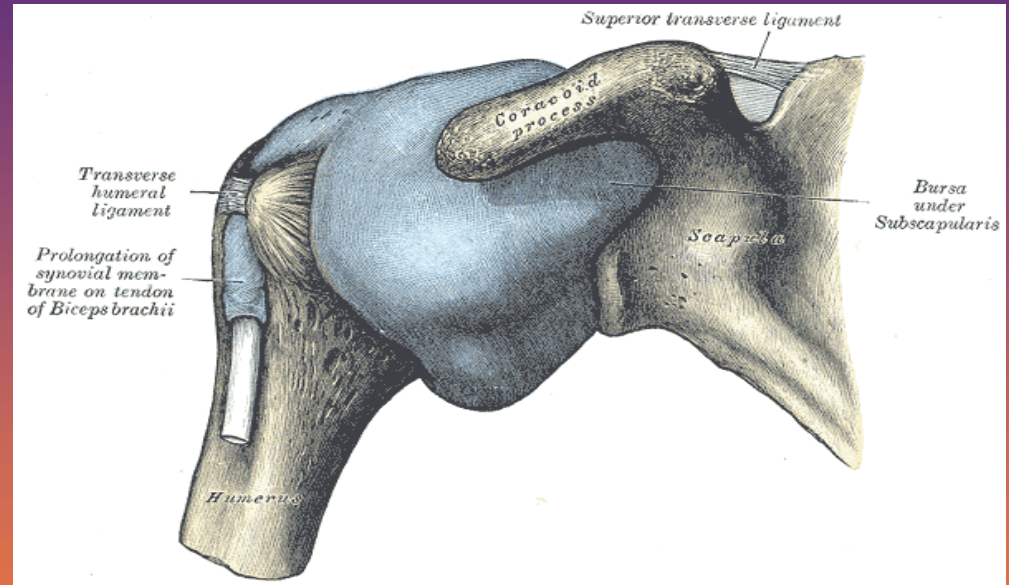


Range of Motion

- 6 degrees of freedom
- Flexion
 - Elevation in the sagittal plane
- Abduction
 - Elevation in the coronal plane
- Rotation
 - Internal / external: Forearm moving in transverse plane

3 Articulations

- Acromioclavicular
- Glenohumeral
- Scapulothoracic

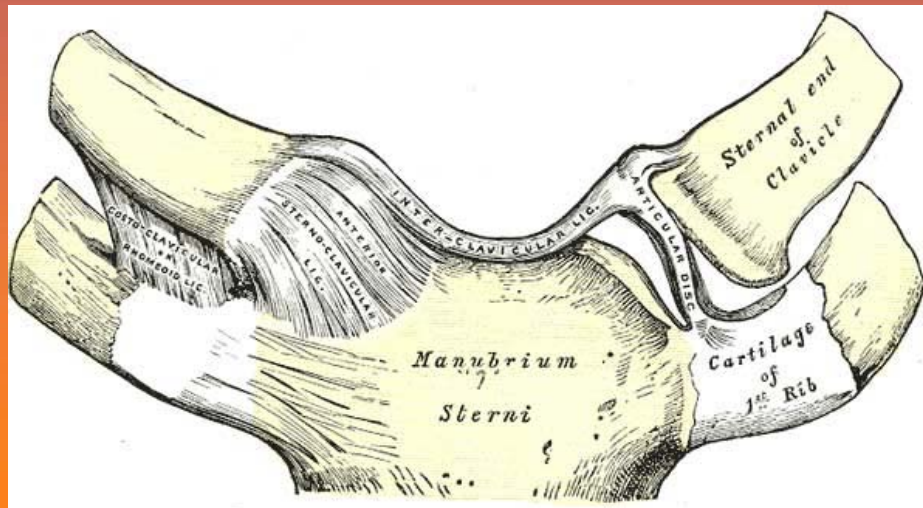


•AC: Restrains both rotation and posterior translation of clavicle

Cocroco-acromial, coroco-clavicular and acromio-clavicular ligaments

Sternoclavicular

- Links upper extremity directly to thorax
 - Fibrocartilage disc between the sternum and the clavicle
 - shock absorber
- Held together by strong ligaments



Glenohumeral

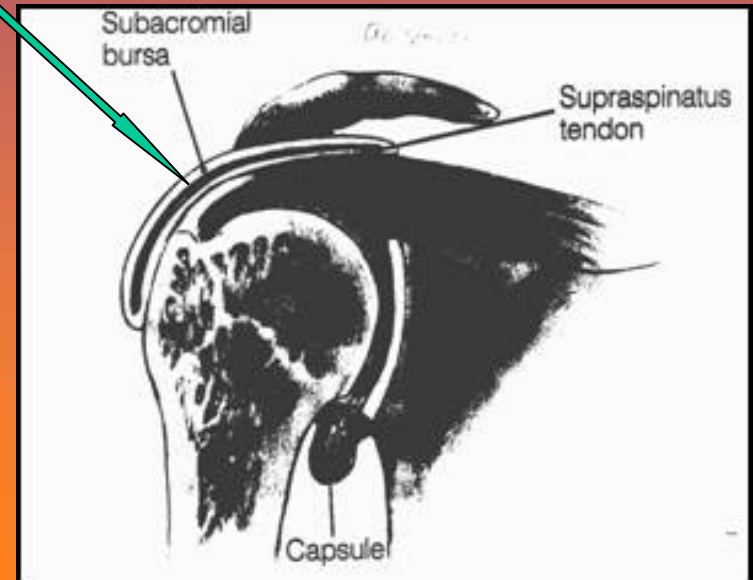
- 4 glenohumeral ligaments, connect the humerus to the glenoid
 - superior, middle, inferior and posterior
- Inferior glenohumeral ligament splits into a front and a back half.
 - These act like a hammock to support the humeral head
- Dislocation inferiorly & anterior most common in young people

Scapulothoracic

- Bone-muscle-bone articulation between the scapula and thorax
- Involves gliding of the scapula on the posterior aspect of the thorax
- The subscapularis and the serratus anterior glide along one another
- No osseous connection with the axial skeleton
 - Allows for a wide range of scapular motion, including protraction, retraction, elevation, depression, and rotation

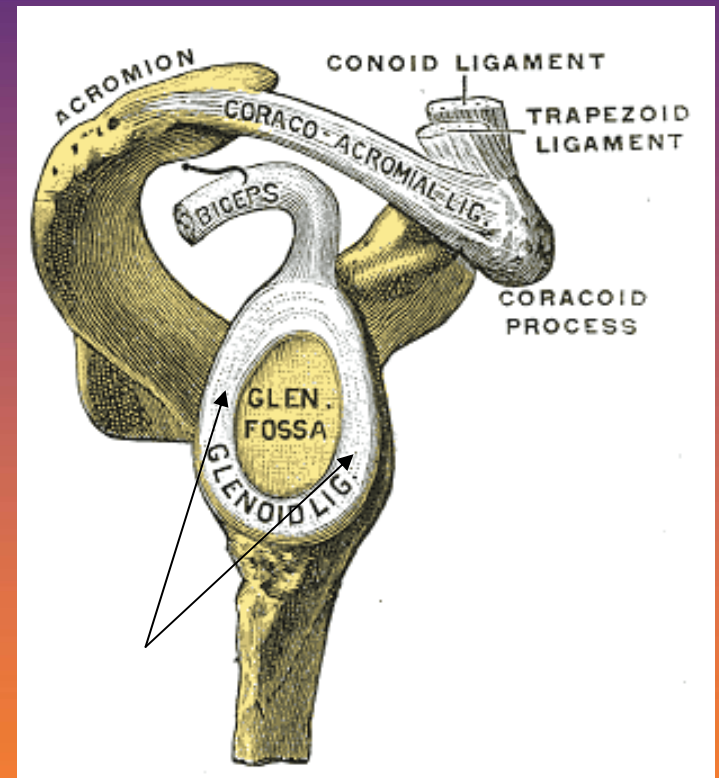
Subacromial Bursa

- Fluid filled sac that decreases the friction between bone & tendon
- Bursa covers the rotator cuff tendons and protects them from the overlying acromion
- Shock absorber



