BIOMECHANICS OF THROWING- PART 1

THROWER'S SHOULDER

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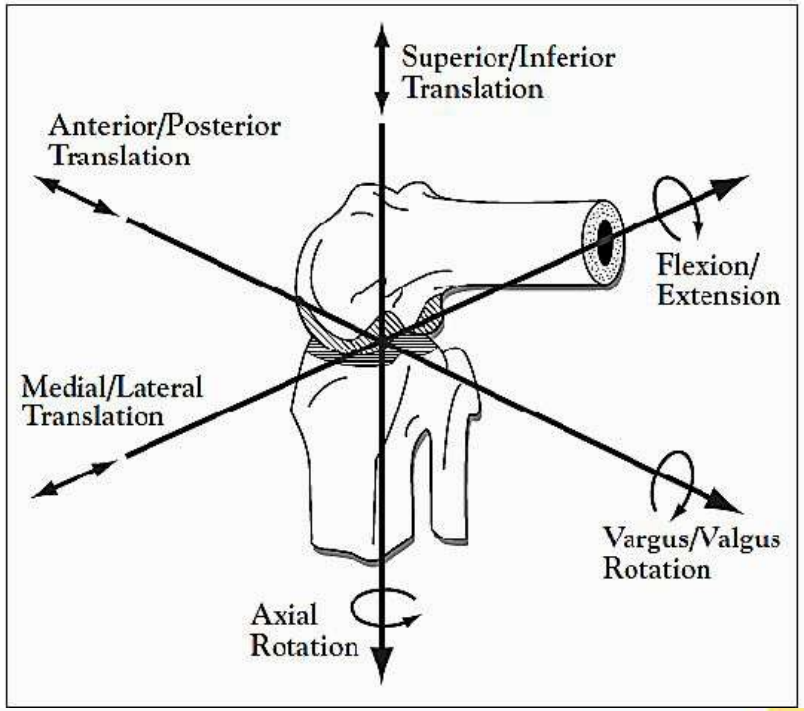
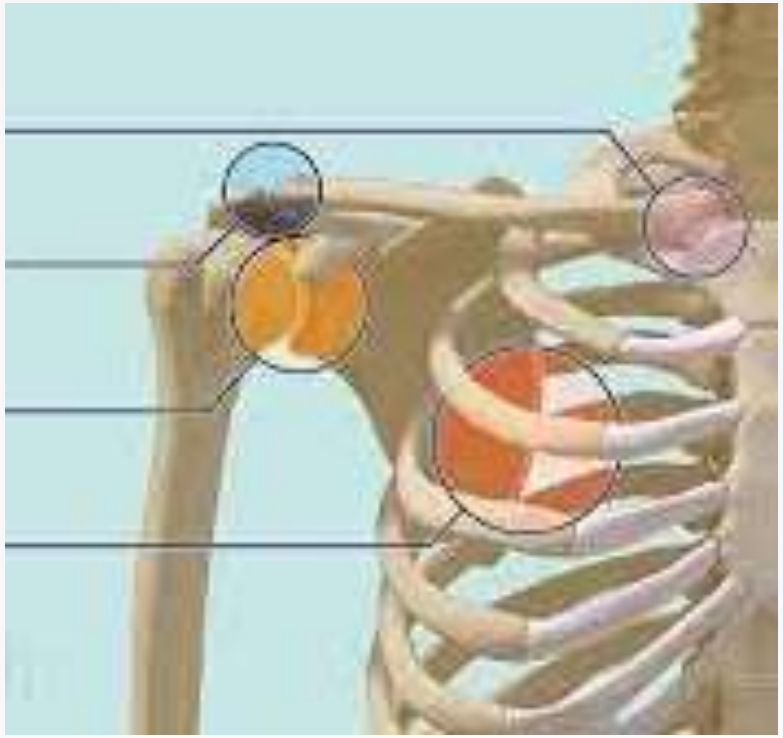
SHOULDER JOINT

- Diarthrodial joints has the greatest propensity for instability.
- The glenohumeral joint has six degrees of freedom of motion -- three rotations and three translations with respec to the anatomic coordinate system.



SHOULDER JOINT IS COMPOSED OF 3 JOINTS

1. GLENO-HUMERAL JOINT
2. ACROMIO-CLAVICULAR JOINT
3. STERNOCLAVICULAR JOINT
4. Scapulothoracic (ST) joint - known as a "functional joint" is not a true joint

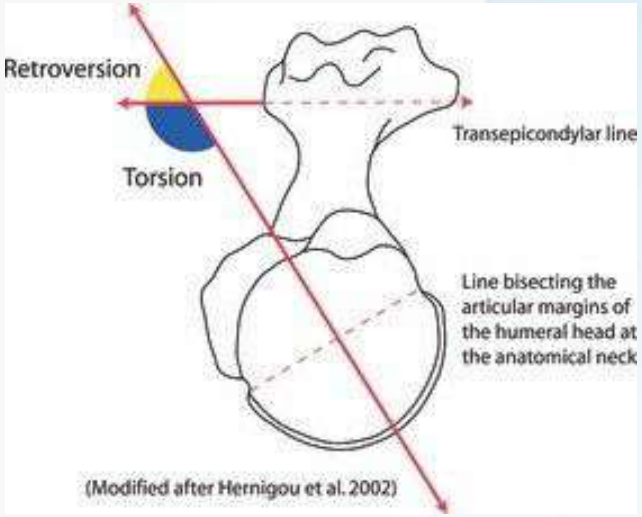


BIOMECHANICALLY COMPLEX SYSTEM

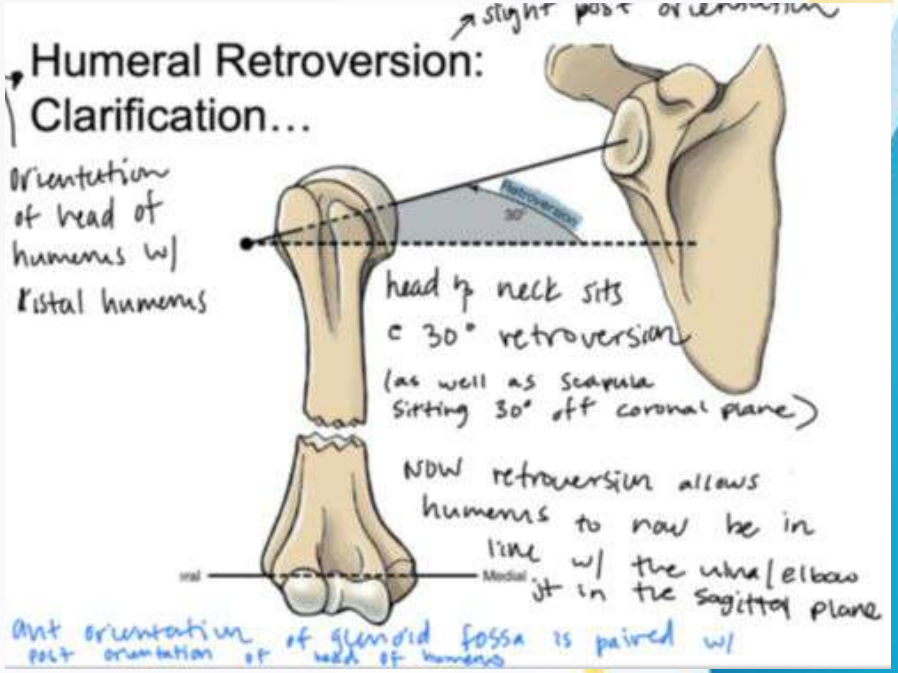
1. BONY STABILITY
2. FIBROCARTILAGINOUS LABRUM
3. CONSTRAINED CAPSULE
4. GHL
5. RC MUSCLE
6. SCAPULOTHORACIC JOINT
7. Negative intra-articular pressure

BONY STABILITY

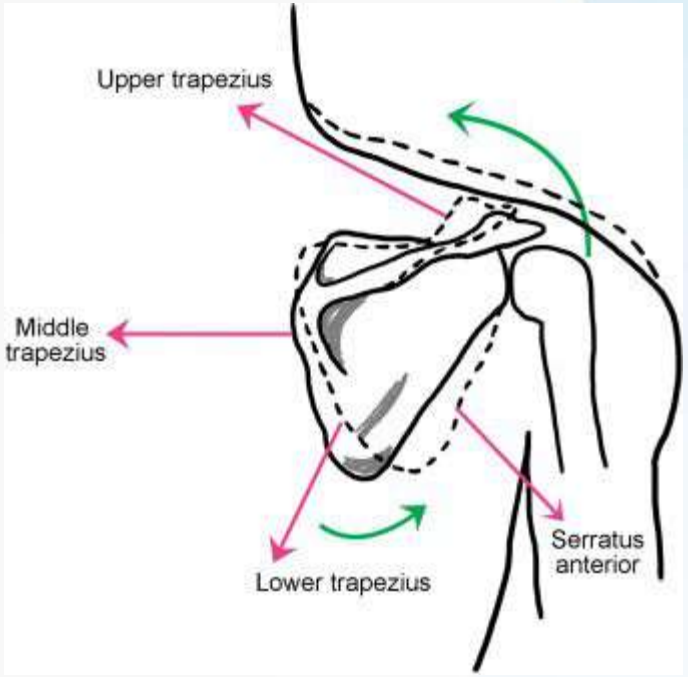
- HUMERAL HEAD ARTICULAR SURFACE IS NORMALLY RETROVERTED BY 30 DEG
- GLENOID RETROVERSION IS 7 DEG
- ARTICULAR SURFACE DEVIATED FROM EACH OTHER BY 2MM.
- IN ABDUCTION HUMERAL HEAD IS MORE CONGRUENT WITH THE GLENOID...CONTACT AREA INC & PRESSURE DEC.



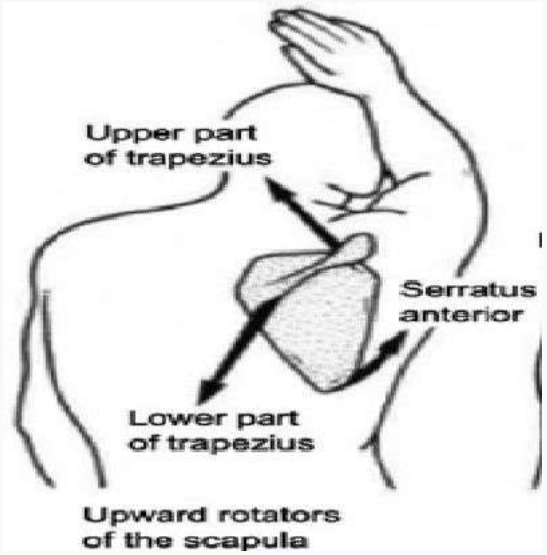
What is the purpose of the humeral



2.Muscular stability Scapulothoracic muscles



- The scapulothoracic articulation comprises a space between the surface of the posterior thoracic cage and the surface of the anterior scapula.
- Scapulothoracic articulation allows increased shoulder movement beyond the initial 120◦ provided by the glenohumeral Joint.



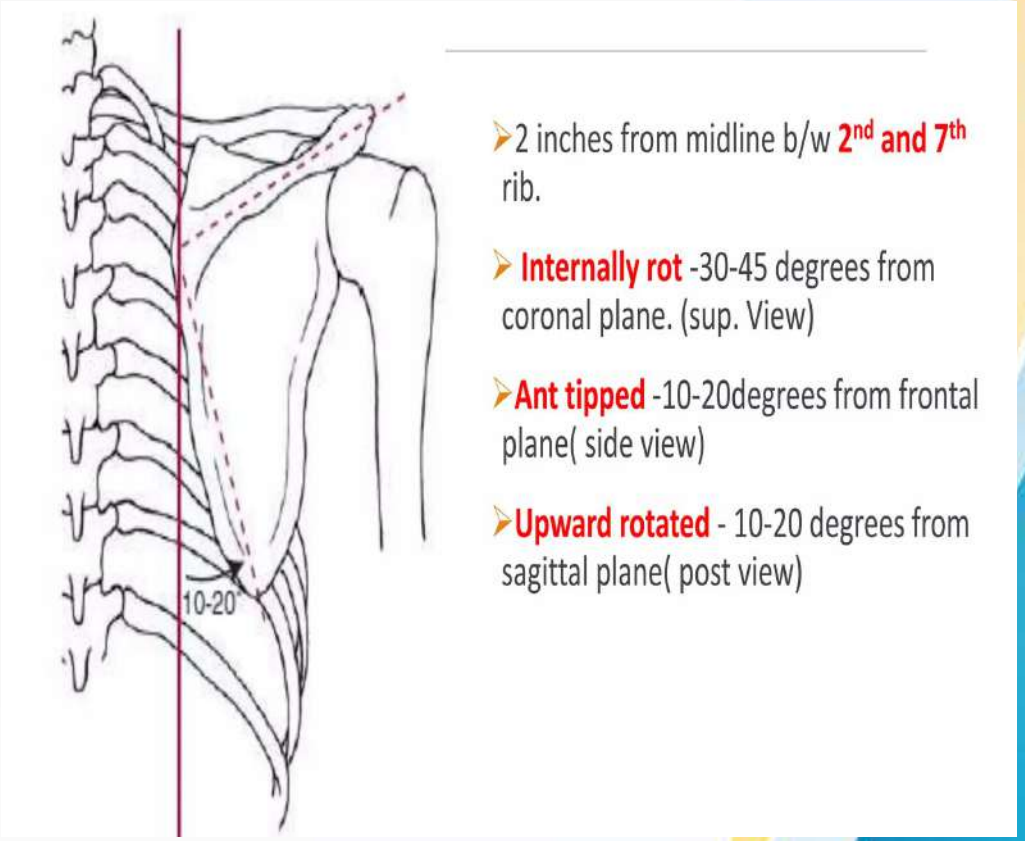
Force Couples within the Shoulder Complex

1. Rotation that occurs at the scapulothoracic articulation is controlled by the force couple of the trapezius and serratus anterior.
2. Elevation that occurs at the glenohumeral joint is controlled by the deltoid/rotator cuff force couple

RESTING POSITION OF SCAPULA

- For everyday activities, scapulothoracic motion provides only 15◦ of internal rotation.

