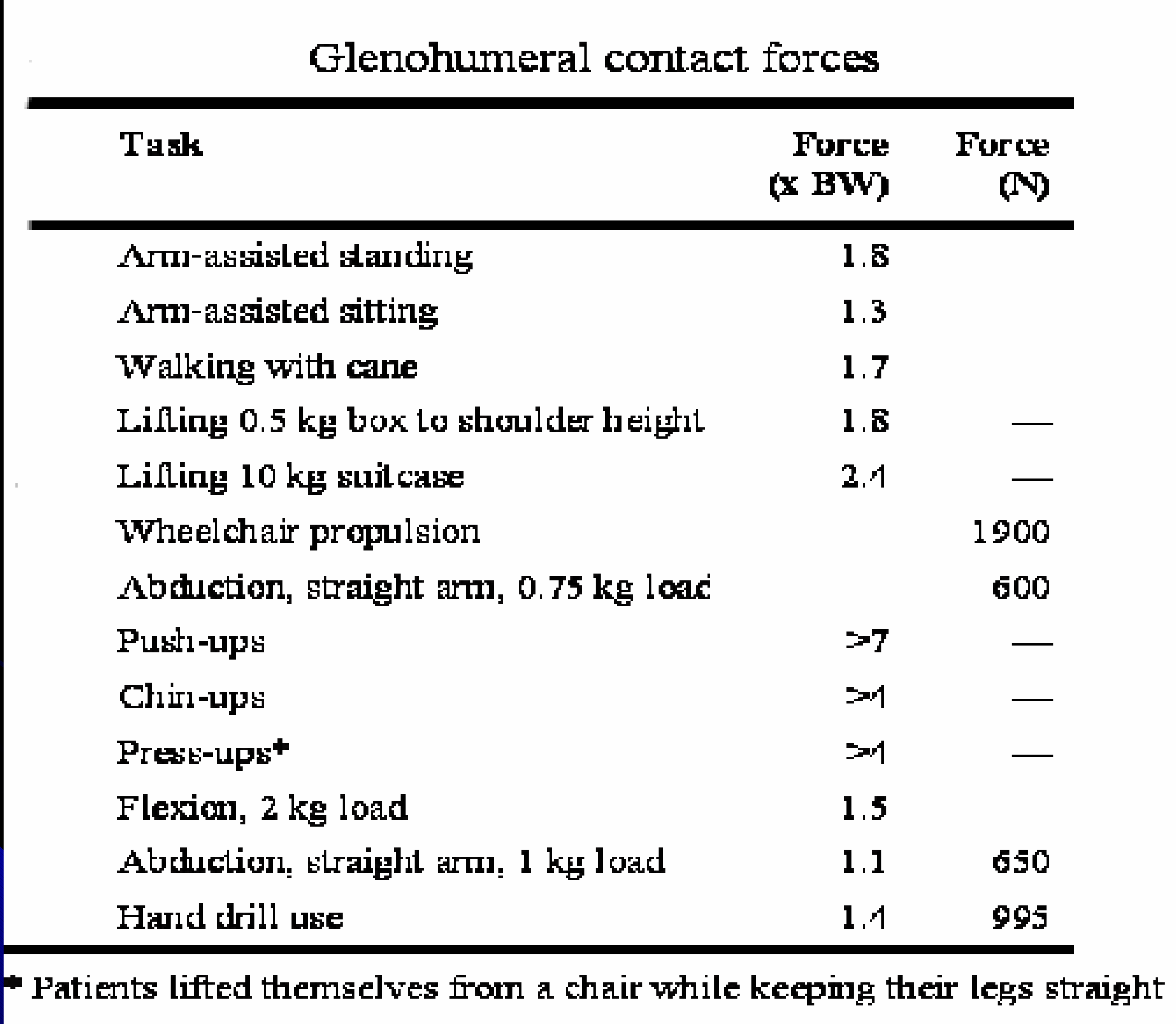
Εμβιομηχανική Ανάλυση των Παραγόντων που Καθορίζουν τη Σταθερότητα της Γληνοβραχιόνιας Άρθρωσης

Χρήστος Γιαννακόπουλος
Ορθοπαιδικός Χειρουργός
ΙΑΣΩ General, Αθήνα

Joint Forces



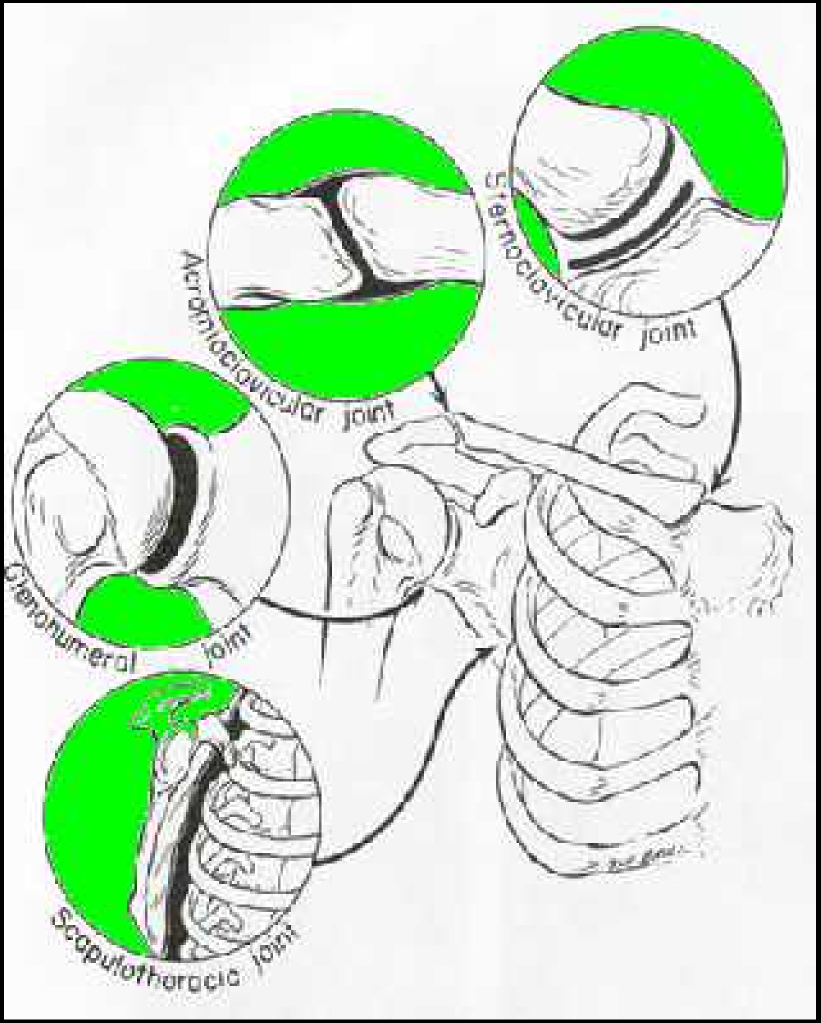
Glenohumeral contact forces

Task	Force (x BW)	Force (N)
Arm-assisted standing	1.8	
Arm-assisted sitting	1.3	
Walking with cane	1.7	
Lifting 0.5 kg box to shoulder height	1.8	—
Lifting 10 kg suitcase	2.4	—
Wheelchair propulsion		1900
Abduction, straight arm, 0.75 kg load		600
Push-ups	>7	—
Chin-ups	>4	—
Press-ups*	>4	—
Flexion, 2 kg load	1.5	
Abduction, straight arm, 1 kg load	1.1	650
Hand drill use	1.4	995

* Patients lifted themselves from a chair while keeping their legs straight

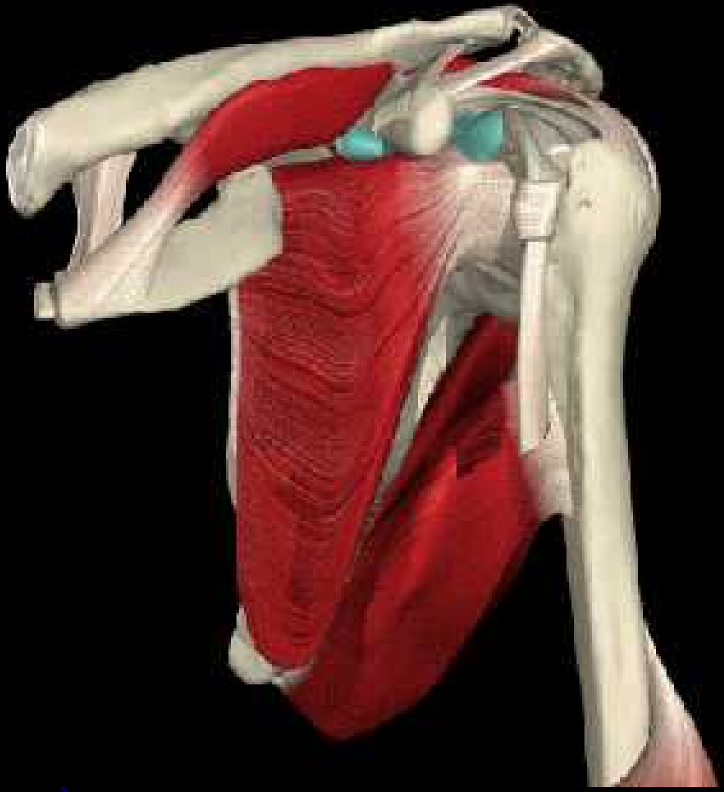
The Shoulder Joint Complex

- Glenohumeral
- Scapulothoracic
- Acromioclavicular
- Sternoclavicular



Muscles of the Shoulder Girdle

17 muscles attach to or originate from the scapula to provide stability and movement