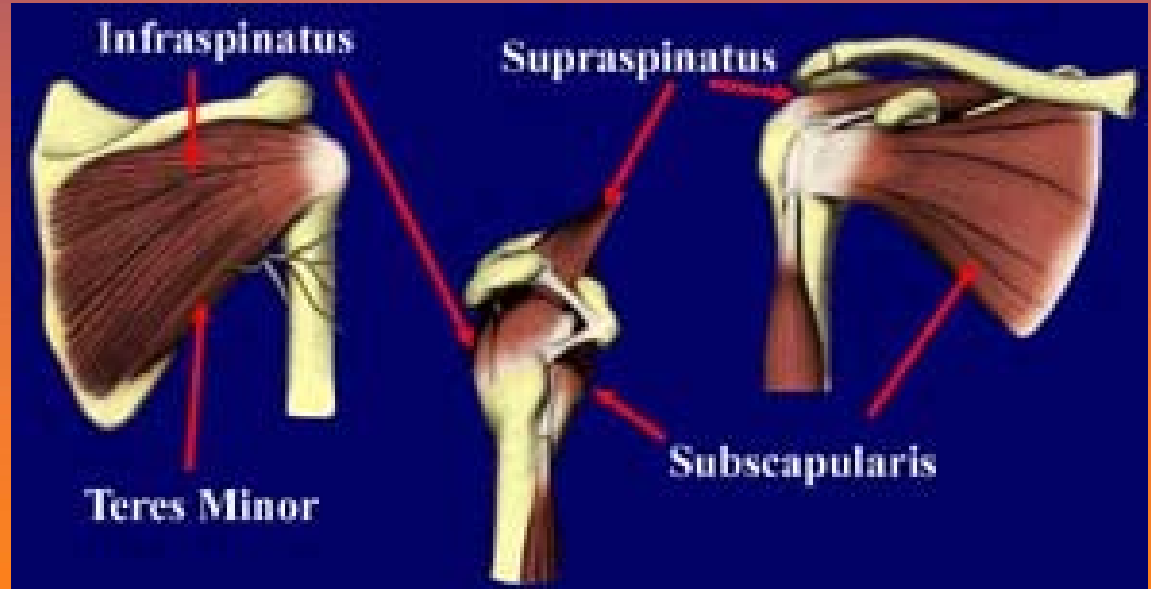
Labrum

- A ring of cartilage surrounding the shoulder joint socket
- Acts like a curved bumper to increase the depth of the glenoid fossa
- Keeps the humeral head in the glenoid fossa and helps to prevent dislocations
- Adds depth
- “Break stop” or centers humeral head



Rotator Cuff

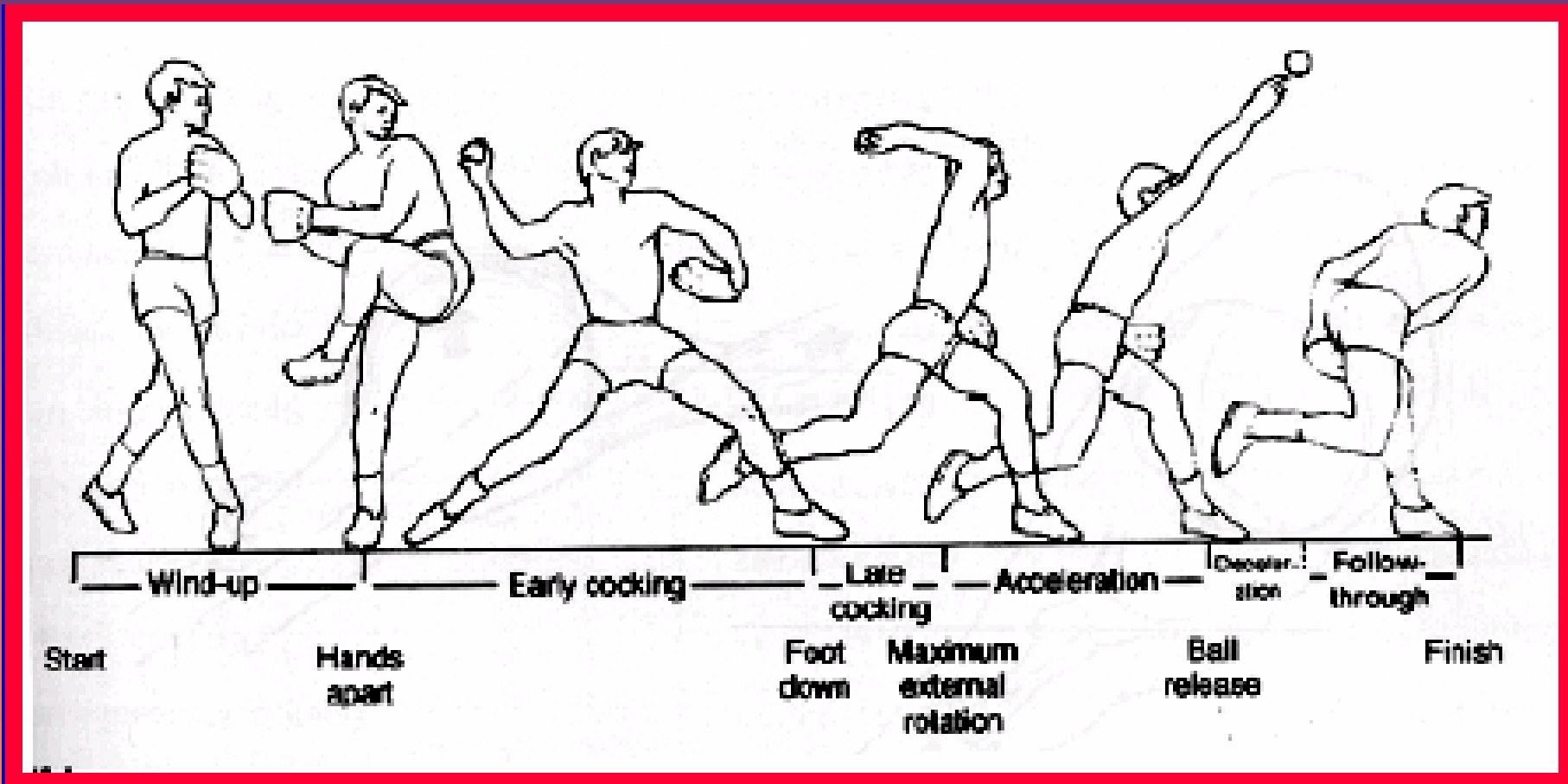
- Four small muscles
 - subscapularis, supraspinatus, infraspinatus and teres minor
- Responsible for the stability of the shoulder joint.
- Holds the humeral head in the glenoid socket during early abduction



Throwing Motion

- Kinetic chain concept
 - Sequence of body segment motions
 - Legs and trunk act as force generation
 - Shoulder is force regulation
 - Arm is force delivery