- If the scapula is fused, limitation occurs mostly with extension and internal rotation.

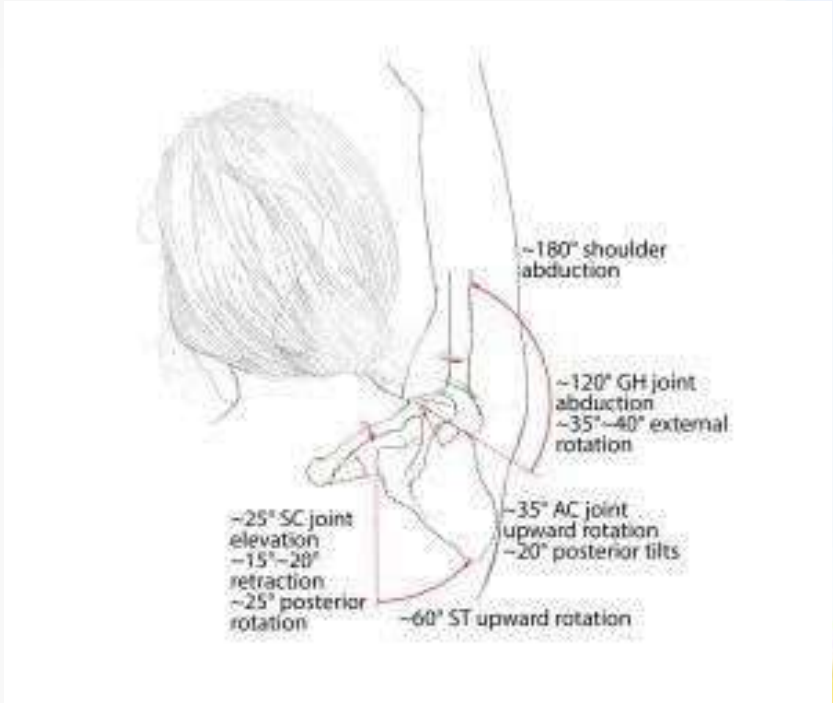


SCAPULA WHAT TO LOOK FOR THROWERS

Medial border prominence is characterized as “yes,” seen, dyskinesis present, or “no,” not seen, dyskinesis not present.
The scapular assistance test creates posterior tilt and can decrease external impingement symptoms.
The scapular retraction test or scapular reposition test to detect changes in strength or pain during isometric shoulder abduction with manual correction of the scapula position by inducing it a posterior tilting and external rotation.S
Pectoralis minor tightness
A rough measurement of pectoralis minor tightness may be obtained by having the patient stand against the wall and measuring the distance from the wall to the anterior acromial tip a side-to-side asymmetry greater than 3 cm considered abnormal.
Direct measurement can be obtained by measuring the distance from the coracoid process to the fourth rib at the rib/sternum articulation

ScapuloHumeral rhythm

- The coordinated movement between the scapulothoracic joint and the glenohumeral joint.
- Ratio between glenohumeral and scapulothoracic joint motion is approximately 2:1.
- Shoulders with multidirectional instability have an increased ratio
- Shoulders with impingement or rotator cuff tears have a decreased ratio

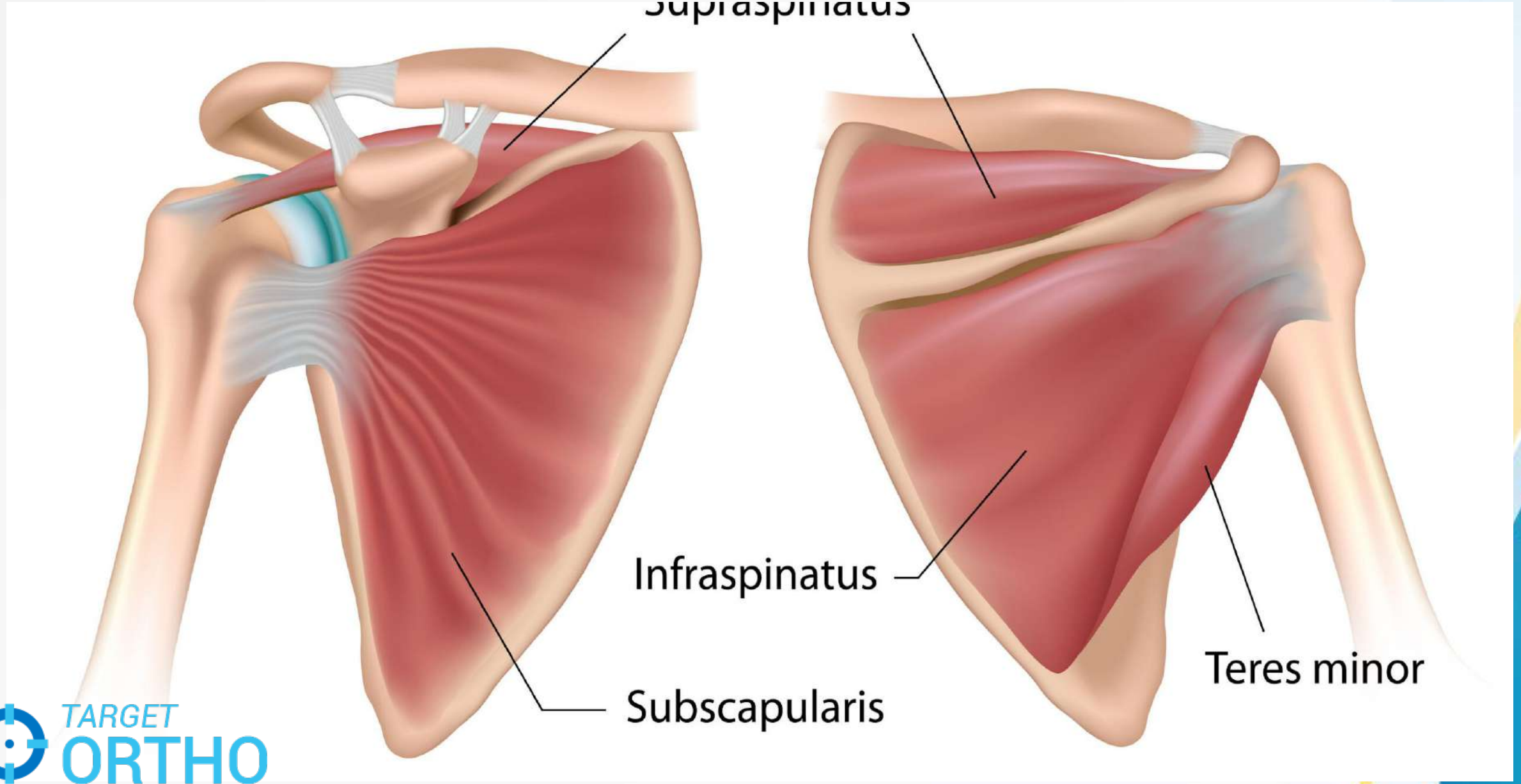


Scapulohumeral rhythm helps preventing active insuffciency of the deltoid???

- Prevents active insuffciency of the glenohumeral muscles by maintaining a good length-tension relationship of the muscles acting on the humerus.
- The deltoid muscle relies on movement of the scapula as it elevates the humerus past 90 degrees of shoulder abduction.
- Without the assistance of the scapular rotators(UT,LT,SA), the deltoid pulls the scapula into downward rotation and the arm can only be raised 60-75 degrees.
- By upwardly rotating the scapula to assist in maintaining the muscle in a lengthened position over the full range of arm abduction

3.Rotator cuff muscles

Rotator cuff muscle	Description	Action
SUPRASPINATUS	Circumpennate muscle. Average width at midportion of tendinous insertion is 14.7 mm. Mean area of insertion is 1.55 cm2	Initializes humeral abduction to 15◦ Deficiency can be compensated for by the remaining rotator cuff muscles
Infraspinatus	Circumpennate muscle. Mean area of infraspinatus insertion is 1.76 cm2	Resists posterior and superior translation Generates 60% of external rotation force
Teres minor	Circumpennate	Muscle Resists posterior and superior translation Generates 45% of the external rotation force
Subscapularis	Multicircumpennate muscle	Contributes to the floor of the bicipital sheath Resists anterior and inferior translation Strong internal rotator

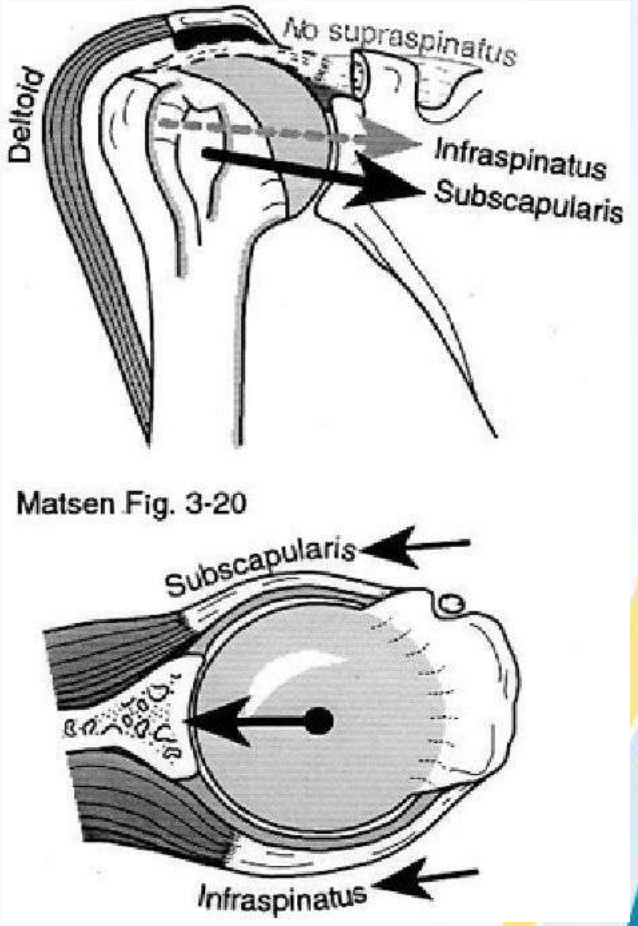


Rotator cuff contribution to stability throughout abduction.

- Infraspinatus and teres minor control external rotation of the humerus and reduce anteroinferior capsuloligamentous strain.
- Subscapularis and the infraspinatus contract to stabilize the glenohumeral joint in abduction at 60–150◦
- Biceps has been found to be the most important stabilizer in neutral rotation, with the subscapularis providing the greatest degree of stabilization in external rotation.