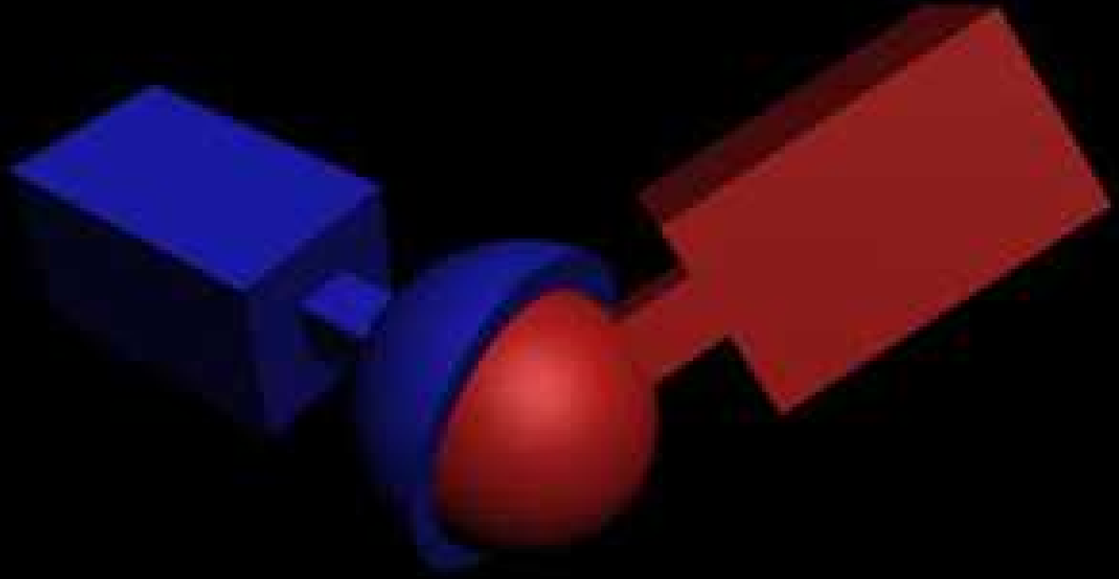
GH Joint Stability

Active stabilizers

Muscles

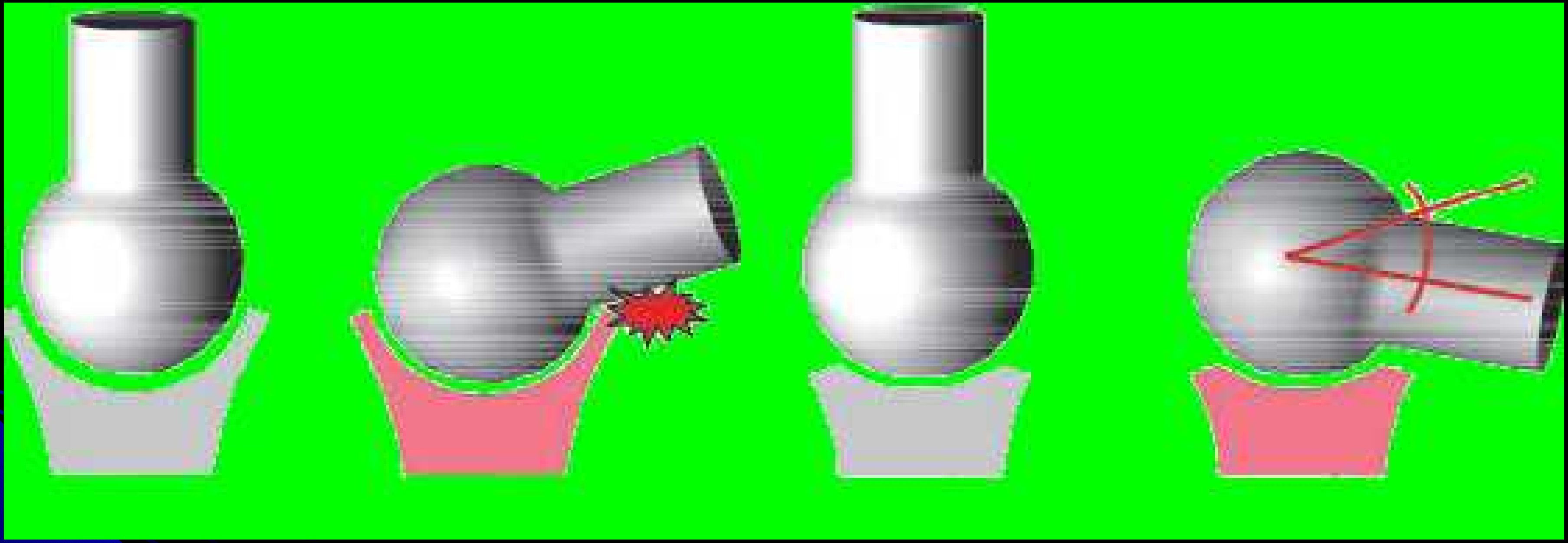
Static stabilizers

Bone geometry
Ligaments
Negative intraarticular pressure
Adhesion/Cohesion effect



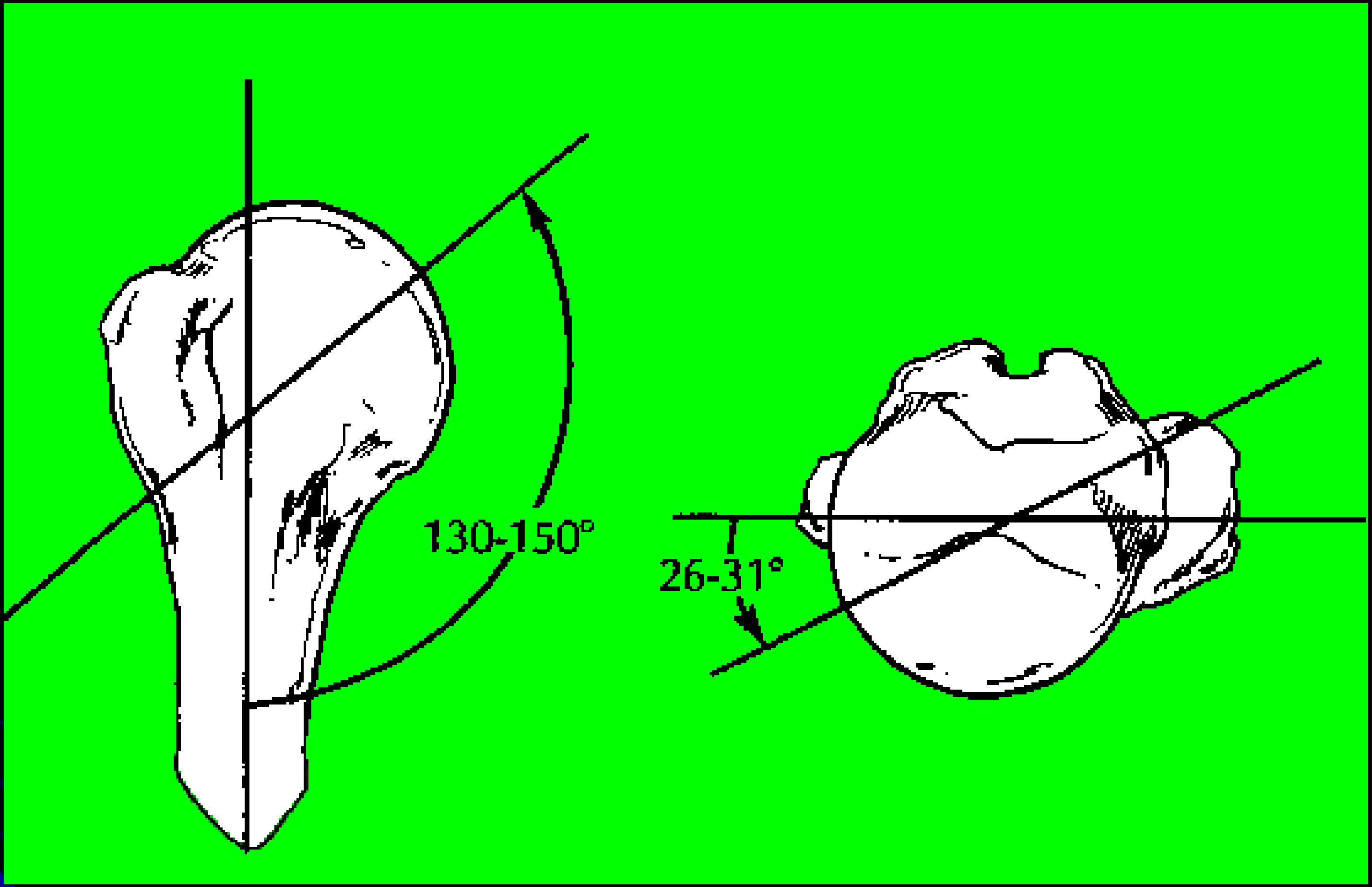
Ball - Socket joint
The glenoid socket contains only one-third of the humeral head