Biomechanics of Throwing



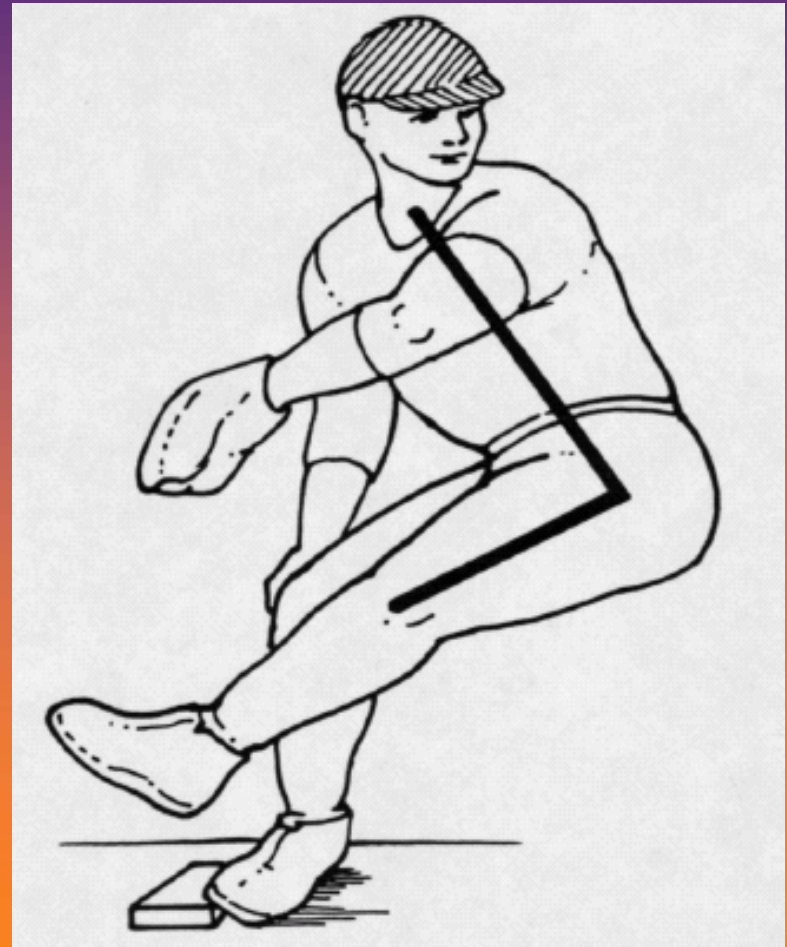
Phase 1 – Wind up

- Preparation of kinetic chain
- Lead foot off ground
- Building potential energy package
- Raises center of gravity
- Minimal stress to shoulder



Phase 2 – Early Cocking

- Positions arm in 90° abduction
- Arm posterior to plane of body
- Initiates external rotation
- Stride initiates
- EMG; Early Deltoid, Late Cuff

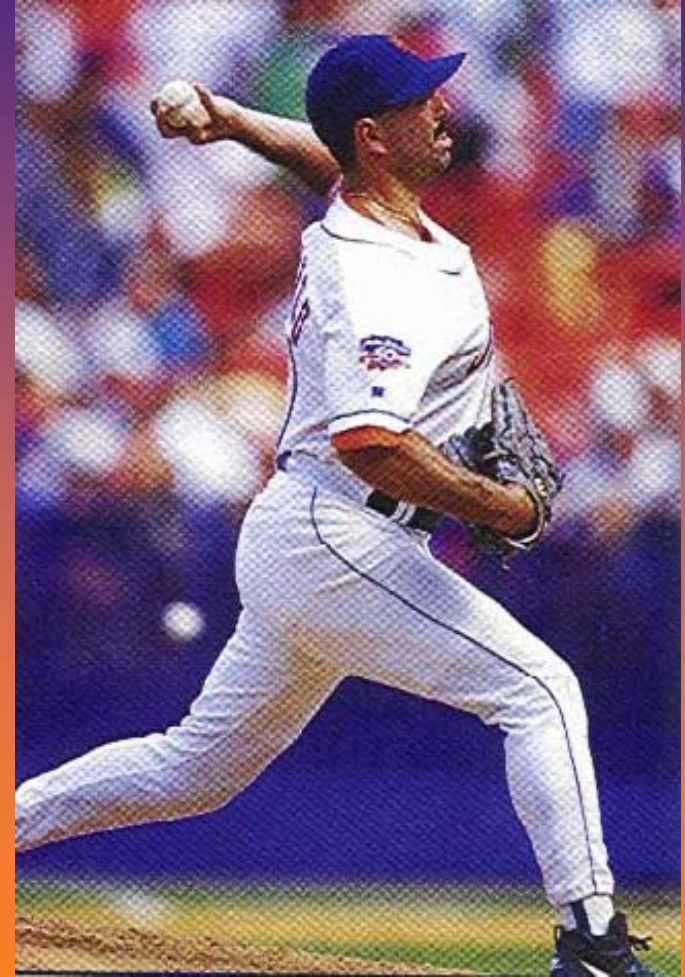


Phase 3 – Late Cocking

- Foot contact
- Maximum abduction, external rotation (40 ° to 170°)
- Trapezius and Serratus Anterior force couple stabilizes scapula
- Peak Rotator Cuff activity
- Deltoid and supraspinatus function together to elevate humerus to greater than 90° of abduction

Late Cocking Cont'd

- Flexion to 90°
- Flexors and extensors work in coordination to control motion
- Moderate valgus force exists
- Problems
 - Anterior instability leading to internal impingement
 - Hyperangulation
 - Scapula Dyskinesia



Phase 4 - Acceleration

- Humerus IR 100 deg / 0.5 sec
- Rotates shoulder to ball release point of 90° rotation
- Velocity near 7000 deg/sec
- Eccentric to concentric conversion