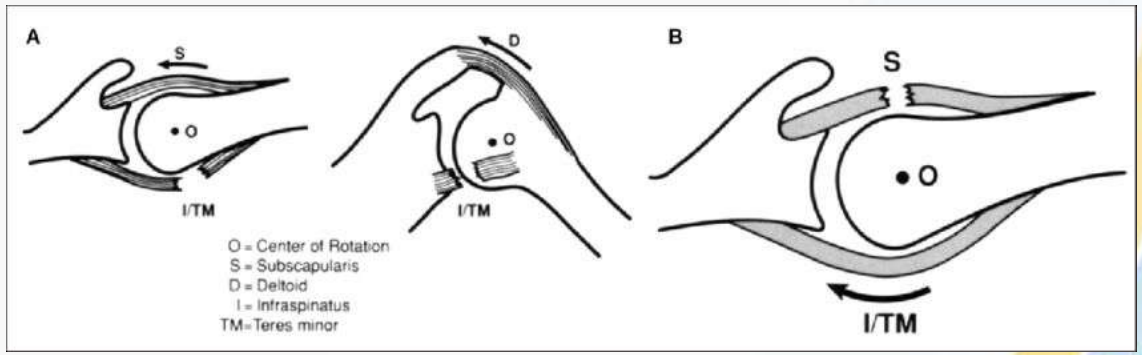
- Transverse force couple which is formed by the subscapularis anteriorly and by the infraspinatus/teres minor posteriorly.

- The rotator cuff muscles lie much closer to the center of rotation on which they act, so their lever arm is shorter and a smaller generated force results.
- Cephalad force of the deltoid counteracted by the depressing force of the subscapularis, infraspinatus, and teres minor.



- Transverse force couple which is formed by the subscapularis anteriorly and by the infraspinatus/teres minor posteriorly.

- Tears involving the infraspinatus/teres minor and subscapularis disrupt the transverse force couple whereas isolated supraspinatus tears could be compensated for by the remainder of the rotator cuff muscles, hence not contributing to instability or superior translation.



ANTERO -SUPERIOR ESCAPE

- Cephalad force of the deltoid counteracted by the depressing force of the subscapularis, infraspinatus, and teres minor.

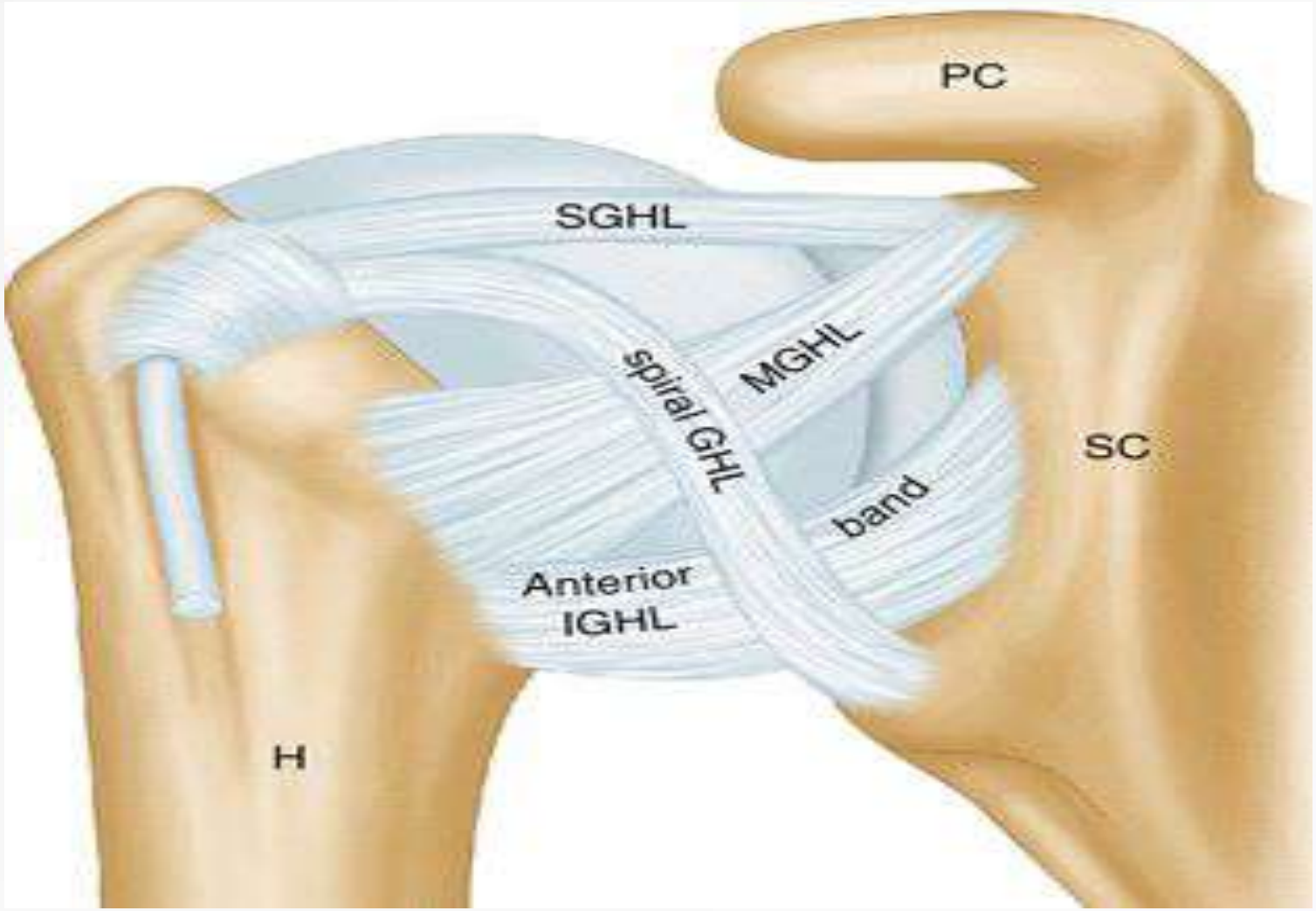
Massive rotator cuff tears+ disruption of the coracohumeral ligament + anterior acromion deficiency

SEVERE ANT-SUP TRANSLATION OF HUMERAL HEAD

** IMPINGEMENT OF CORACOACROMIAL ARCH & SCLEROSIS ACROMION [SUBACROMIAL SCLEROSIS K/A SOURCIL SIGN]

Ligamentous and labral stability

GHL	Description	Action
Superior glenohumeral ligament (SGHL)	Originates from the supraglenoid tubercle, anterior to the origin of the long head of the biceps, and inserts on the proximal tip of the lesser tuberosity	Resists inferior translation with the adducted arm in neutral rotation Along with the coracohumeral ligament (CHL), it limits external rotation of the adducted shoulder
Middle glenohumeral ligament (MGHL)	Originates on the supraglenoid tubercle and anterosuperior portion of labrum and inserts onto the lesser tuberosity blending with fibers of the subscapularis tendon	Anterior stabilizer with arm in adduction and up to 30–45◦ abduction



Inferior glenohumeral ligament complex (IGHLC)	**Has three components: an anterior band, an axillary pouch, and a posterior band. The anterior band originates from the anterior labrum and attaches to the glenoid rim. The posterior band is not found in all patients**	**Resists anteroinferior humeral head translation, especially with the arm in external rotation, abduction, and extension. The anterior band tightens with abduction and external rotation of the glenohumeral joint At neutral position (0◦ abduction and 30◦of horizontal extension) the anterior band becomes the primary static stabilizer of the glenohumeral joint The posterior band is the primary static stabilizer with the arm in flexion and internal rotation, providing posterior stability**
Coracohumeral ligament (CHL)		Resists posterior and inferior translation in the suspended shoulder Inferior stabilizer with the arm in adduction, and it tightens with external rotation

The glenoid labrum

- It is a ring of triangular shape in section overlying the periphery of the glenoid. Its free edge projects into the joint.
- The base is attached by fibrocartilage and fibrous bone.
- It blends superiorly with the origin of the long head of the biceps tendon.

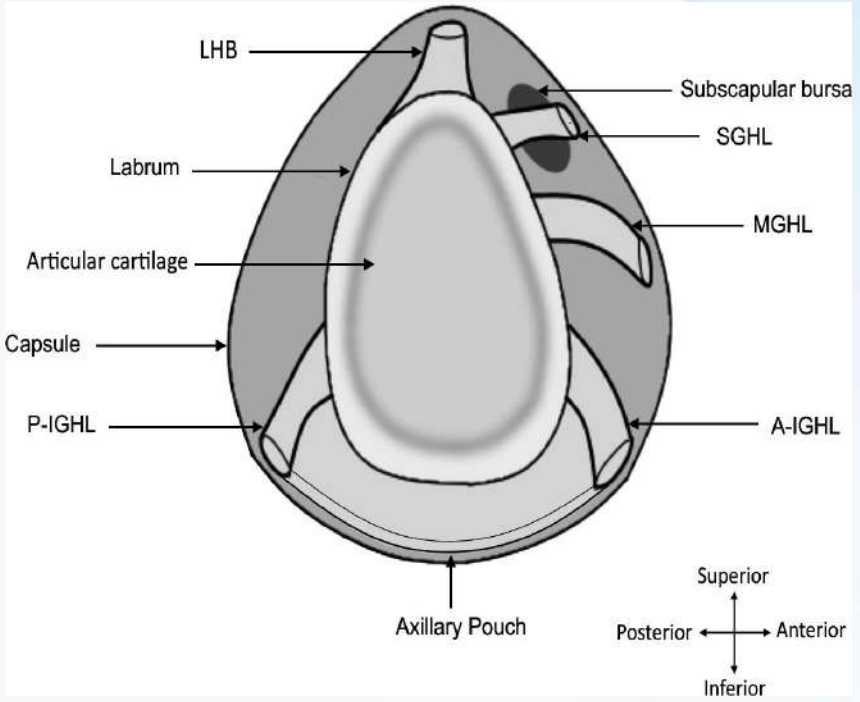
❑ It functions

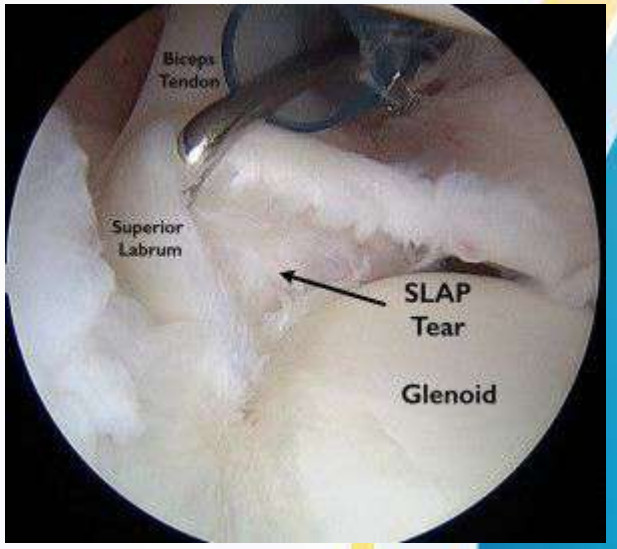
✔ to deepen the glenoid,

✔ increase congruity,

✔ generate a suction effect,

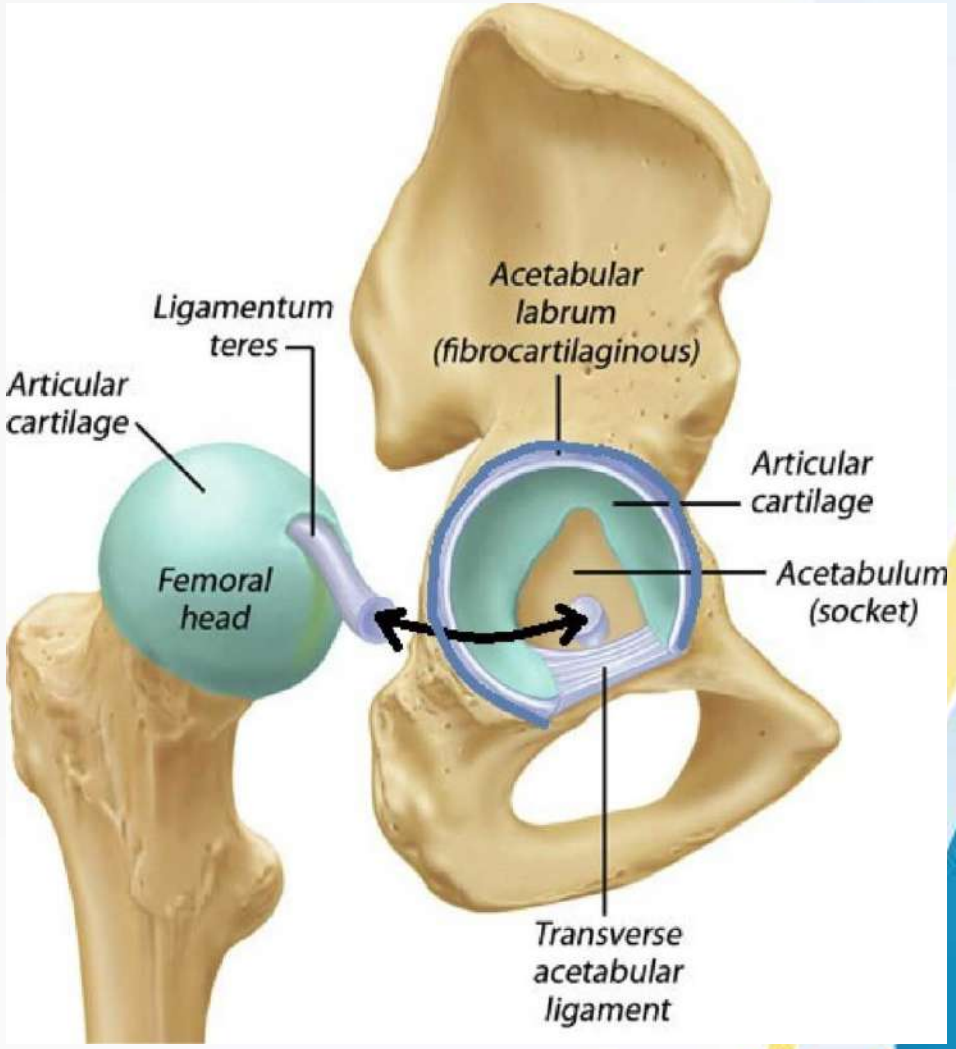
✔ enhances stability of the glenohumeral joint.