Correlation of Form and Function



Glenohumeral Joint

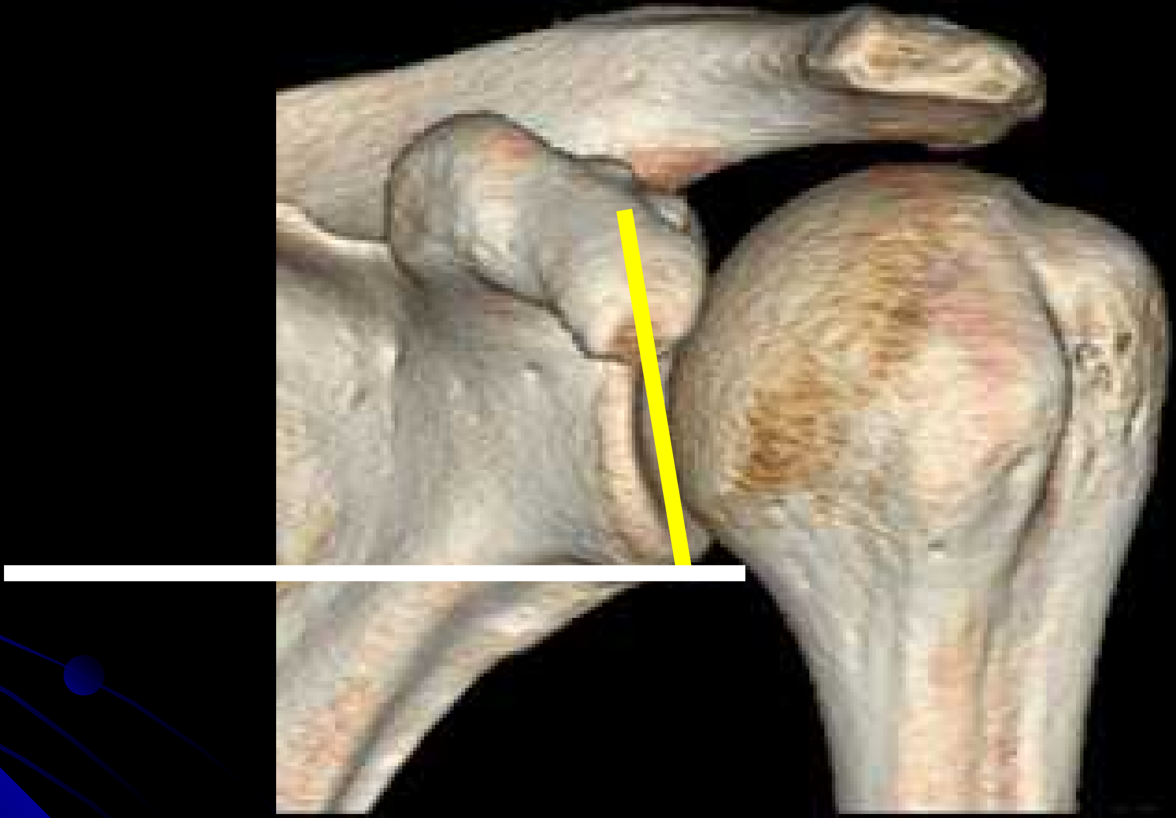
Humeral Head



30 degrees retroverted and 45 degrees medially inclined compared to long axis of the humerus.

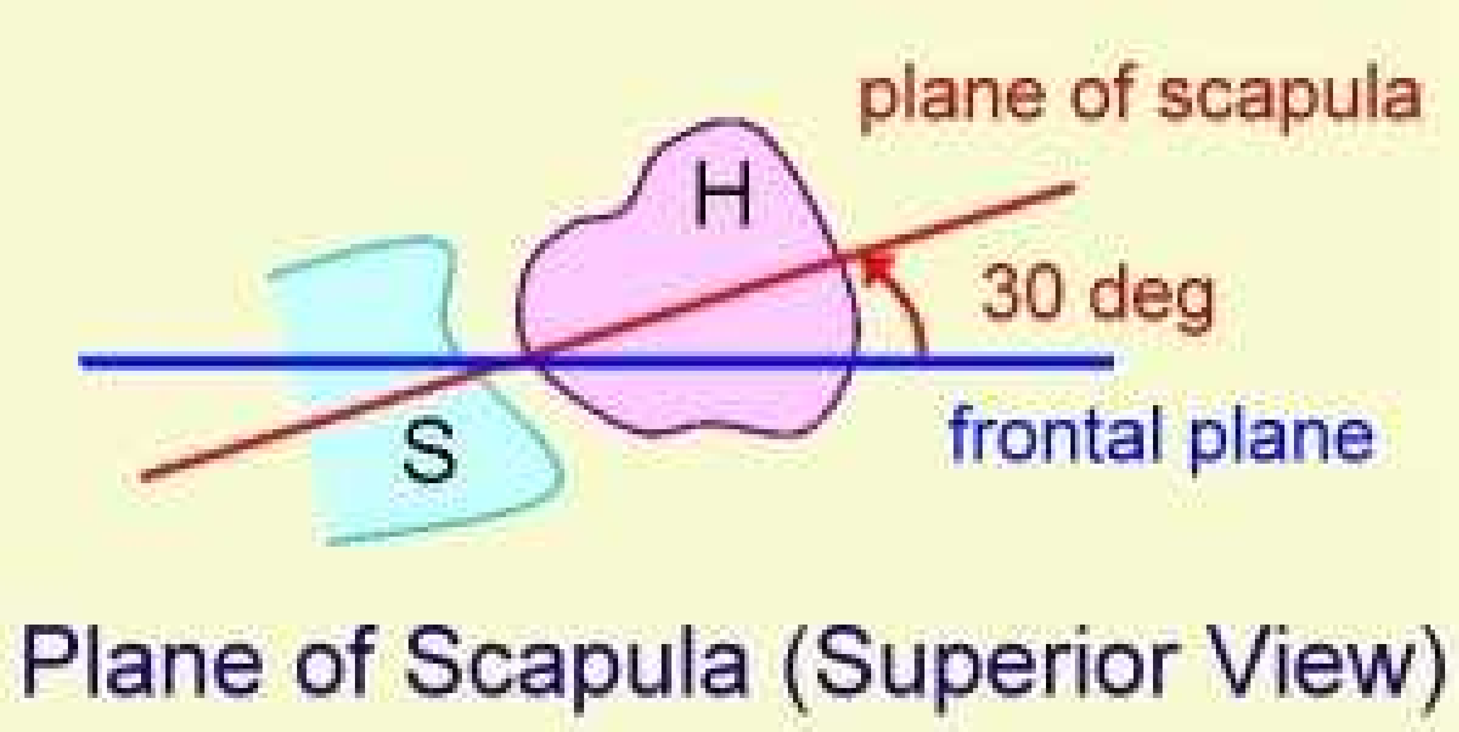
The upper limb is well forward and away from body plane.