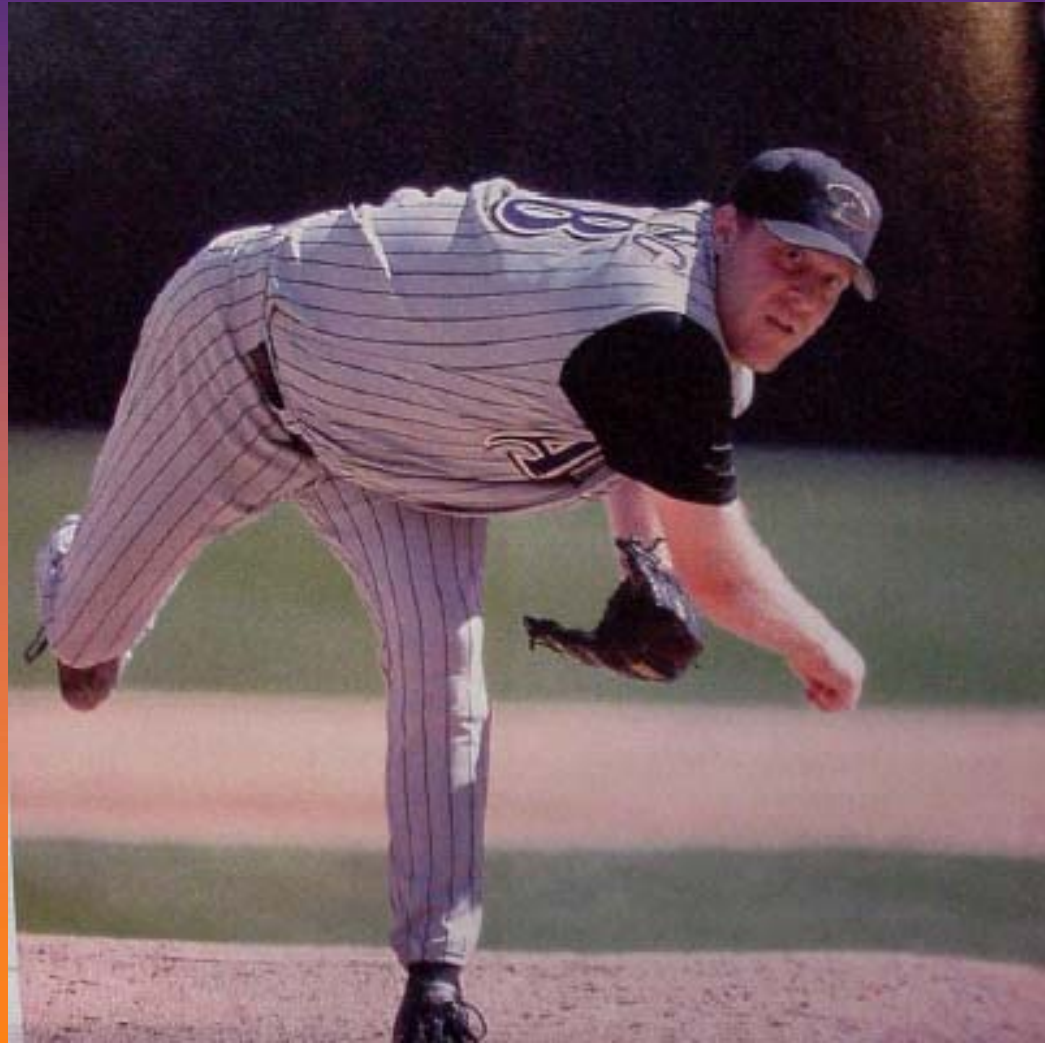
Phase 5 - Deceleration

- Most violent
- Ball release to 0° rotation
- Eccentric contraction to slow arm
- Posterior capsule stress
- Joint loads
 - Posterior shear = 400N
 - Inferior shear = 300N
 - Compressive > 1000N



Phase 6 – Follow-through

- Ball release, adduction
internal rotation,
deceleration
- Rebalancing
- Muscles to resting levels
- Timing of Phases
 - Total 2 seconds
 - Wind-up to late cocking 1.5
seconds
 - Acceleration 0.5 seconds
 - Deceleration to end 0.5
seconds



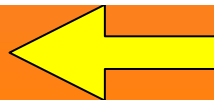
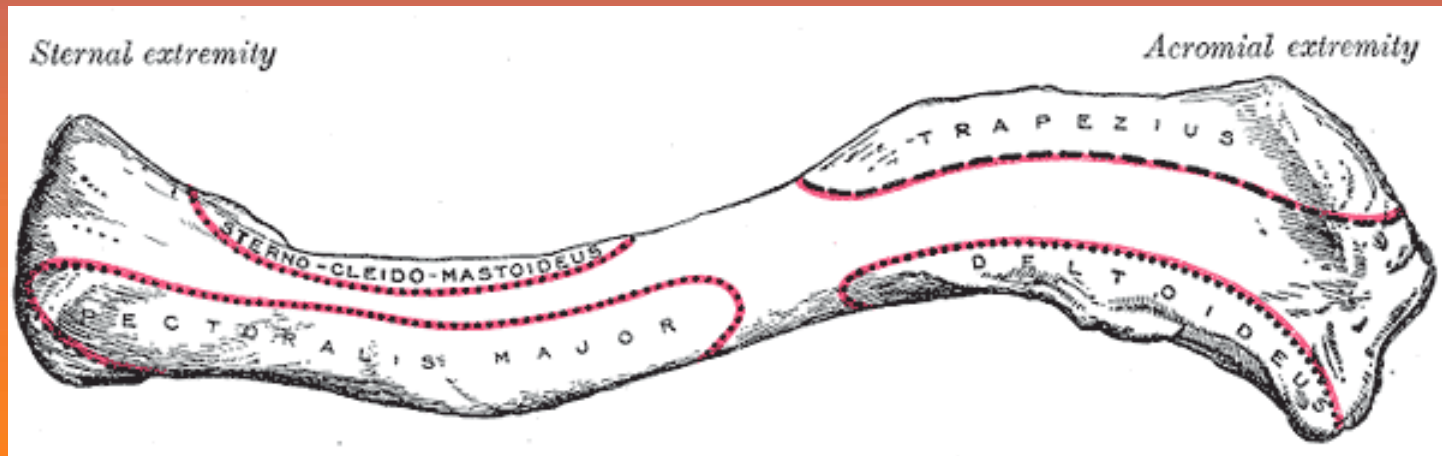
Common Shoulder Injuries

- Dislocation
 - Subluxation
- Impingement
- Rotator Cuff Tear
- Dead Arm

The End

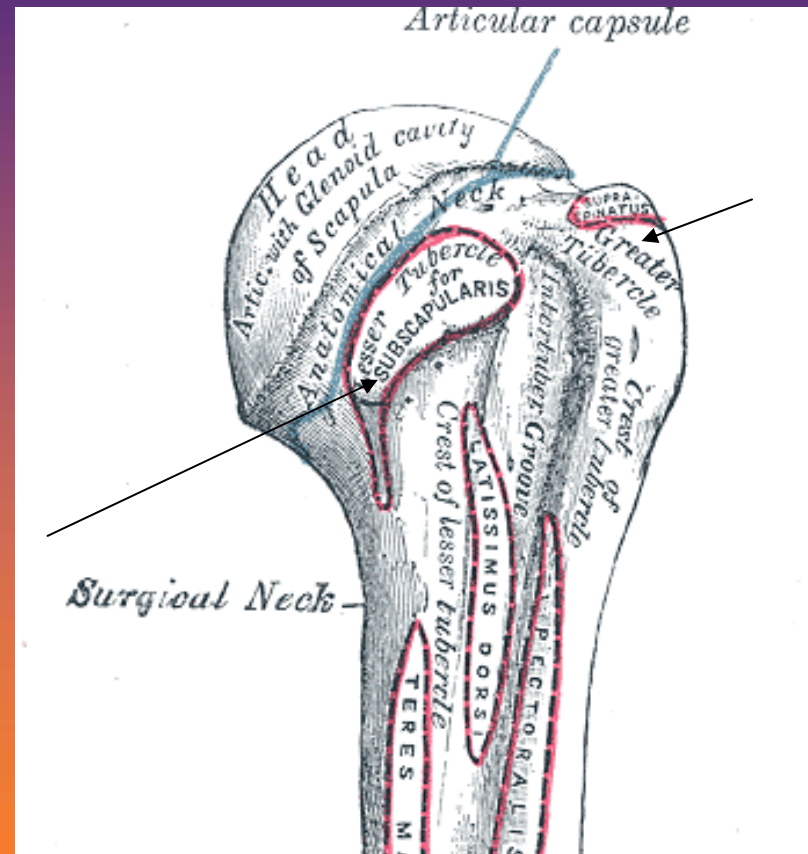
Clavicle

- Acts as a strut connecting the thorax to the upper extremity
- Protects underlying brachial plexus & vascular structures
- Attachment site for many of the muscles that act on the shoulder