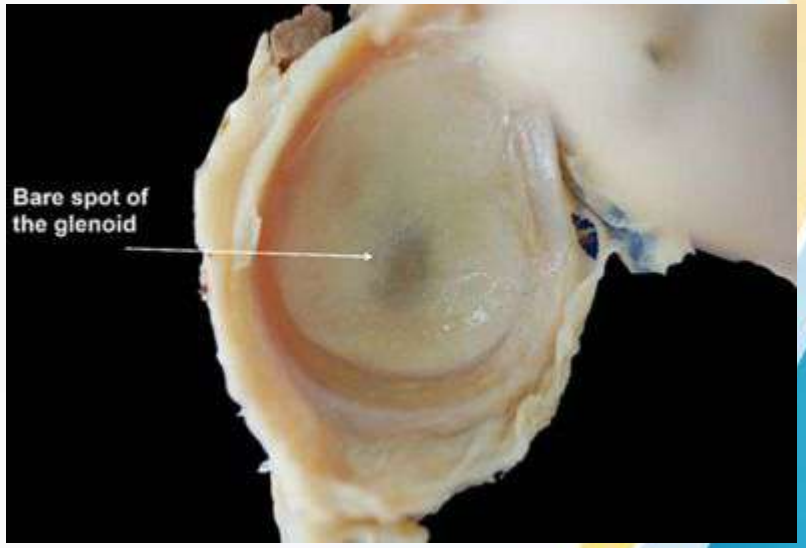


FUNCTION OF LABRUM

1. To serve as an attachment site for the glenohumeral ligaments to the glenoid rim.
2. To function as an antishear bumper, which is more evident during mid-ranges of shoulder motion.
3. The slight deepening effect and mobility of the labrum probably serve to help keep the humeral head centered in the glenoid.

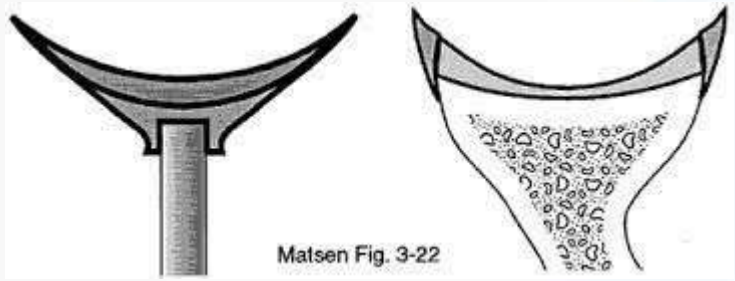


- AREA OF THINNER ARTICULAR CARTILAGE AT CENTRAL PORTION OF GLENOID-----
  TUBERCLE OF ASSAKI



A stabilizing role of the glenoid labrum: the suction cup effect

- Centering the humerus in the glenoid--
- The glenoid labrum acts as a bumper, deepening glenoid concavity and amplifying the concavity-compression mechanism.
- Centers the head of the humerus in the glenoid without muscle action and is effective in midrange positions in which the capsule and ligaments are not under tension.



Throwers/ C.I.O.U Shoulder

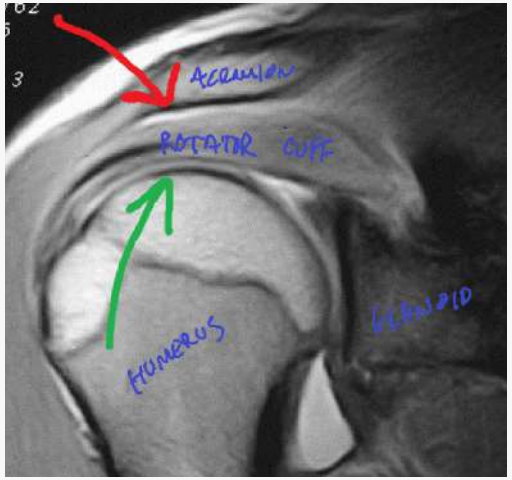
Pain..Pain is often aspecific, localizing to the posterior shoulder,,late cocking position provocative

Maximum passive ER

Loss of IR

Anterior Capsule Laxity

Posterior-shoulder tightness

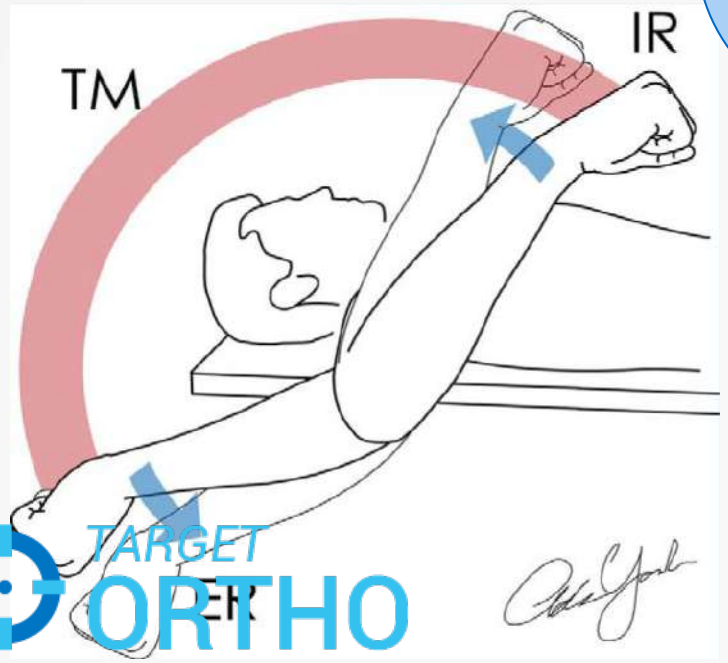


Pathophysiology

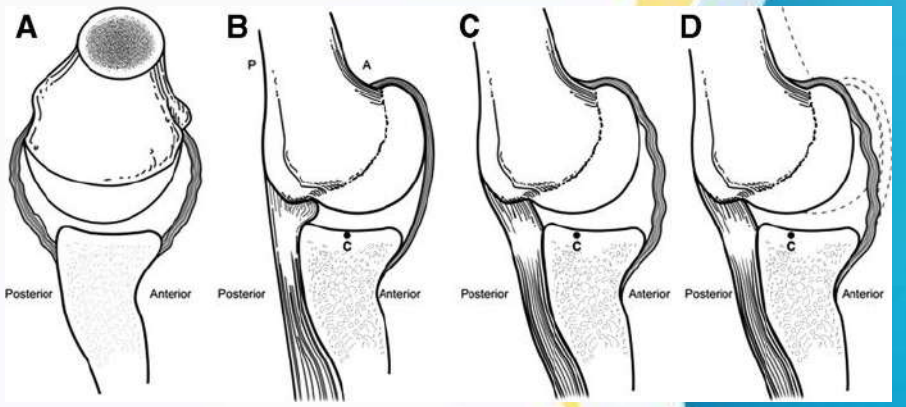
GT abuts against the POSTERO SUP Glenoid