Scapula

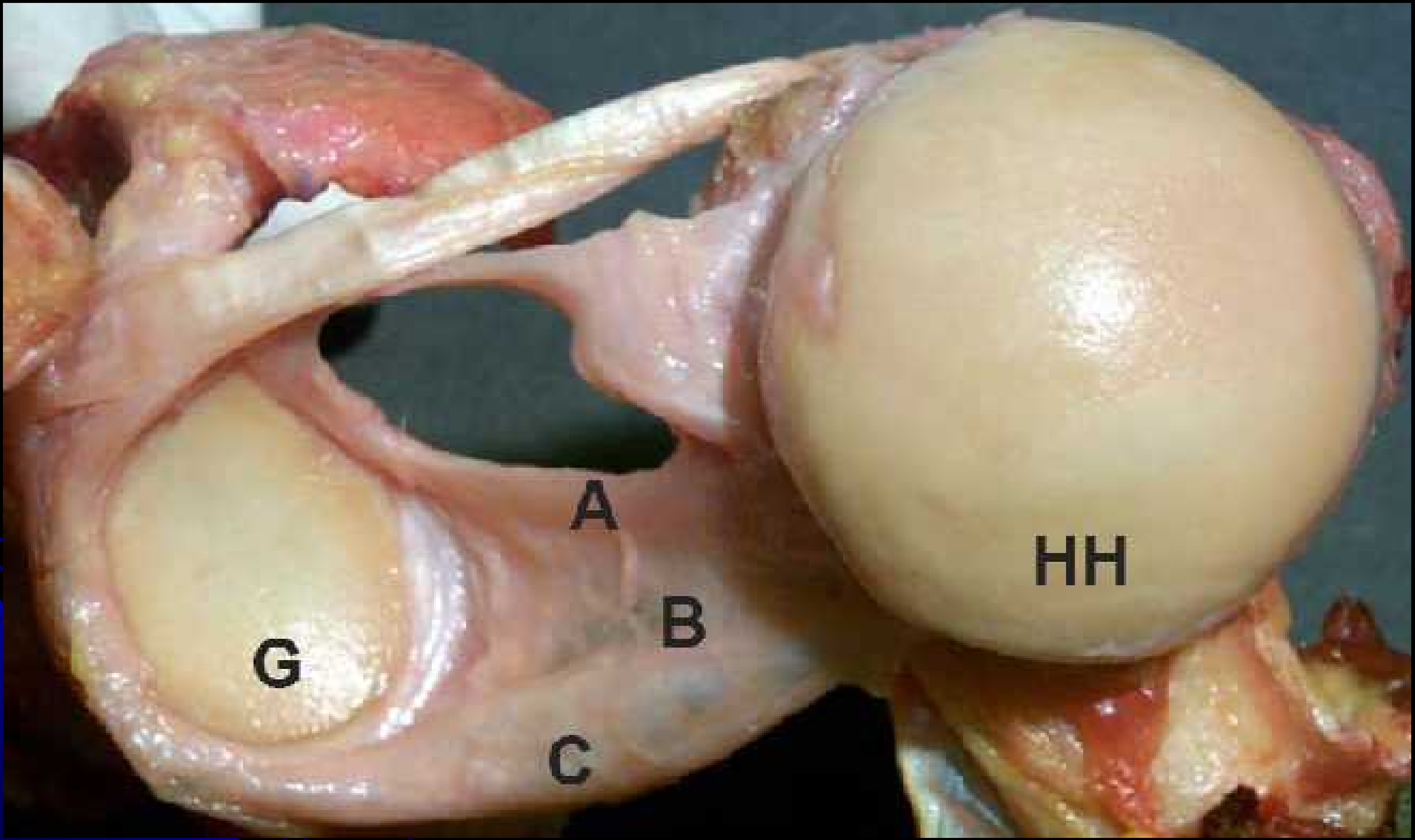


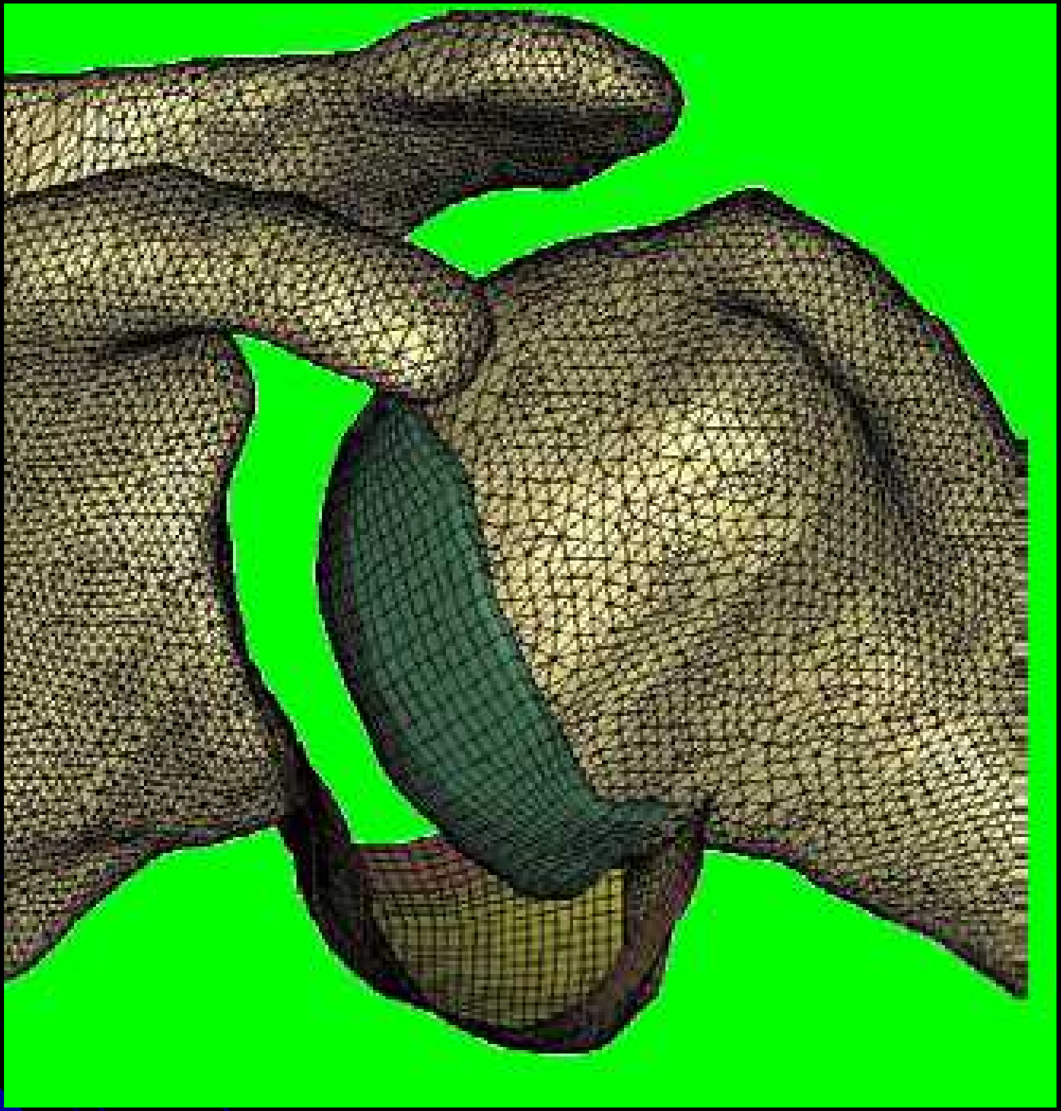
5º of superior inclination (upward tilt) of the glenoid cavity

Scapula



Version of the glenoid is more variable and ranges from an average of 5 to 7 degrees of retroversion


A
B
C
G
HH

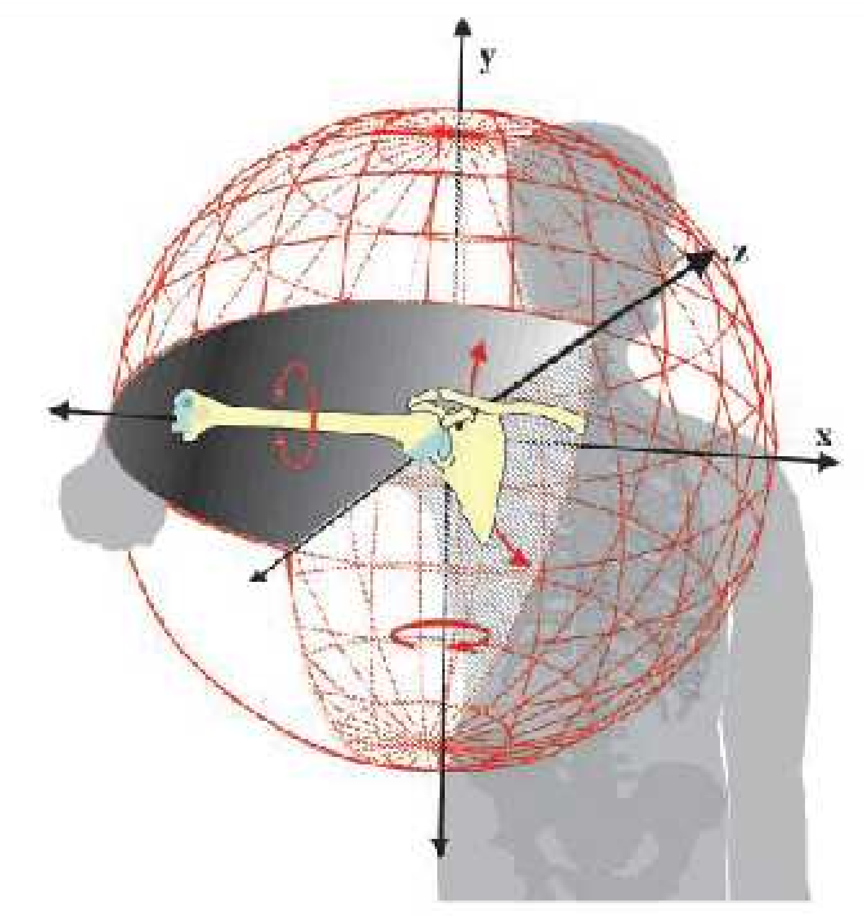


Functions of the Shoulder Complex

- To link the upper extremity to the trunk
- dependent arm position
- control of rotator cuff muscles
- To provide extensive mobility of the arm in space
- To provide stability for elbow and hand skillful or forceful movements

GH Joint Movements

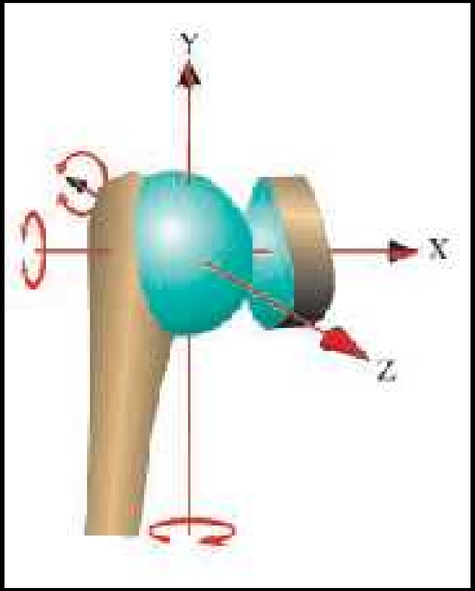
- Flexion
- Extension
- Abduction
- Adduction
- External rotation
- Internal rotation
- Horizontal abduction
- Horizontal adduction
- Circumduction

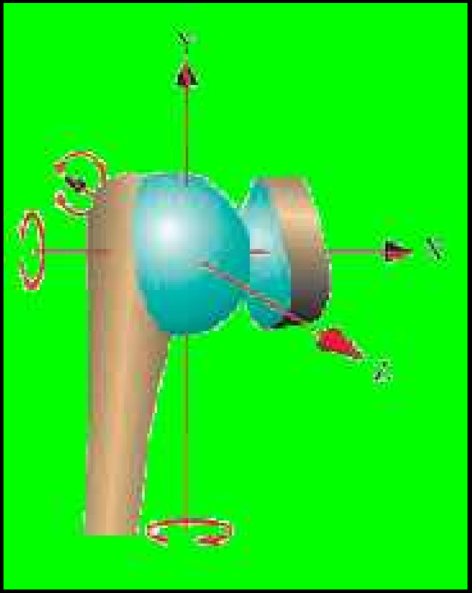


Center of rotation.