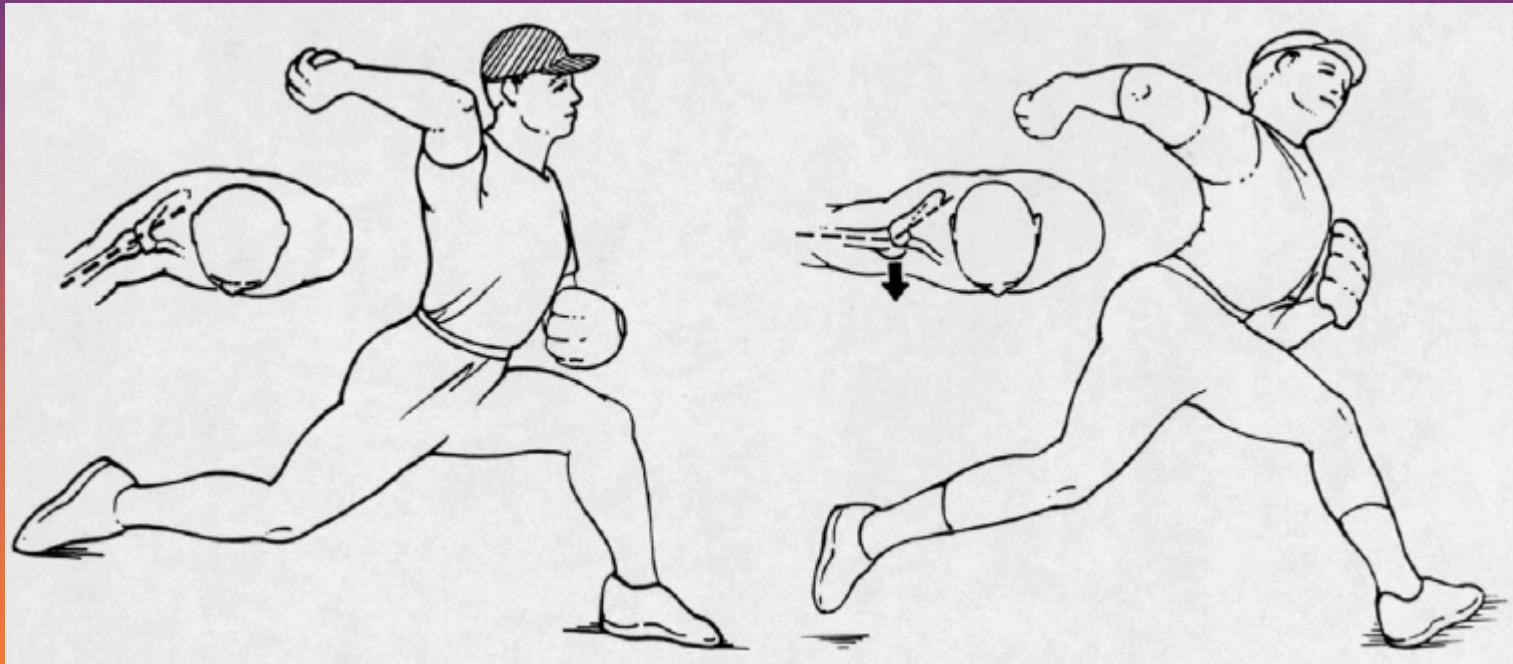


Humerus

- The head of the humerus has 2 projections, the greater and lesser tuberosities.
 - It is at these points that the rotator cuff tendons attach

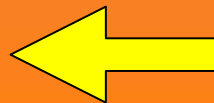


Hyperangulation



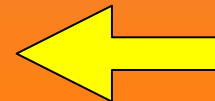
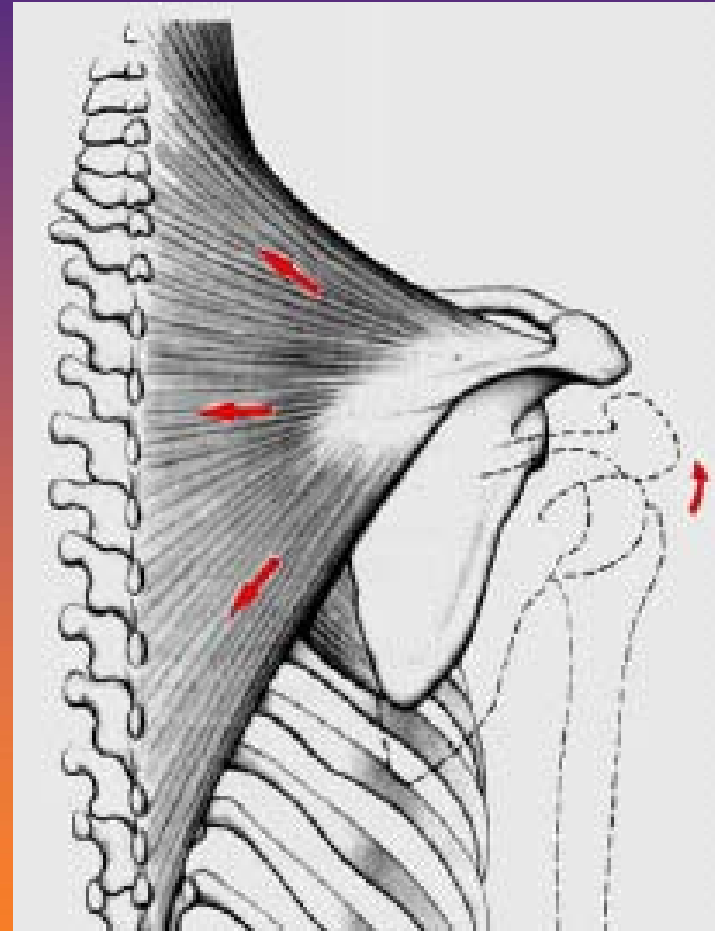
Hyperangulation

- The abduction – external rotation position of the cocked baseball shoulder places a physiologic compression on the posterior labrum and posterior rotator cuff
- Leads to the common problem of internal impingement
- Cause
 - Muscular weakness (loss of dynamic stabilization)
 - Anterior Capsular stretch