LOSS OF IR GIRD

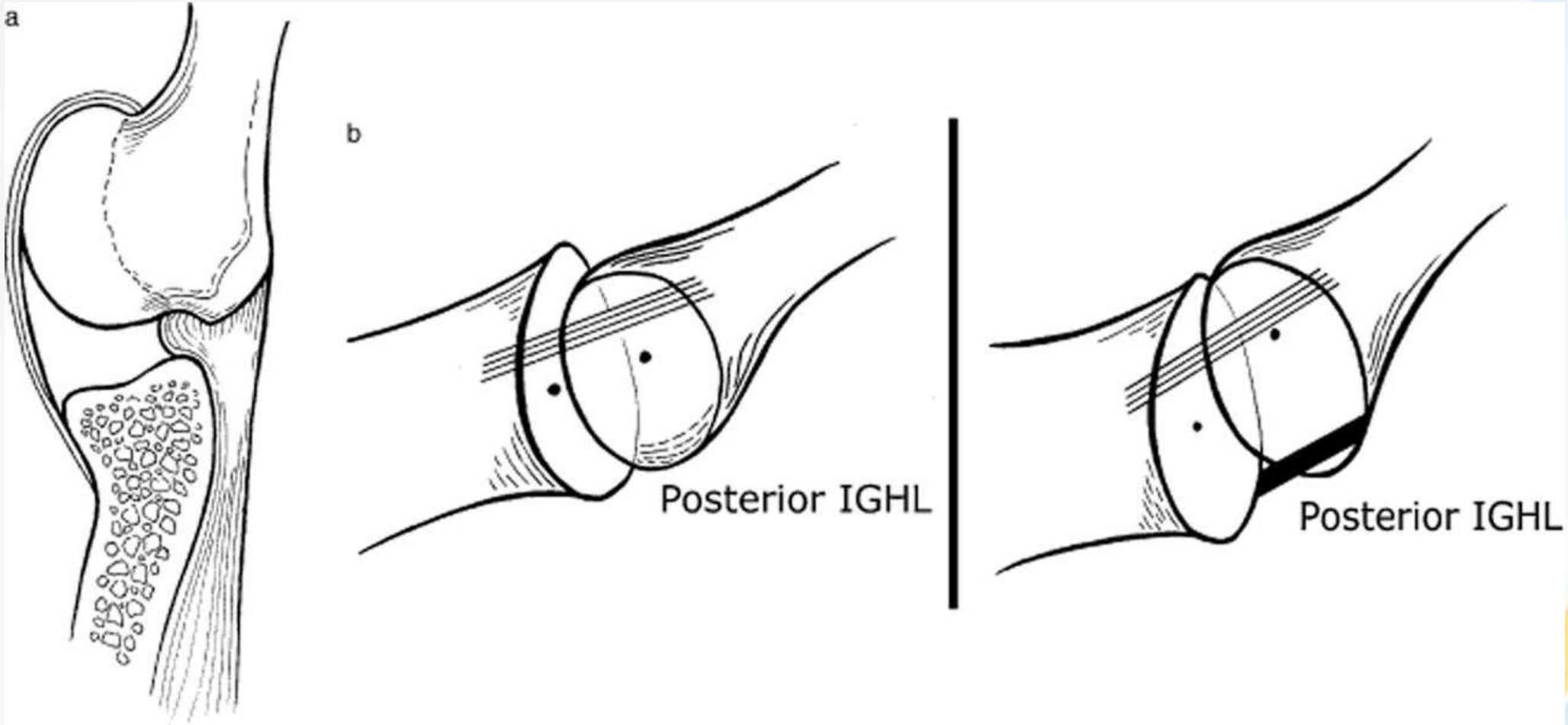
MICRO TRAUMA anterior Capsule



Maximal/ HYPER EXTERNAL ROT ATIONS with ABDUCTION



INTERNAL IMPINGEMENT

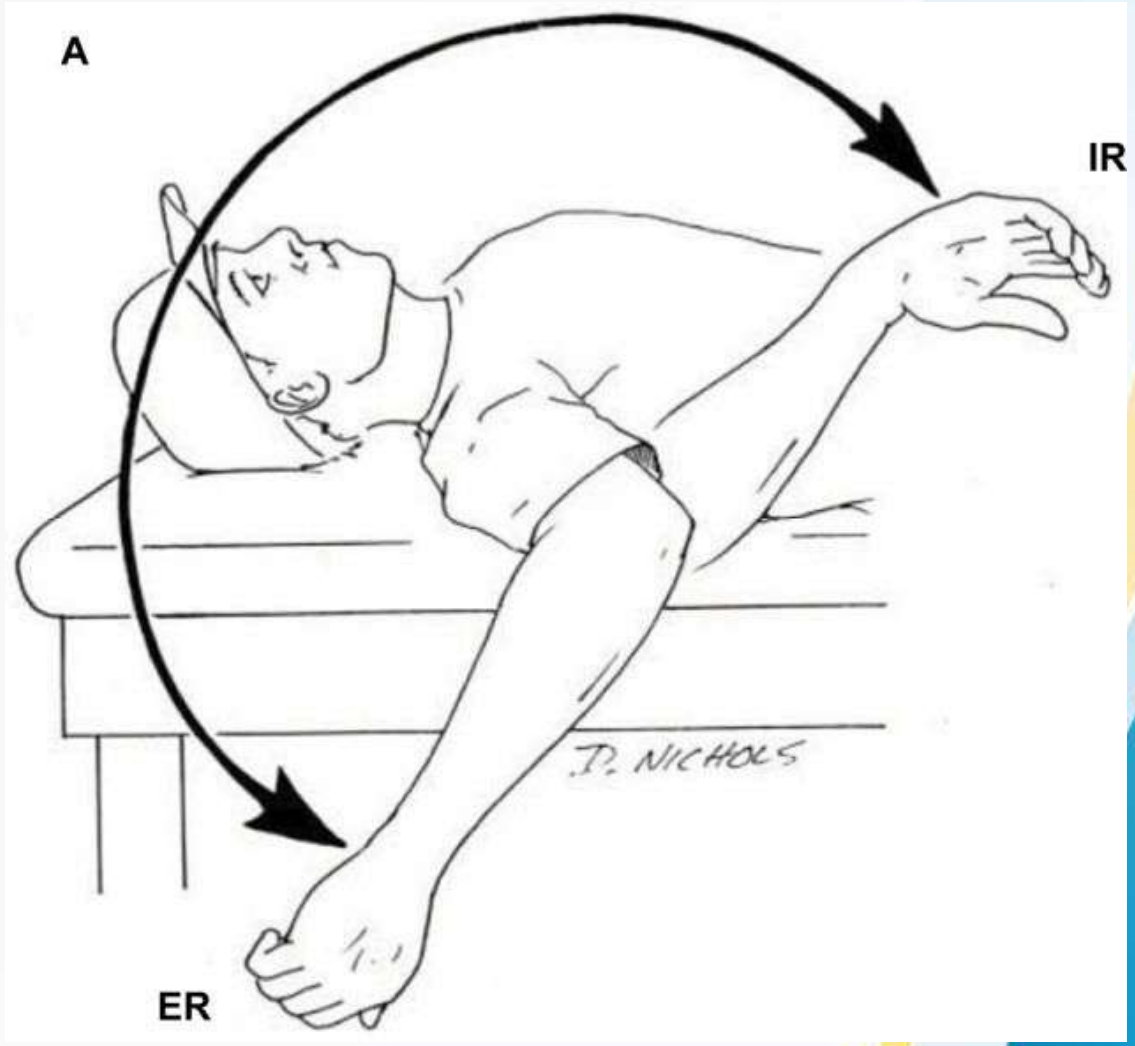


With the shoulder in the ABER position, the rotator cuff is impinged as the greater tuberosity abuts against the posterosuperior glenoid.

With the contraction of the posterior inferior glenohumeral ligament (IGHL), the new glenohumeral point of rotation is shifted in a postero-superioral direction.

THROWING SHOULDER

1. Increased External Rotation in Abduction
2. Glenohumeral internal rotation deficit (GIRD)
3. Anterior Microinstability
4. TYPE 2 SLAP
5. ANTERIOR CAPSULAR LAXITY
6. POSTERIOR CAPSULE FIBROSIS