The center of rotation of the humeral head in abduction,
during the external rotation.
The curved yellow arrow represents the path and direction of the greater tuberosity
as the arm externally rotates.

Glenohumeral Joint





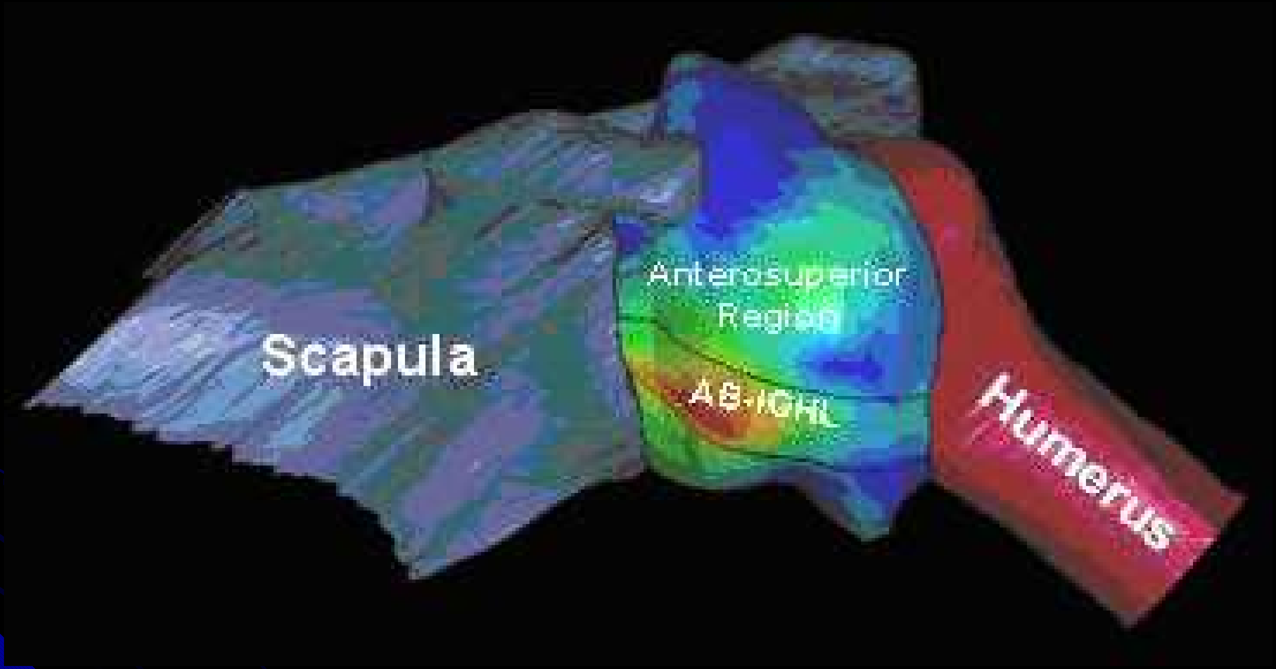
Greatest ROM of any joint but very limited inherent stability.

Relies on various ligaments and RC tendons for support.

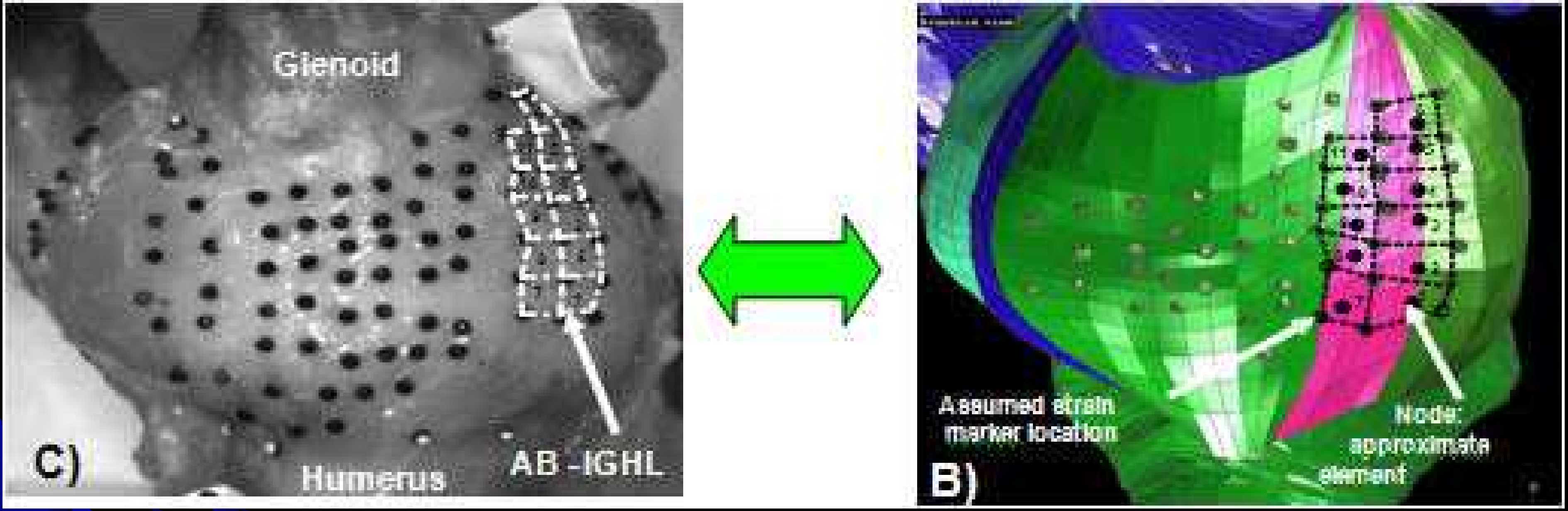
Glenohumeral Joint Capsule and Ligaments