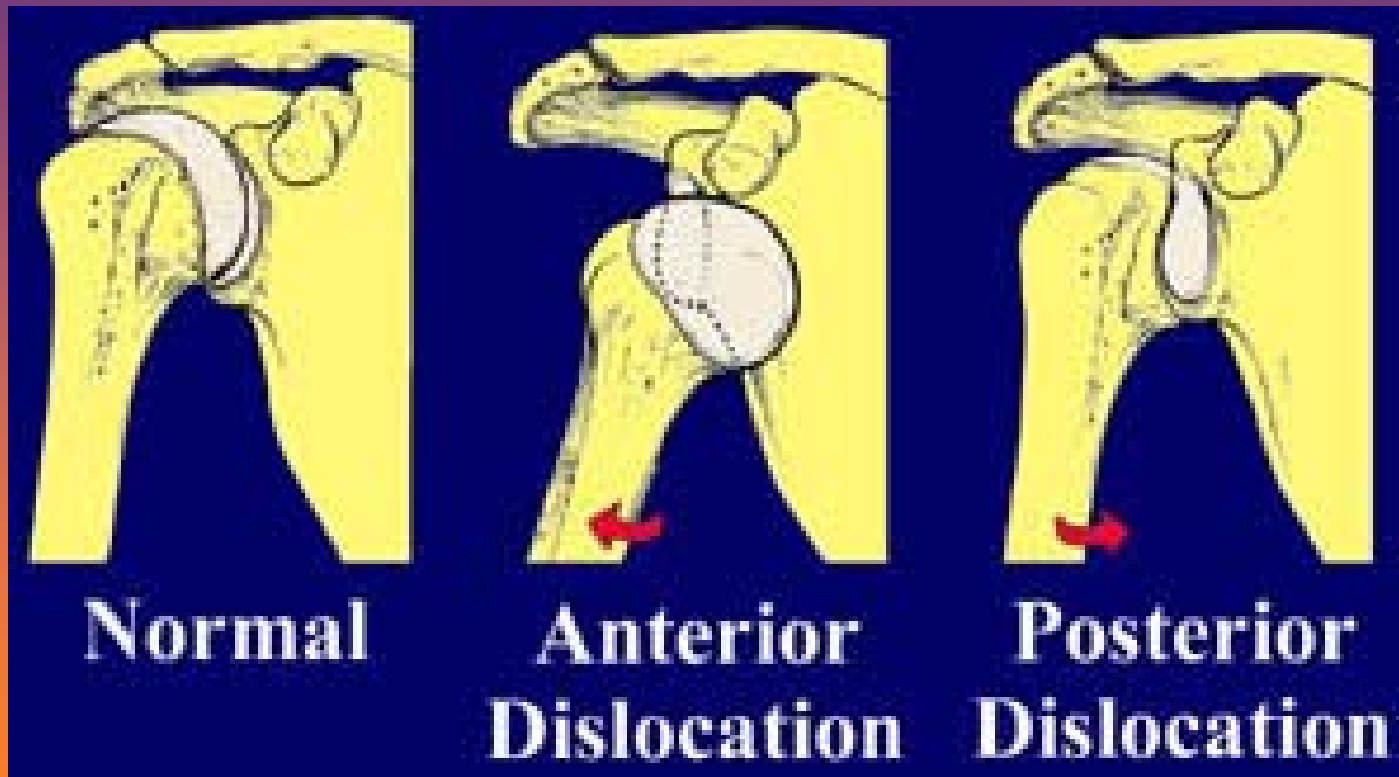


Scapula Dyskinesia

- Lack of full retraction with cocking
- Scapula receives load from the trunk and transfers them to the arm
- Must retract and protract around thoracic wall for cocking/acceleration to deceleration
- Association with tight pec. major and minor; weak trapezius, serratus anterior, and rhomboids



Dislocation



Dislocation Cont'd

- Shoulder ball and socket joint twisted apart
- Occurs after a significant injury in young, active people usually under 30 years old
- Older patients: accompanies other injuries such as fractures or rotator cuff tears
- Subluxation occurs if the head only partially slips out and then slips back in
- 3 major groups:
 - Traumatic
 - Atraumatic
 - Habitual

Traumatic (anterior) Instability

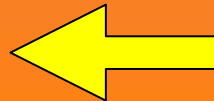
- Sporting injuries, major accidents/falls are the most frequent causes
- Associated with structural abnormalities such a Bankart lesion or a Hill-Sachs defect

Atraumatic Instability

- Caused by repeated micro trauma to the shoulder as seen in throwing athletes
- Associated with structural abnormalities such as articular surfaces damage, capsular laxity and rarely a Bankart lesion
- Arthroscopic examination of the shoulder is invaluable
- Treatment in 2 stages:
 - Physical Therapy & Injections
 - Surgery

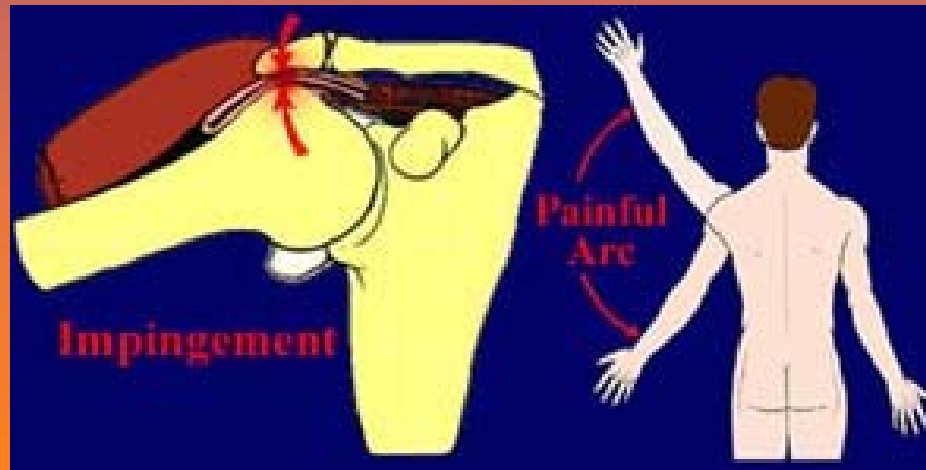
Habitual Instability

- Caused by inappropriate action or balance between various shoulder muscles
- Diagnosed by arthroscopic examination
- Treatment
 - Physical Therapy



Impingement

- Results from abnormal contact between the greater tuberosity and the under surface of the acromion during shoulder abduction
- Classically this contact occurs at 60°-120° of shoulder abduction resulting in a painful arc in mid abduction

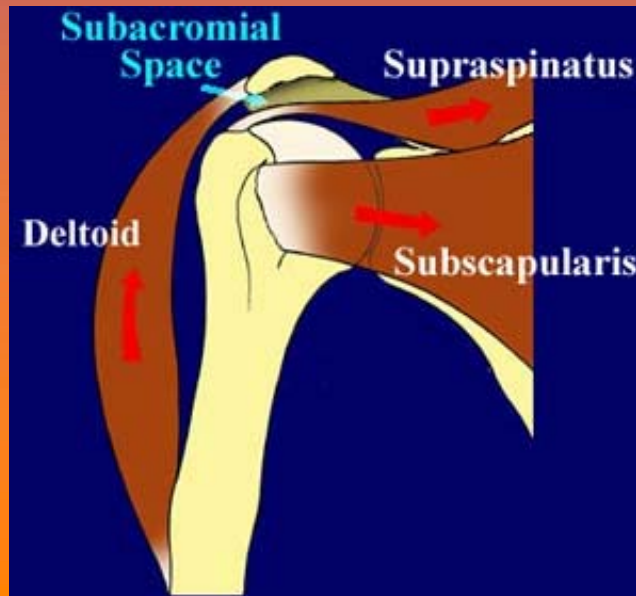


Cause

- Rotator cuff dysfunction (weakness)
 - Due to degenerative changes within the rotator cuff muscles & is an age related phenomenon
 - May follow a painful injury or traumatic tear

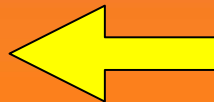
Symptoms

- Pain and weakness during activity, especially while elevating the arm sideways
- Pain localized around the deltoid muscle and may interrupt sleep



Treatment

- Dependant on the severity of the symptoms, age and occupation of the patient as well as whether there is an associated rotator cuff tear
- If NOT associated with rotator cuff
 - Steroid injection into the subacromial bursa & physical therapy
- If associated with rotator cuff or injections fail
 - Arthroscopic subacromial decompression
 - 90% success rate
 - Surgery
 - Rotator cuff repair may be necessary



Rotator Cuff Tear

- Rotator cuff muscles are known to undergo degenerative changes with age
- In some cases this could lead to pain, weakness or instability necessitating treatment