THROWING ATHLETE

EXCESSIVE EXT ROTATION WITH ABDUCTION

HYPEREXTERNAL ROTATION

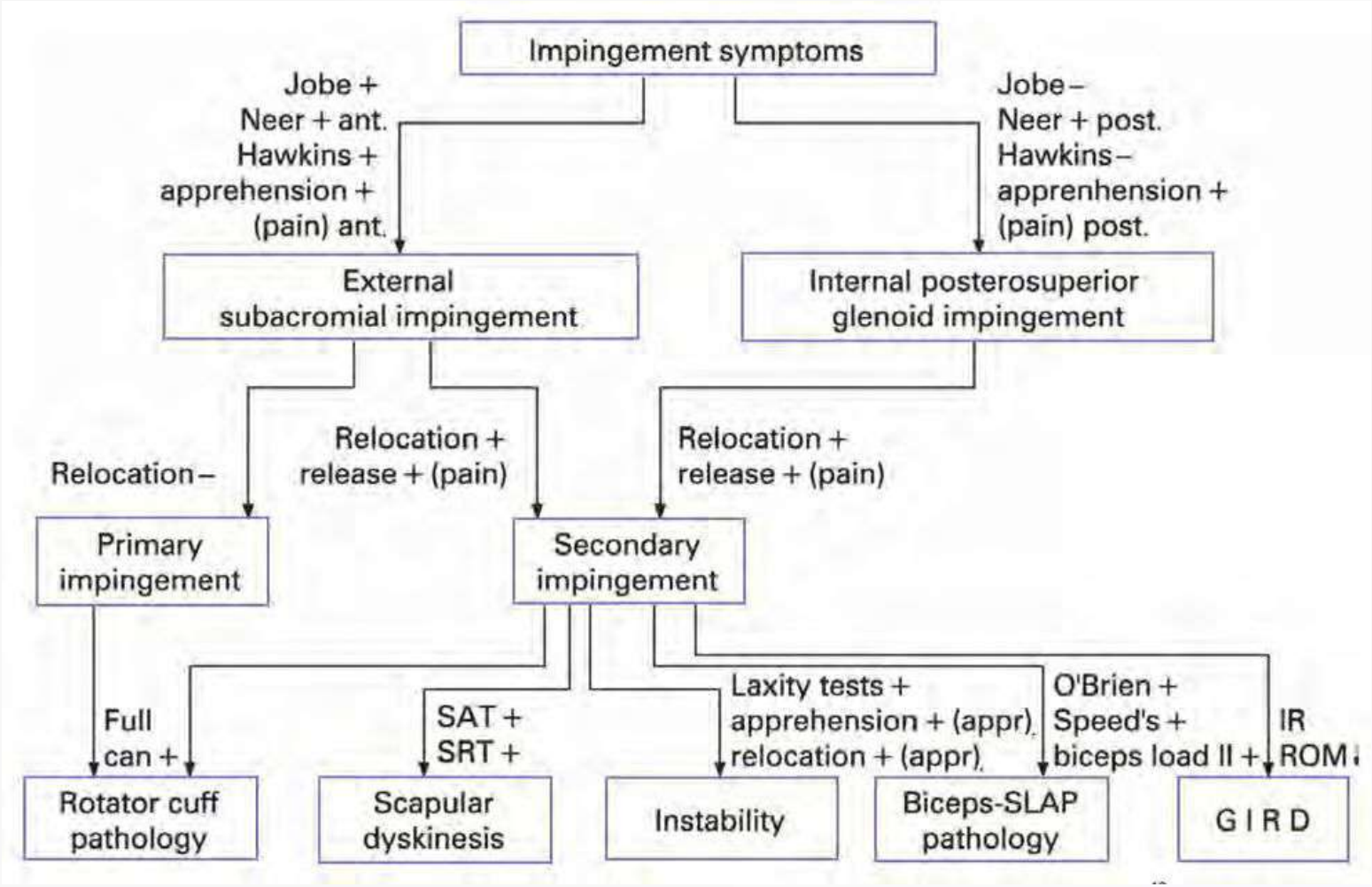
ANTERIOR CAPSULAR LAXITY

LOSS OF IR with ABDUCTION

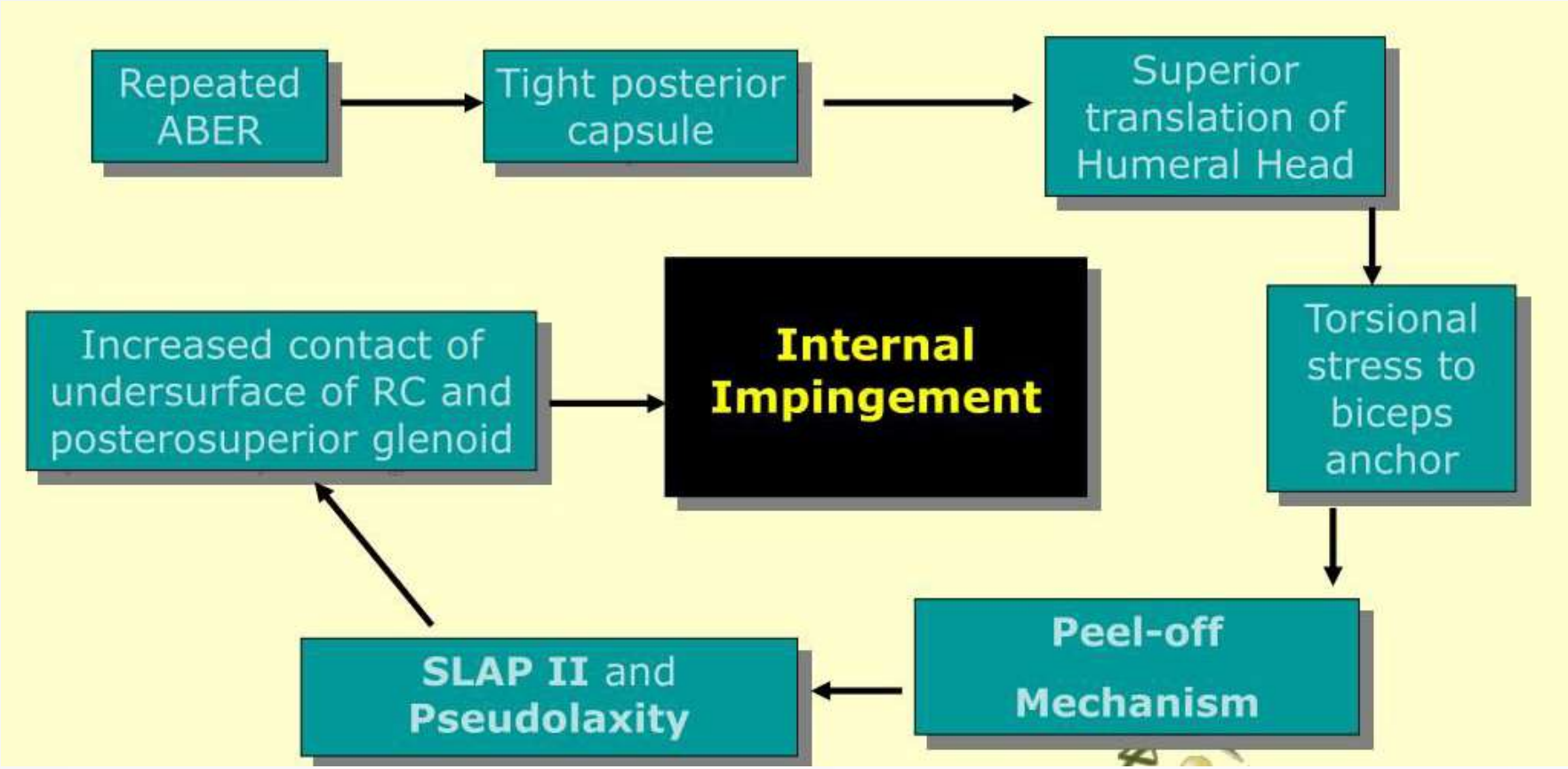
GIRD>20%

POSTERIOR INFERIOR FIBROSIS /CONTACTURE DUE TO REPETITIVE COCKING

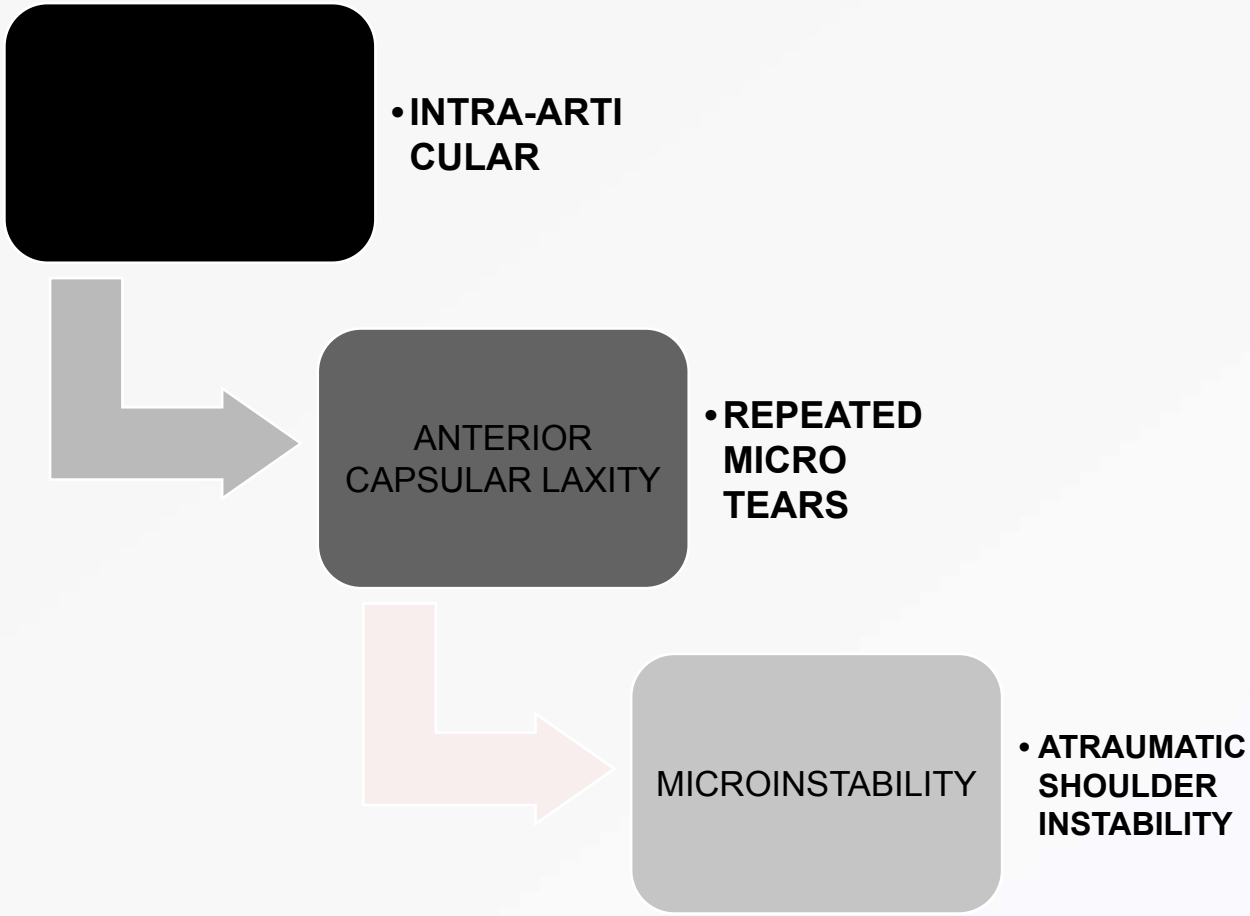
APPROACH



MECHANISM OF INTERNAL IMPINGEMENT



INTERNAL IMPINGEMENT



ATRAUMATIC SHOULDER INSTABILITY

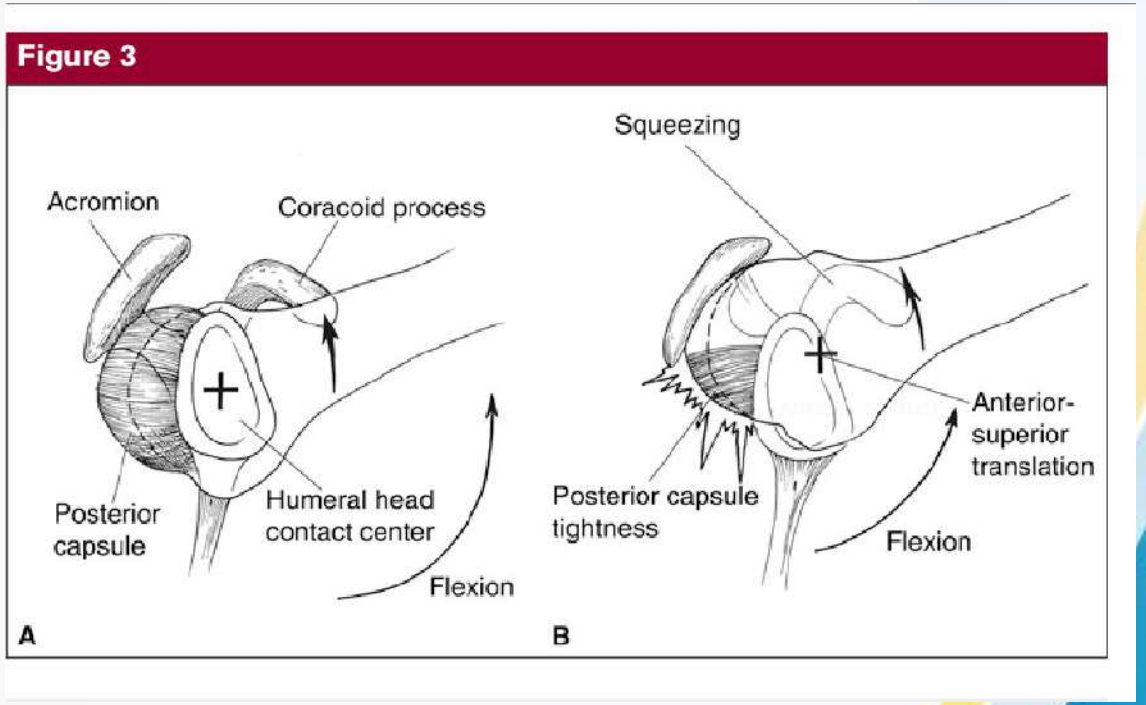
- PSEUDOLAXITY a/w SLAP Lesion
  - Repetitive throwing

↓

- STRETCHES OUT ANT CAPSULOLIGAMENTOUS COMPLEX

↓

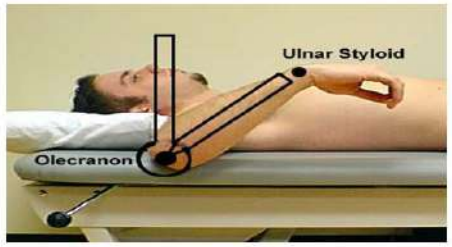
- ANTERO-SUP MIGRATION OF HUMERAL HEAD



GIRD- GLENOHUMERAL INTERNAL ROTATION DEFICIT

- Glenohumeral internal rotation deficit (GIRD) is an adaptive process in which the throwing shoulder experiences a loss of internal rotation (IR).
- LOSS IN DEGREES [loss of >20]° of IR OF GLENO HUMERAL INTERNAL ROTATION OF THROWING SHOULDER COMPARED WITH NON THROWING.
- Pathologic GIRD has been defined as a loss of IR combined with a loss of total rotational motion.

Shoulder internal rotation(0~70°)



Test Position

- Subject supine
- Shoulder 90o abduction
- Forearm neutral
- Elbow flexed 90o
- Stabilize arm

Goniometer Alignment

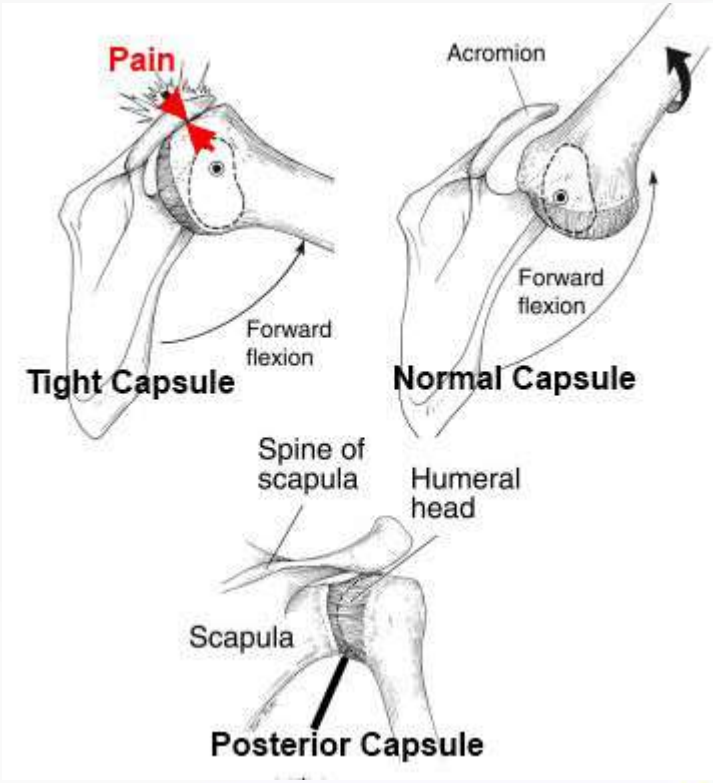
- Axis – olecranon process of ulna
- Stationary arm – aligned vertically
- Moving arm – aligned with ulna (styloid process)

EVERY GIRD IS PATHOLOGICAL??

- NO
- Decreased IR (compared to nonthrowing shoulder) can exist without concomitant shoulder pathology when total rotational motion (TRM) of the shoulders is symmetric.
- Due to increased retrotorsion (decreased anteversion) of the humerus, which shifts the arc of motion more posteriorly (external).
- Pathologic GIRD,exists when there is a loss of TRM >5° compared to the contralateral shoulder.

MANAGEMENT FOR GIRD

- POSTERO-INFERIOR CAPSULAR STRETCHING (NOT JUST GLOBAL/CAPSULAR STRETCHING XXXX) PROGRAM FOR 6 WEEKS.



6 weeks stretching program

- The flexibility training induced significant increases in ROM alongside increases in peak passive torque (stretch tolerance) and the ROM at which stretch was first perceived.
- This occurred without changes in muscle-tendon mechanical properties .
- Limb-specific ROM increases were underpinned by neural adaptations
- Five repetitions of 30-second duration self-stretch every day for 6 weeks[MIN OF 4 WEEKS]

POSTEROINFERIOR CAPSULAR STRETCHING

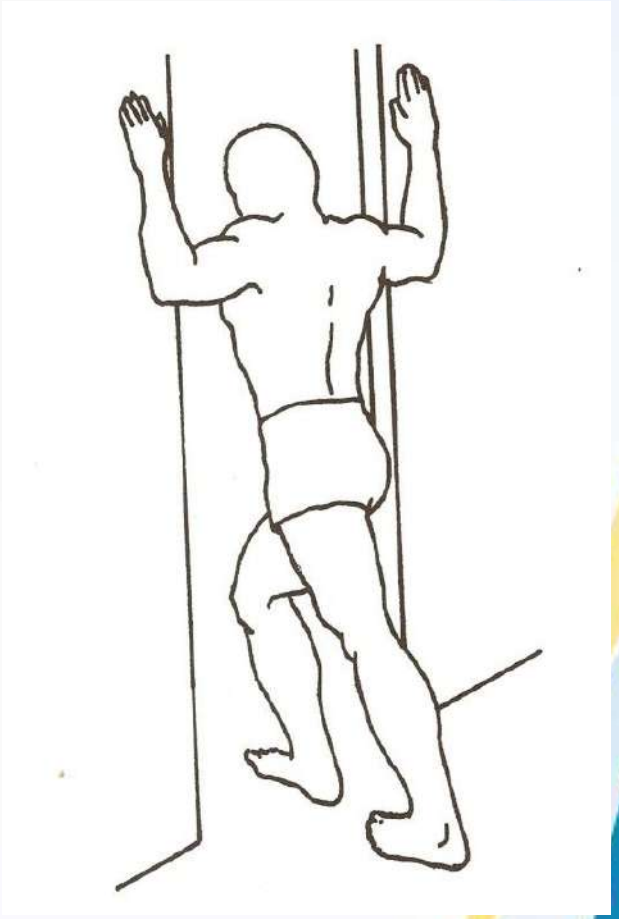
- 1. SLEEPERS STRETCH--- PATIENT SIDELYING WITH SCAPULA STABILIZED AGAINST WALL SHOULDER & ELBOW FLEXED AT 90 DEG.

- PASSIVE IR TO THE ARM APPLIED BY NON DOMINANT ARM TO DOMINANT WRIST.