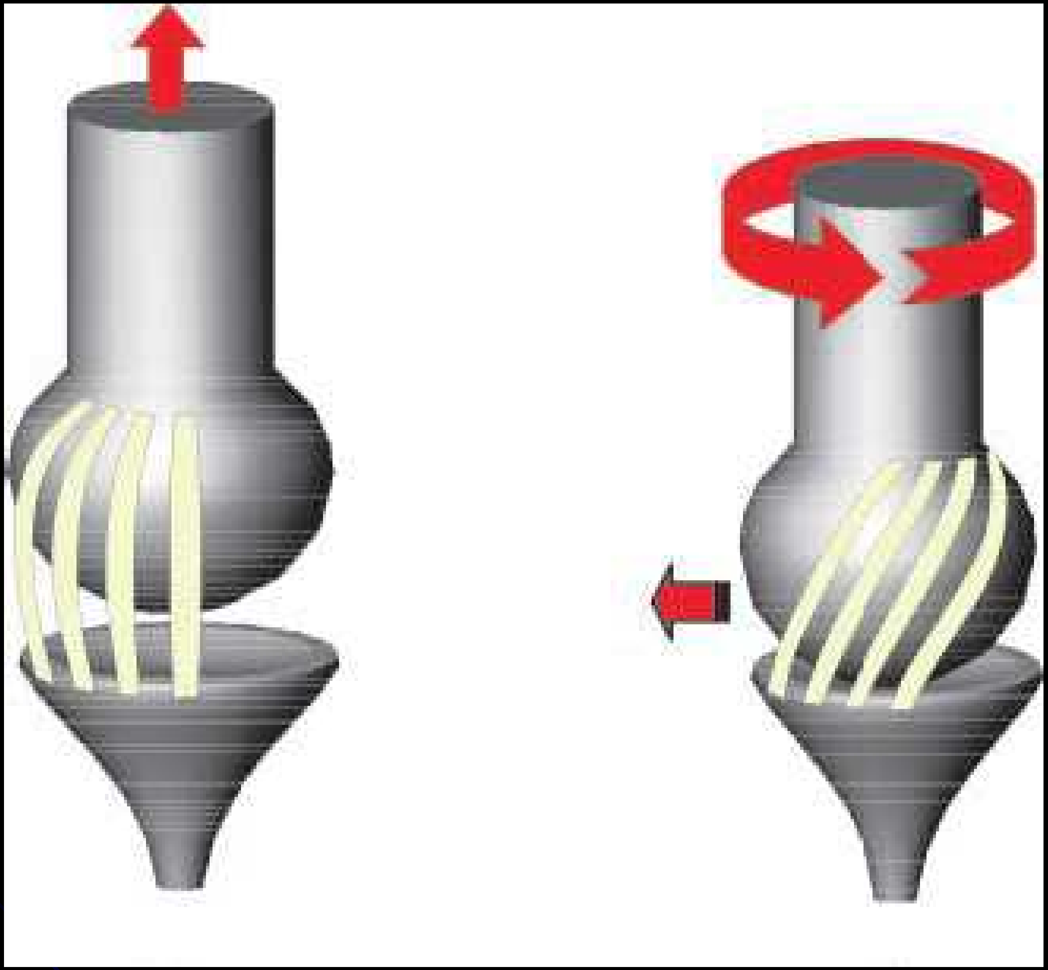
condensations of the joint capsule

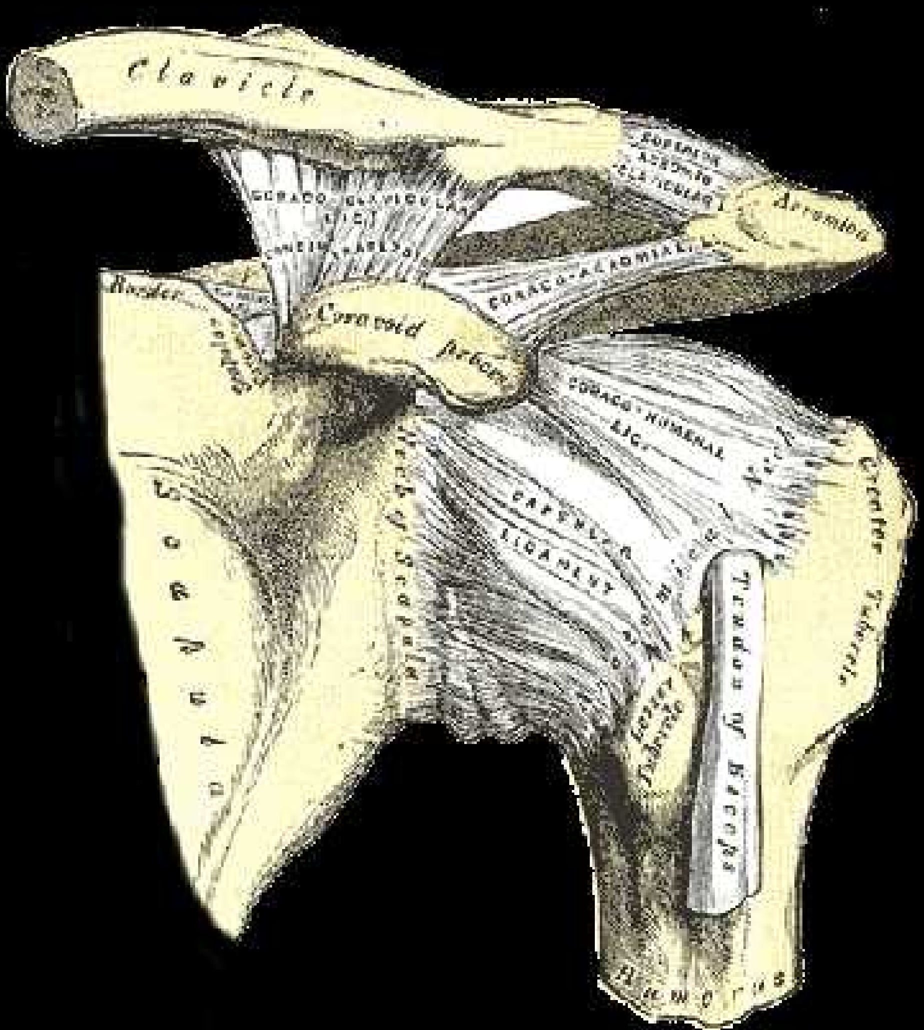
The Shoulder Capsule

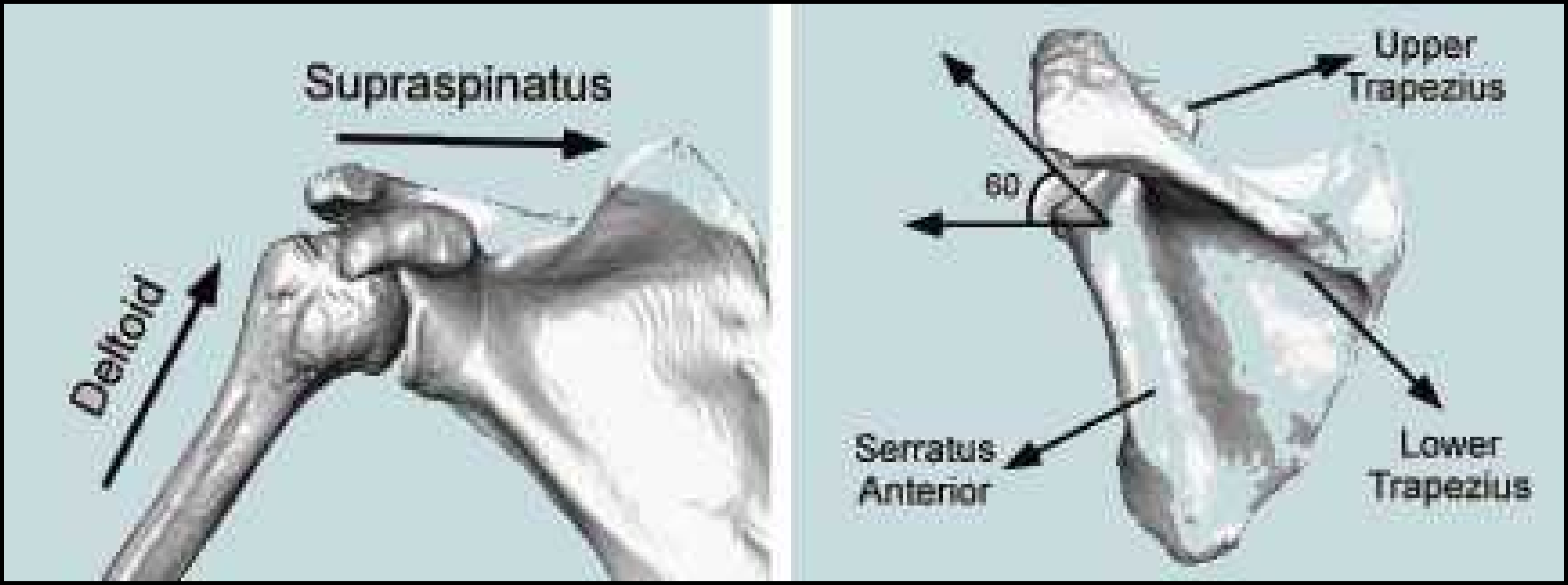


Inferior GHL is the primary anterior stabiliser of the abducted shoulder.

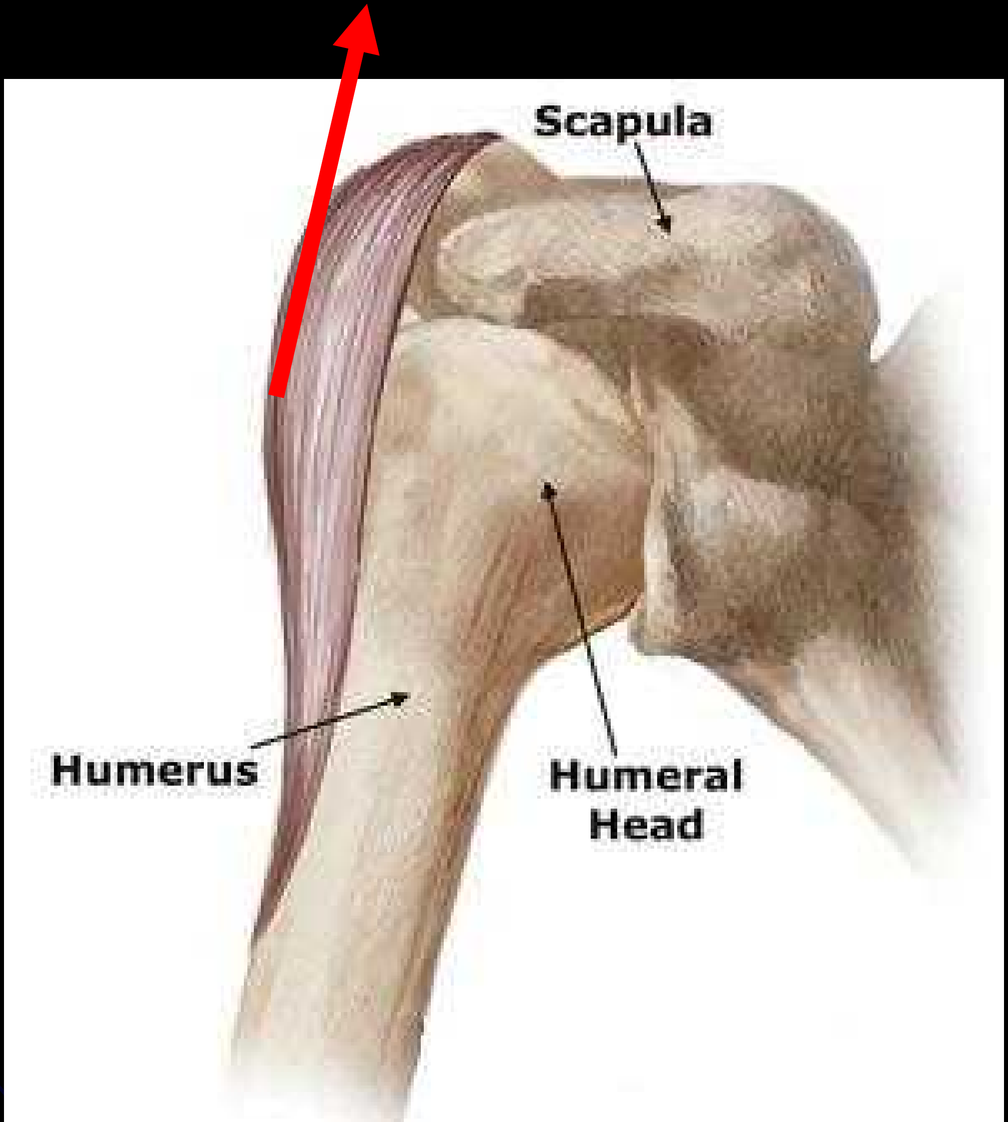

Glenoid
Humerus
AB -IGHL
C)
Assumed strain marker location
Node: approximate element
B)