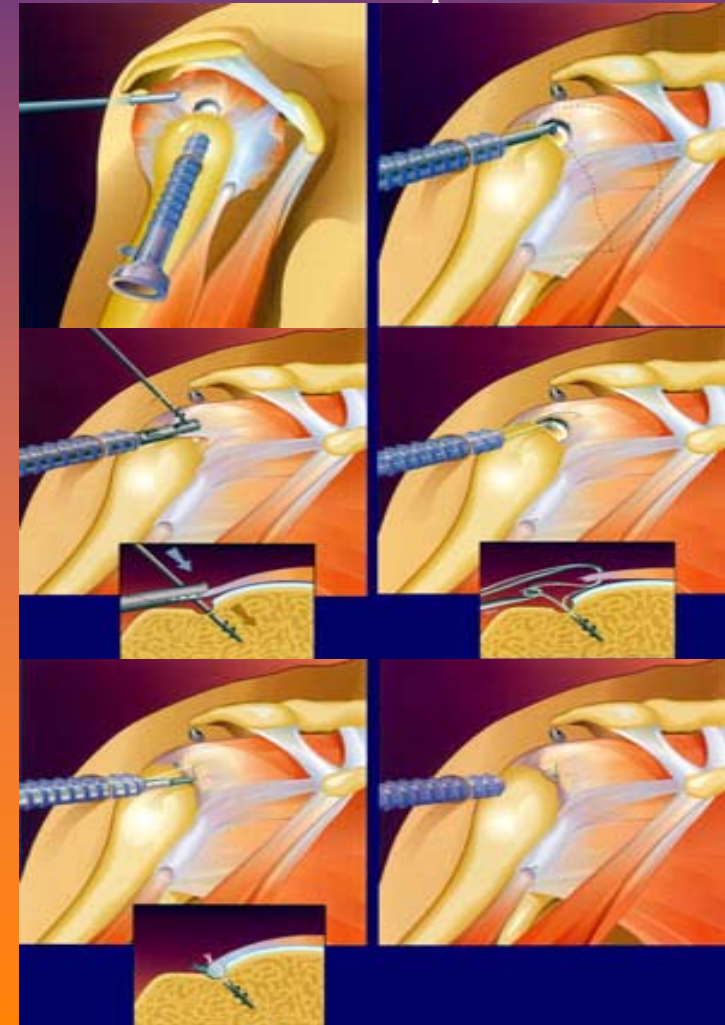
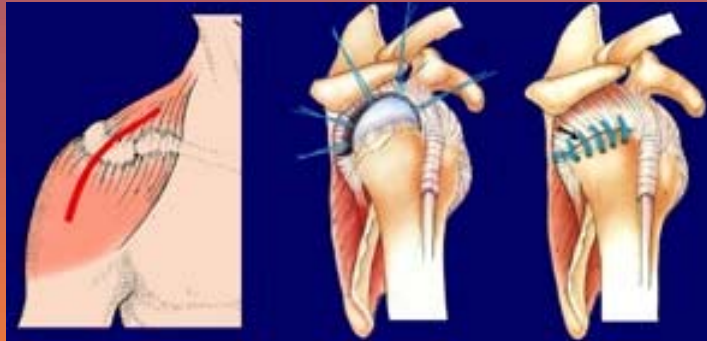
Treatment

- Steroid injections, pills & physical therapy
- Surgical repair of the rotator cuff in combination with subacromial decompression is best long-term outcome
- Arthroscopic or open surgical techniques
 - Depending on the size of the tear
- Postoperative recovery period is rather prolonged and may take up to 3-6 months

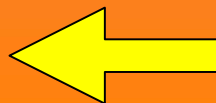
Treatment Cont'd

Arthroscopic Rotator Cuff Repair

Open Rotator Cuff Repair

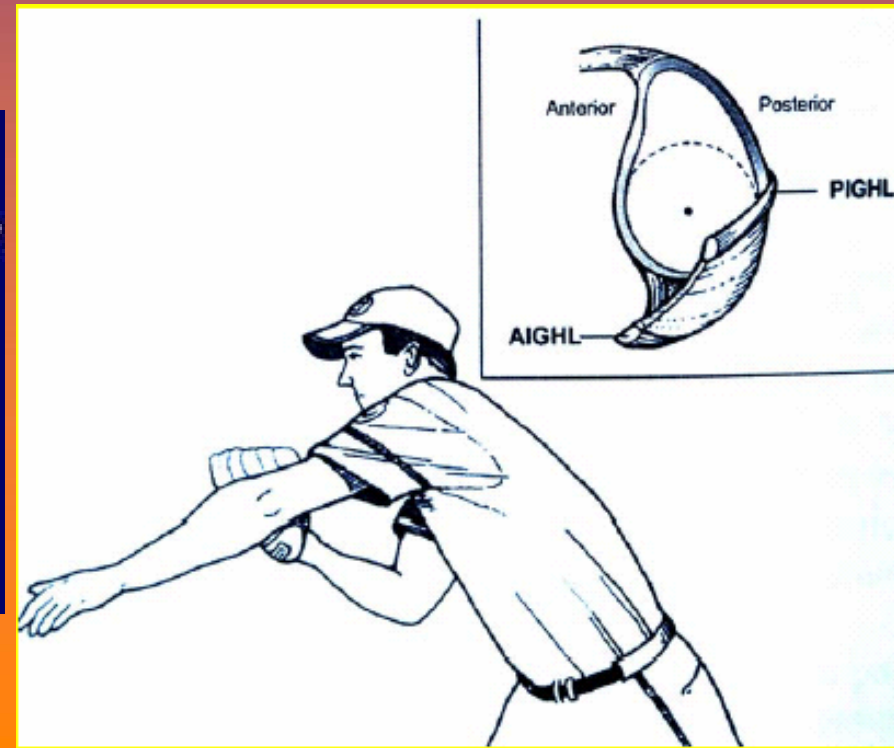
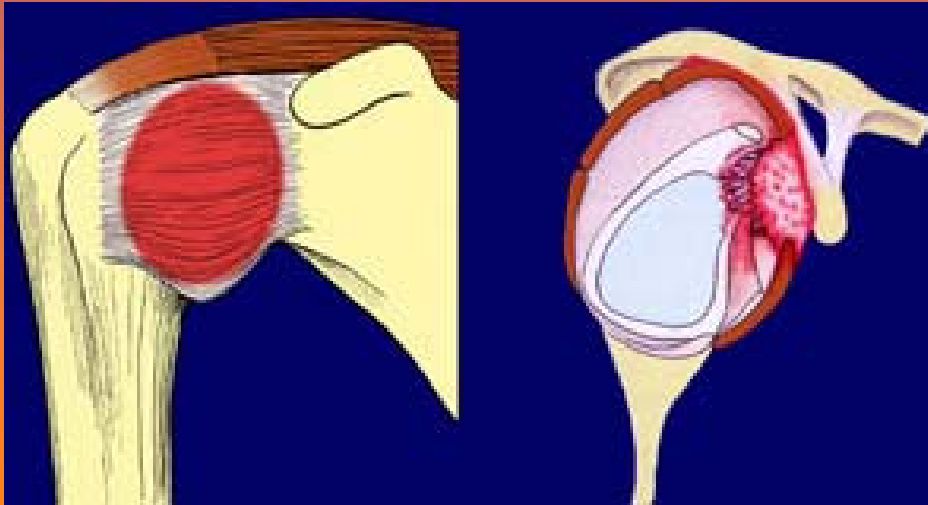