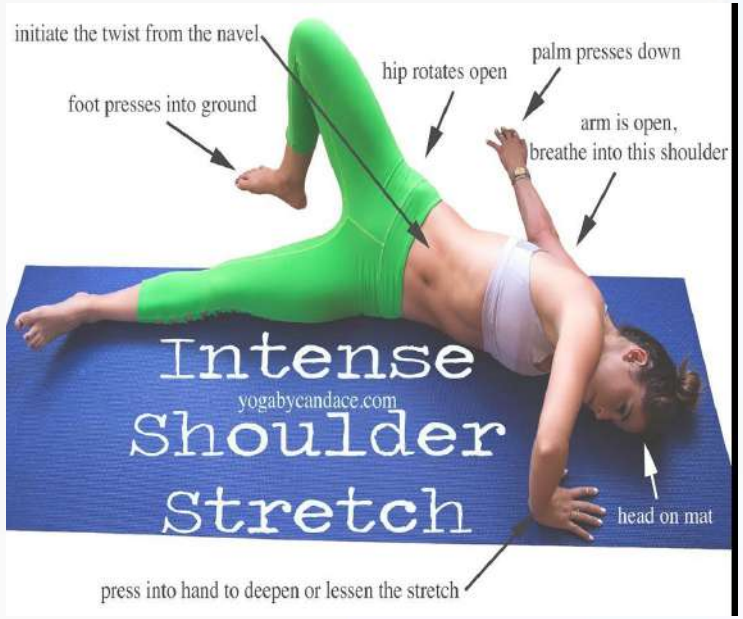
- 2.CROSS ARM STRETCH

- Patient standing with the shoulder flexed 90° and passive adduction applied by the nondominant arm to the dominant elbow.
- Posterior stretch primarily stretches the posteriormusculature to a greater degree than the posterior inferior capsule.

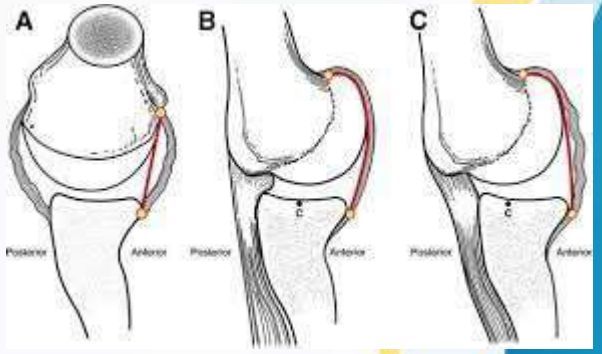
- 3. DOOR WAY STRETCH
- Shoulder is abducted 90° and the elbow flexed 90° with the elbow on the edge of an open doorway. The patient leans forward and inferior to apply an inferior capsular stretch to the shoulder,



- 4. ROLL OVER STRETCH
- Same as the sleeper stretch except that the shoulder is only flexed 50° to 60°
- patient rolls forward 30° to 40° from vertical side lying.



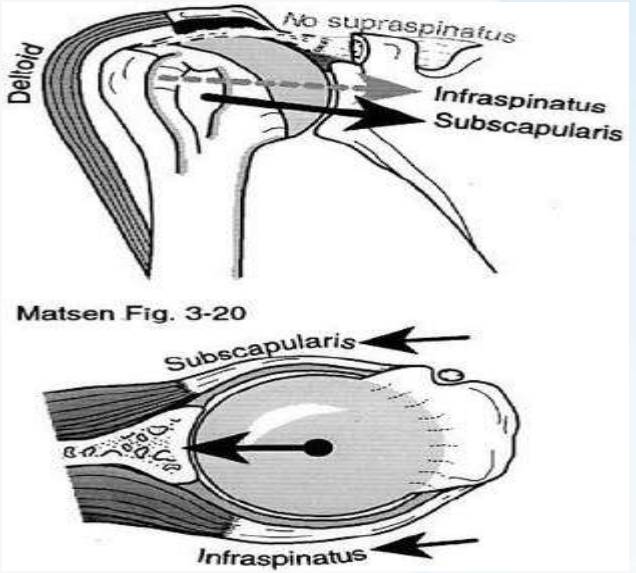
CONCAVITY COMPRESSION
CAM EFFECT
PEEL BACK MECHANISM
SLAP TEAR

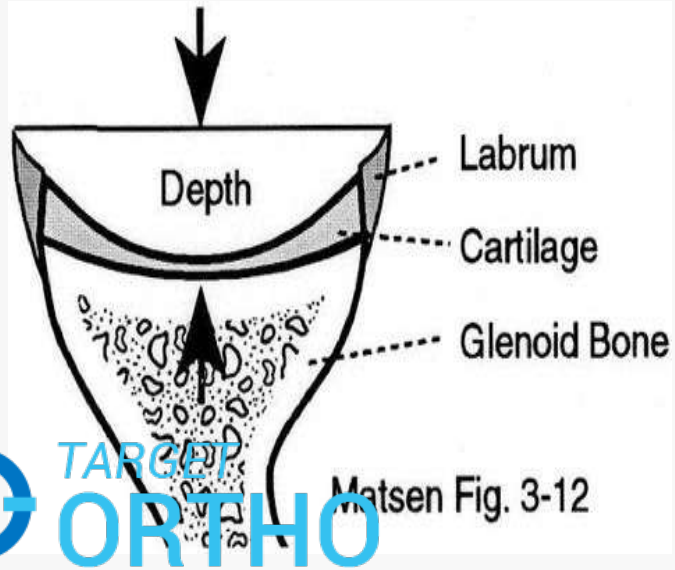


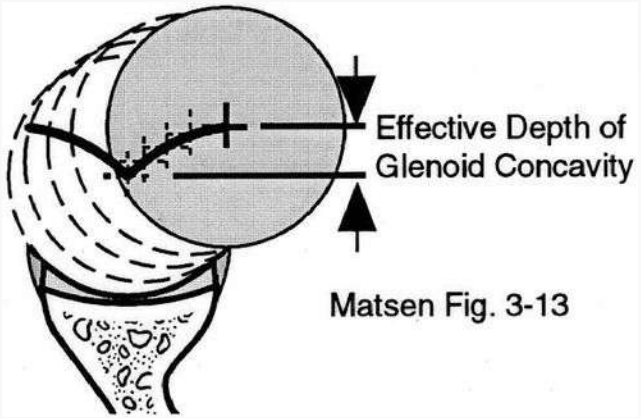
CONCAVITY COMPRESSION

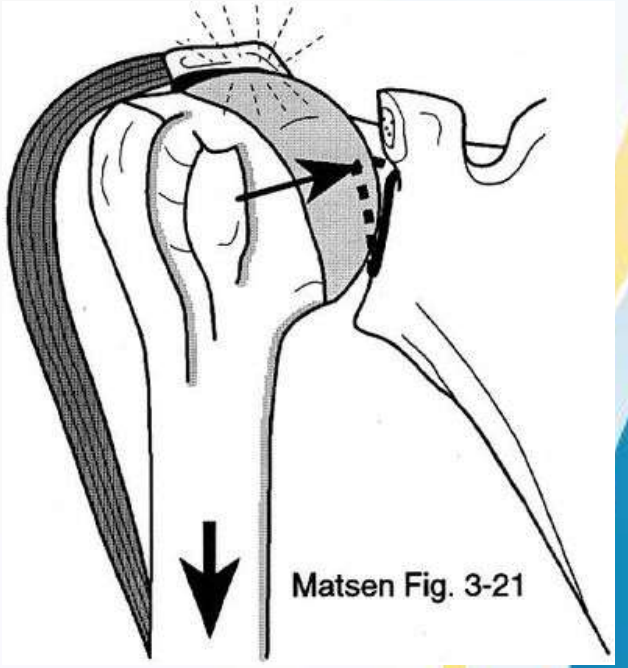
- Concavity compression is a stabilizing mechanism in which compression of the convex humeral head into the concave glenoid fossa stabilizes it against translating forces & to resist the upward pull of the deltoid

- The stability is related to the depth of the concavity and the magnitude of the compressive force.



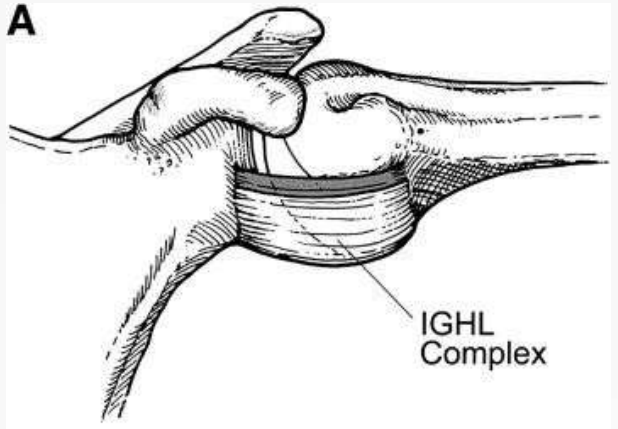


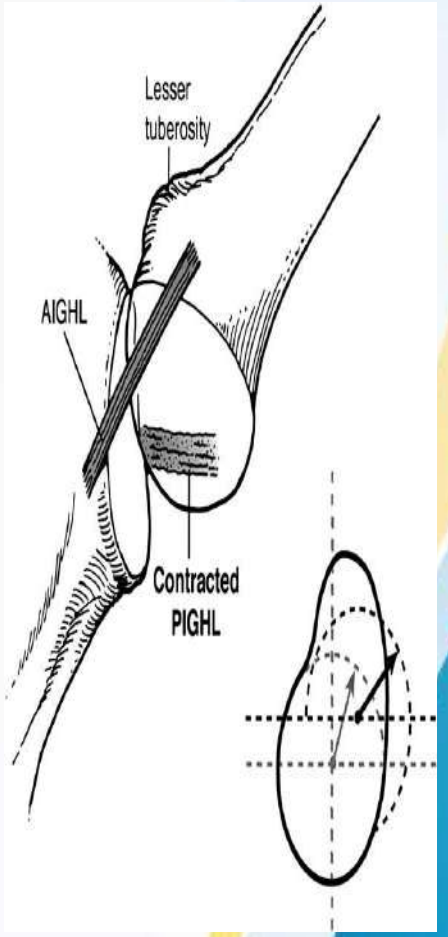




TETHERED SHOULDER--CAM EFFECT

- Dynamic IGHL complex, bounded by an anterior band and posterior band, performing like a hammock to support the humeral head when the arm is in abduction.
- Full abduction and external rotation (the cocked position), the posterior band of the IGHL is below the humeral head.
- If the posterior band is contracted, it will exert a posterosuperior force on the humeral head





Cam effect of the humerus on the anteroinferior capsule

During combined abduction and external rotation

the posterior cable is shortened, simulating a contracted posterior band, it acts as a tether, shifting the **glenohumeral contact point posterosuperiorly**

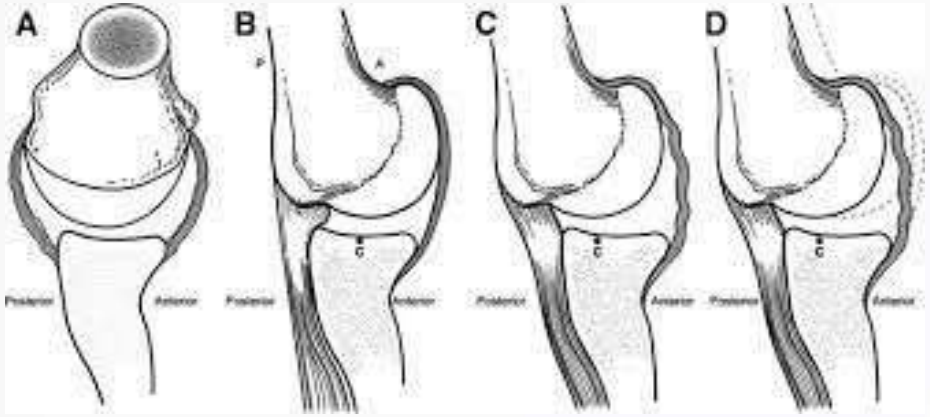
shortened posterior cable reaches its maximum elongation with glenohumeral external rotation before the anterior cable maximally elongates

anterior band is still permitting external rotation anteriorly

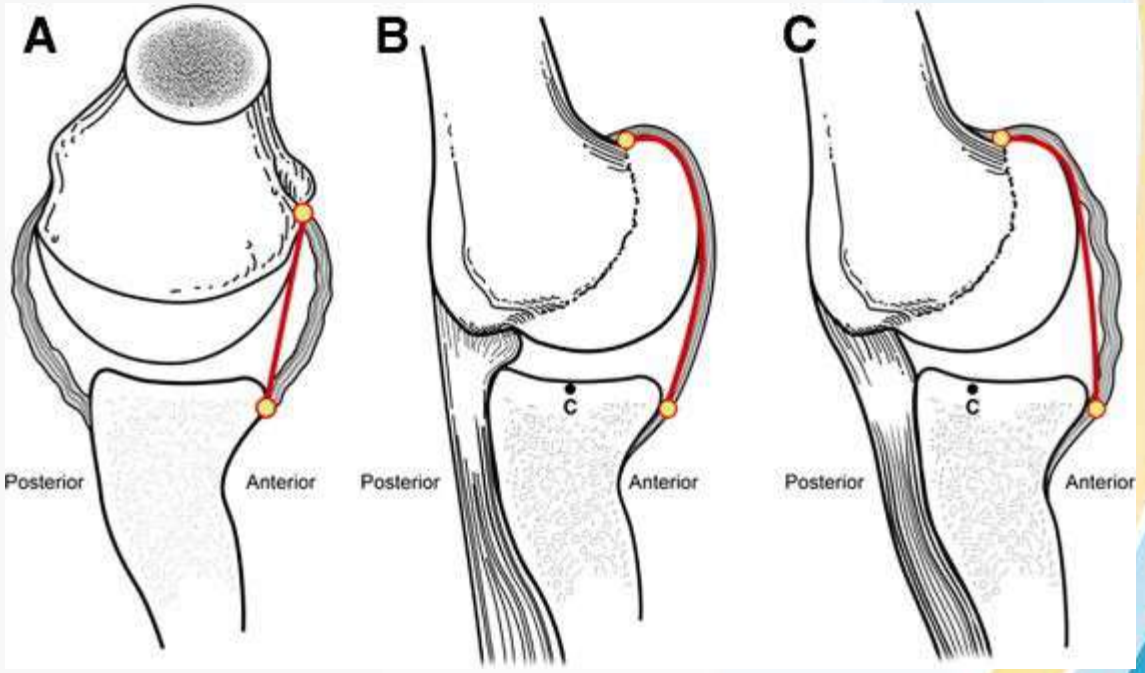
posterior band is tethering the shoulder from beneath the humeral head, exerting a posterosuperior force on the humerus