Clavicle
SUPERIOR ACROMIO CLAVICULAR
Acromion
CORACO-CLAVICULAR LIG.
CONOID TRAPEZOID
CORACO-ACROMIAL
Border
Coracoid process
CORACO-HUMERAL LIG.
Greater Tubercle
Neck of Scapula
Scapula
CAPSULAR LIGAMENT
Lesser Tubercle
Tendon of Biceps
Humerus



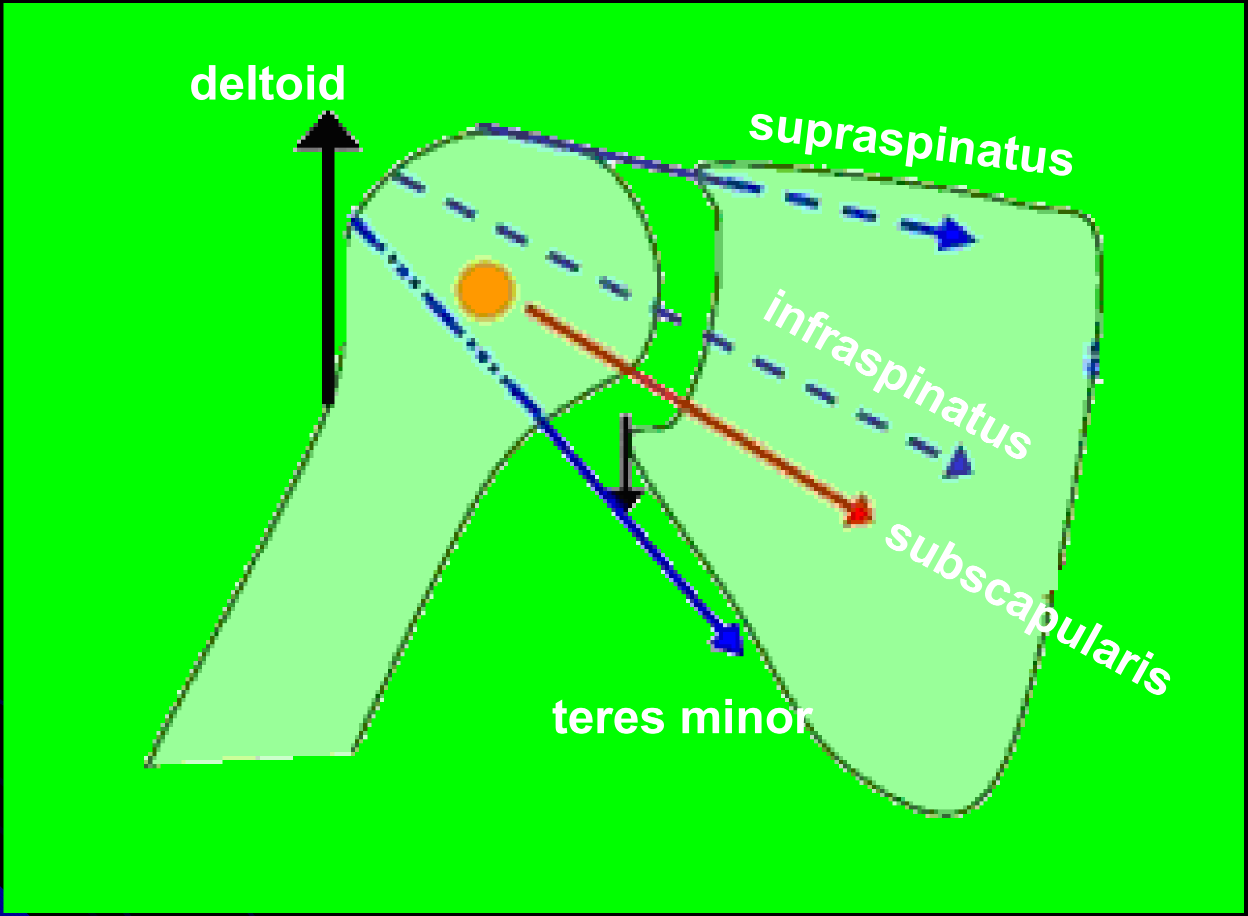
During arm abduction the supraspinatus and deltoid work together and create a force couple that promotes stability (concavity-compression) via compression of the humeral head on the glenoid (supraspinatus contraction) while raising the arm (deltoid contraction). (B) During latter phases of arm elevation several muscles create a scapular force couple that rotates the scapula nearly 60 degrees upward.



Isolated deltoid pull would have pulled the humerus against the acromion.
This is prevented by TM and IS contraction.
They do not prevent abduction as they act along the axis of abduction.

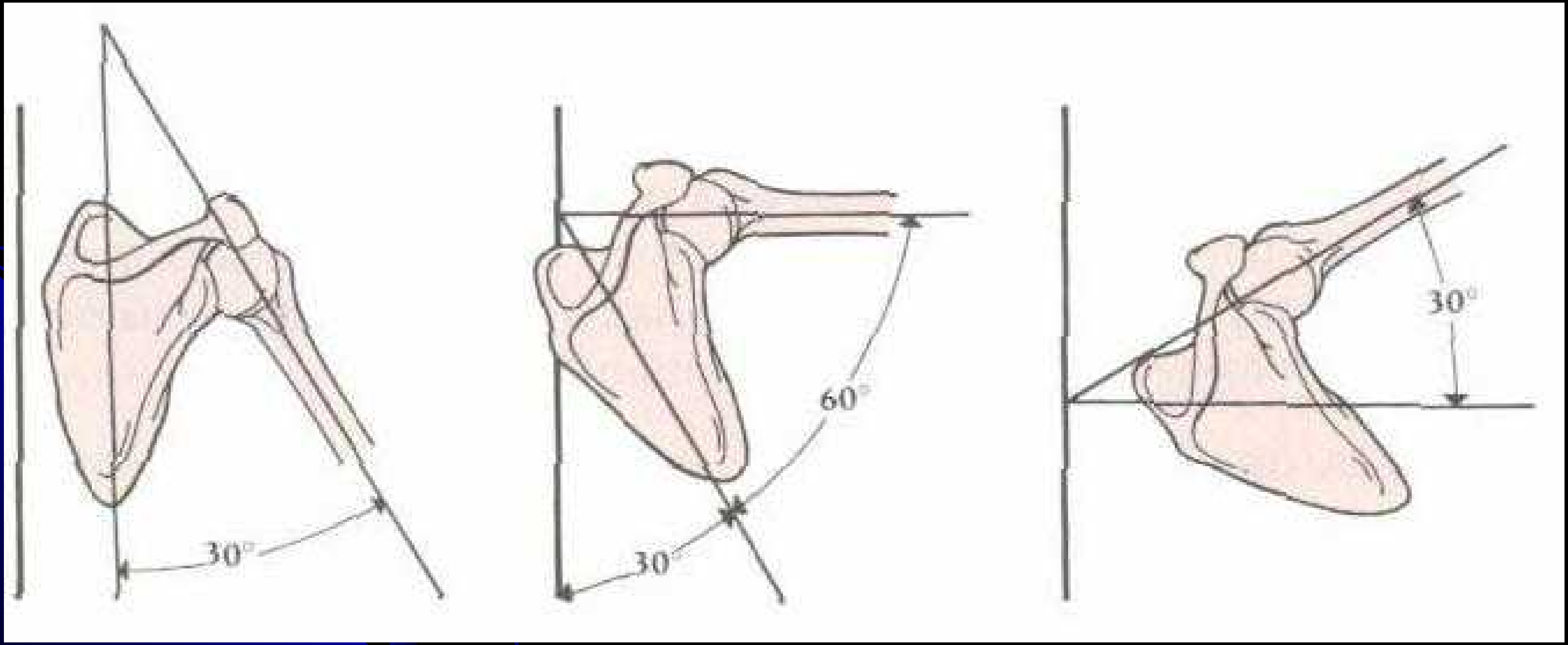
- With the arm overhead, deltoid subluxes humeral head inferiorly.
- The RC prevents this subluxation by pressing the humeral head into the glenoid.