Arthroscopic RC Repair Video



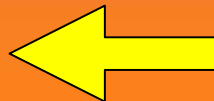
Dead Arm

- Shoulder stiffness due to thickening and fibrosis of the capsule
- Posterior capsular repetitive micro-trauma during the follow-through phase of throwing
- Lack of glenohumeral internal rotation

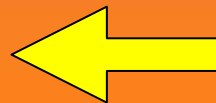
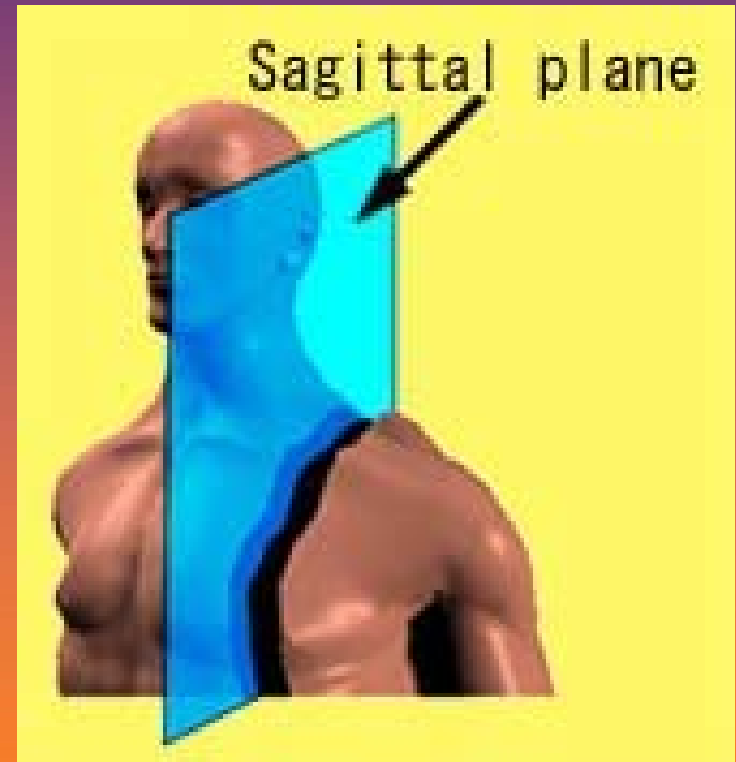
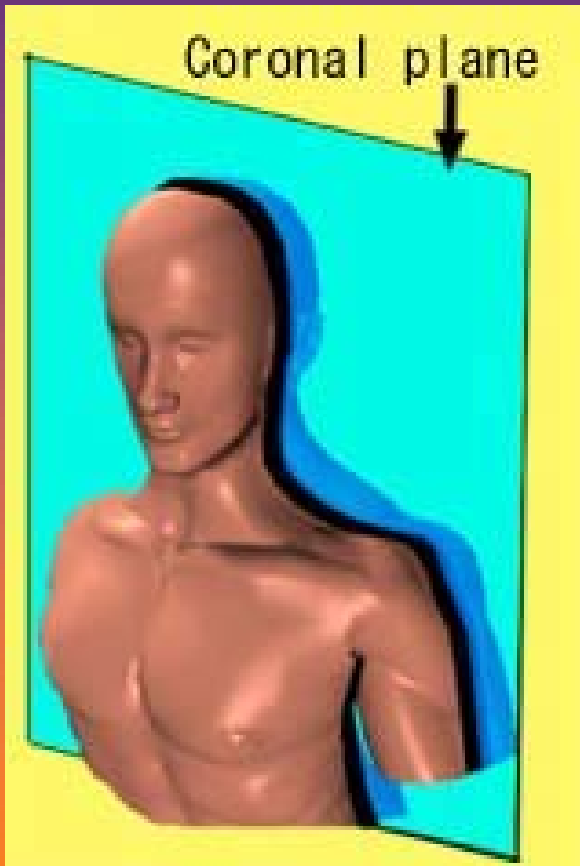


Treatment

- Steroid and local anesthetic injections in glenohumeral joint & physical therapy
- For severe stiffness the most effective is manipulation under general anesthetic with a steroid and local anesthetic injection into the joint & intensive physical therapy



Planes

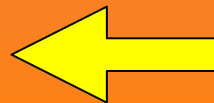


Hill-Sachs defect

Depression fracture caused by contact between humeral head hitting the glenoid rim.

Treatment:

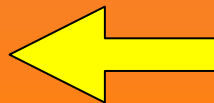
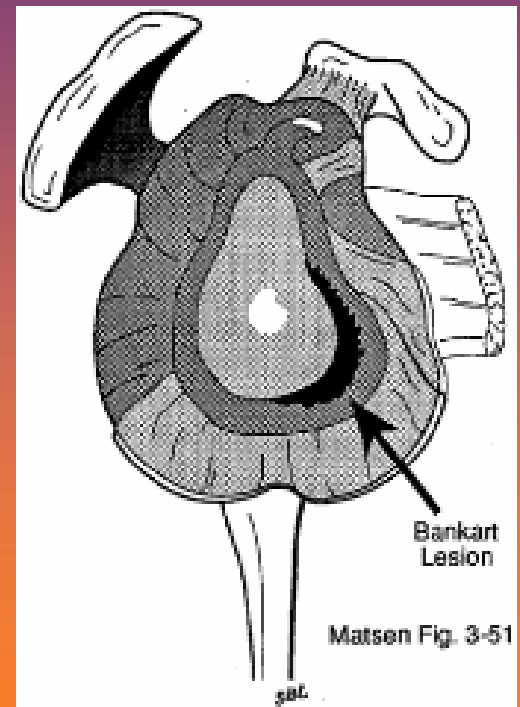
- reduction under sedation or general anesthetic followed by 4 weeks of immobilization in an external rotation brace



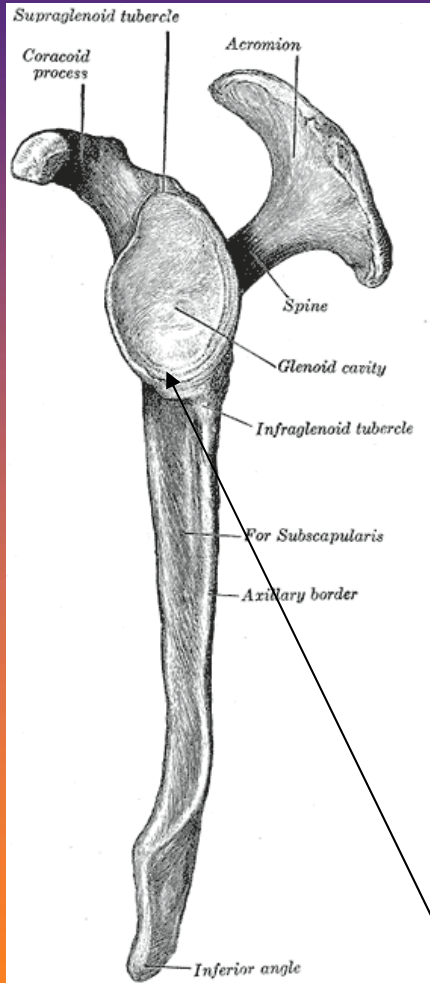
Bankart lesion

Detachment of the cartilaginous edge of the glenoid (shoulder socket)

- creates a pocket, which in the position of shoulder abduction and external rotation allows abnormal displacement of the humeral head on the glenoid



Scapula



The glenoid articulates with the humerus; The edge of the glenoid is deepened by a cartilaginous structure - the **labrum**