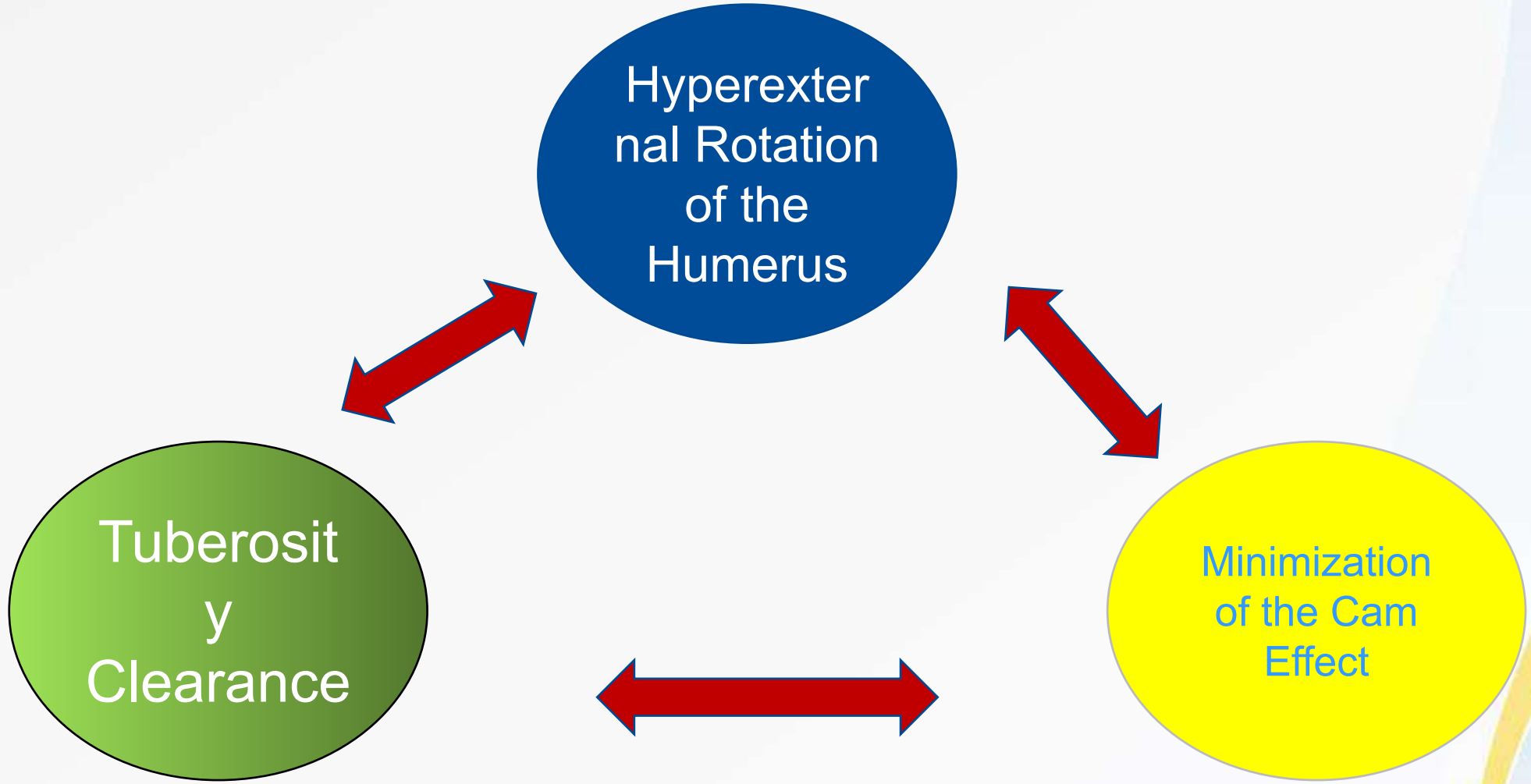
greater tuberosity also shifted posterosuperiorly, & no longer abuts against the the posterosuperior glenoid in combined abduction and external rotation, and additional external rotation can be obtained.

anteroinferior capsule is no longer tightly draped across thecalcar after the shift occurs



- 1. The tethering effect of the shortened posterior capsule shifts the glenohumeral contact point posterosuperiorly, allowing the greater tuberosity to clear the glenoid rim through a greater arc of external rotation before internal impingement occurs.
- 2. The shift in the glenohumeral contact point minimizes the cam effect of the proximal humerus on the anteroinferior capsule to allow greater external rotation due to the redundancy in the capsule.





**Abduction and external rotation causes the anteroinferior capsule to drape tightly across the protuberant inferior articular surface of the humerus,which is quite prominent due to its location adjacent to
the arc of the humeral calcar.**

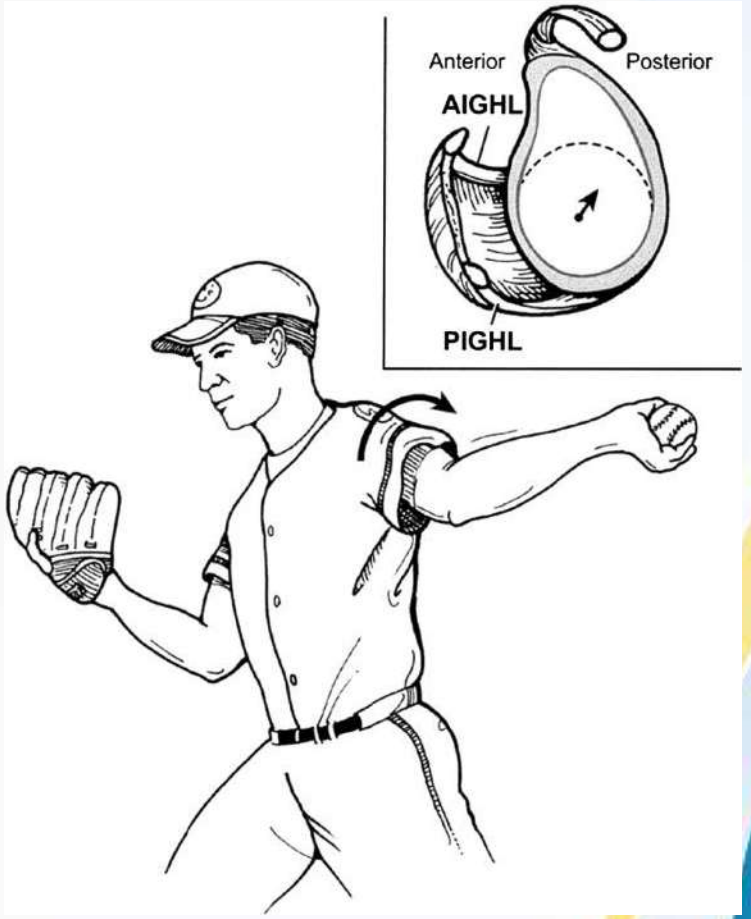
When the contact point is shifted posterosuperiorly in a thrower's shoulder, the cam effect of the humeral head is dramatically decreased.

The anteroinferior capsule is no longer tightly draped across a protruding humeral head

The loosened capsule is, in effect,functionally lengthened by virtue of the change in position of the contact point, allowing a greater degree of external rotation.

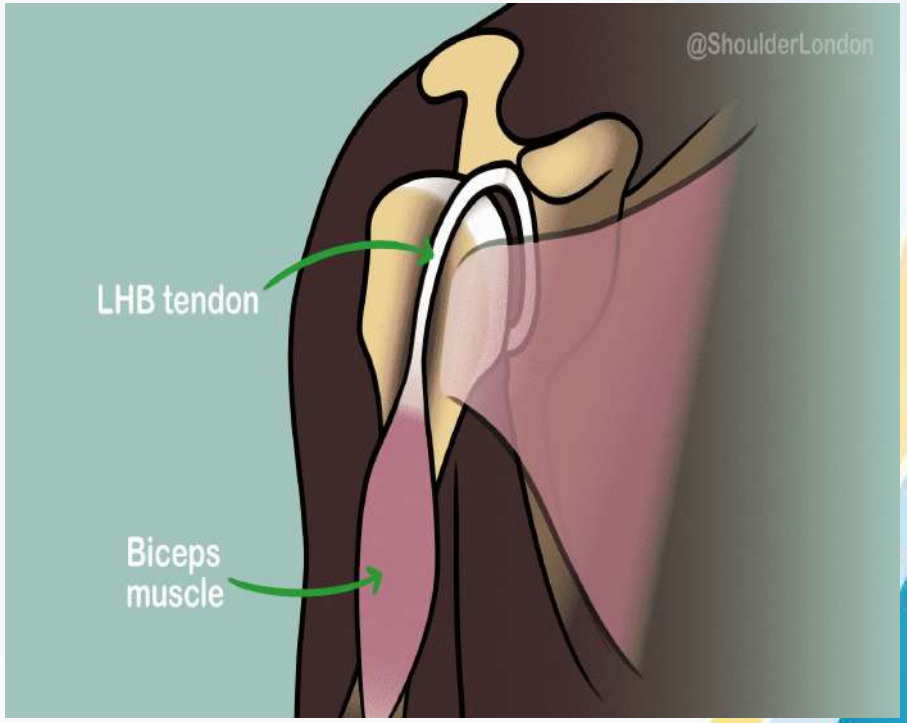
INTERNAL ROTATION VELOCITY

- Maximum internal rotation velocity in the elite pitcher is approximately 7,000° /second.
- The most effective way to maximize internal rotation velocity is to maximize the arc of rotation by means of hyperexternal rotation in late cocking.
- The longer the arc of rotation through which angular acceleration is achieved, the greater the velocity of the hand, and therefore the greater the velocity of the ball at ball release.
- A proprioceptive sense of reaching the set point of external rotation, a/k/a SLOT.



The long head of the biceps tendon- PEEL BACK

- 1. Active depressor [dec IGHL stress] and a static stabilizer of the glenohumeral joint.
- Loss of the biceps induces increased forces in glenohumeral ligaments and is associated with a superior shift in the glenohumeral articular contact point.
- In patients with rupture of the long head of biceps tendon,humeral head translates superiorly during abduction.



Can Biceps compensate for glenohumeral Joint instability??

With loading of the biceps, there is significantly decreased anterior-posterior translation, particularly with external rotation.

Stabilize the joint anteriorly when the arm was in internal rotation and served as a posterior stabilizer when the humerus was in external rotation

With loss of dynamic stabilizers, the biceps tendon takes on larger stresses, presenting as s hypertrophy in patients with chronic rotator cuff insufficiency.

Biceps tendon can often be found dislocated from the bicipital groove in association with subscapularis tendon tears.

Peel-Back Mechanism with HYPER ER

ABD+ER
[late cocking]
rotation produces a torsional force to the base of the biceps anchor.

Biceps tendon & its vector shifts to a more posterior position

posterior shift in vector

a twist at the base of the biceps

dynamic vertical pesterior angle

LABRUM TO ROTATE MEDIALLY OVER GLENOID ONTO POST-SUP SCAPULAR NECK

TRANSMIT TORSIONAL FORCE TO POSTERIOR LABRUM

BICEPS ROOT WILL SHIFT MEDIAL TO SUPRA GLENOID TUBERCLE

- Peel-back phenomenon is a consistent finding in patients with posterior SLAP lesions or combined anteroposterior SLAP lesions.
- It is absent in normal shoulders and in some anterior SLAP lesions that do not have extension into the posterosuperior quadrant.