Dynamic Shoulder Stability

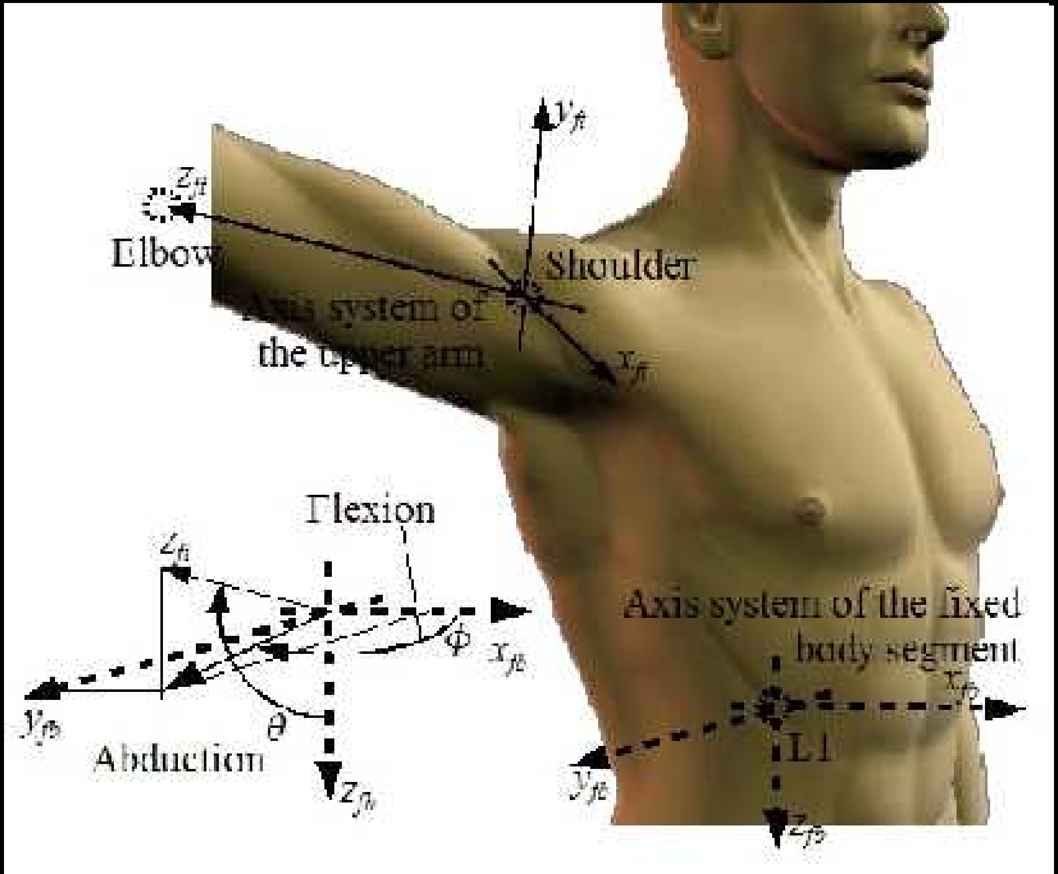


Scapulothoracic Rhythm

2:1 (humerus:scapula)

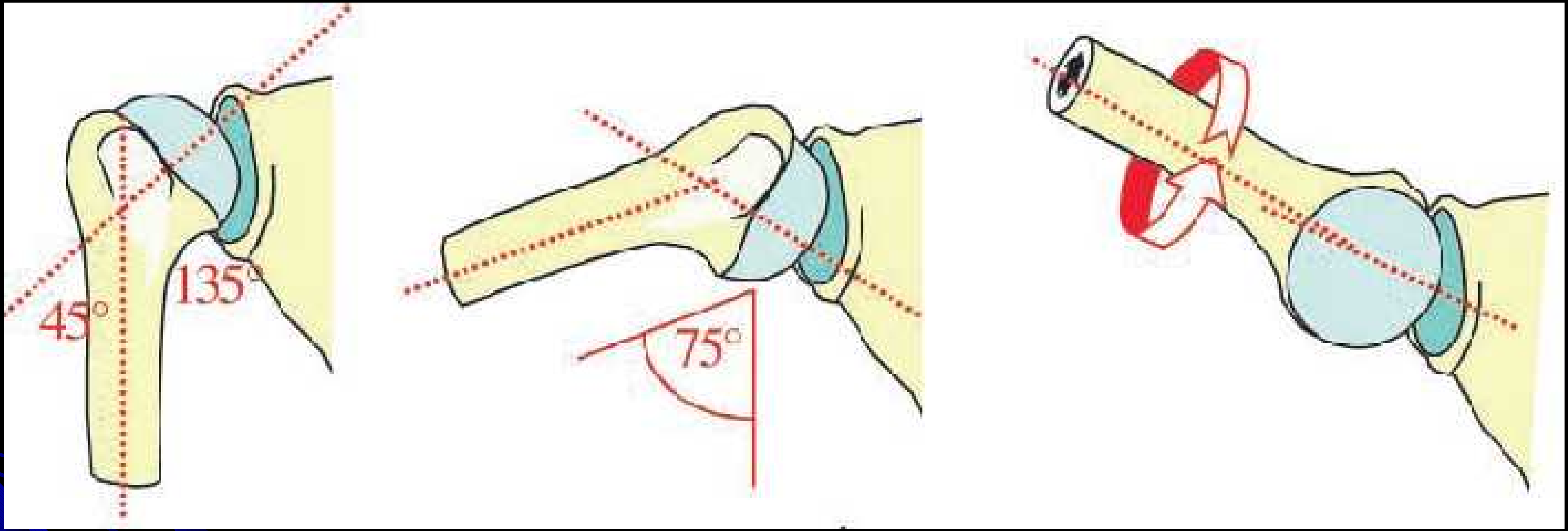


Example: Abduction

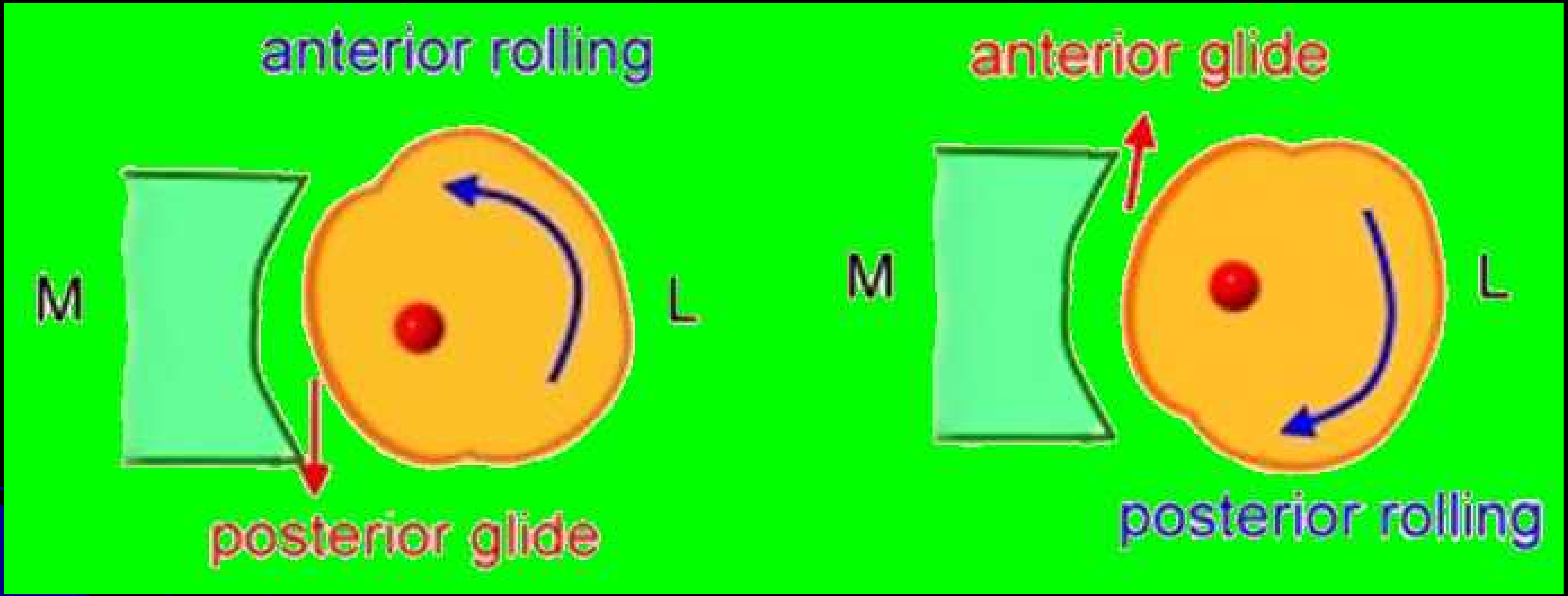


lateral rotation of scapula (Trapezius, Serratus anterior)
Shoulder abduction is a function of supraspinatus and deltoid.
Synergistic contraction of teres minor and infraspinatus.

External Rotation in Abduction



The greater tubercle will impinge on the coracoacromial ligament or the acromion process unless the humerus externally rotates.



Movement in the joint is mainly rotational, with little translation.

Movement at the shoulder is not isolated but accompanied by movements at the scapulo-thoracic joints and the spine.

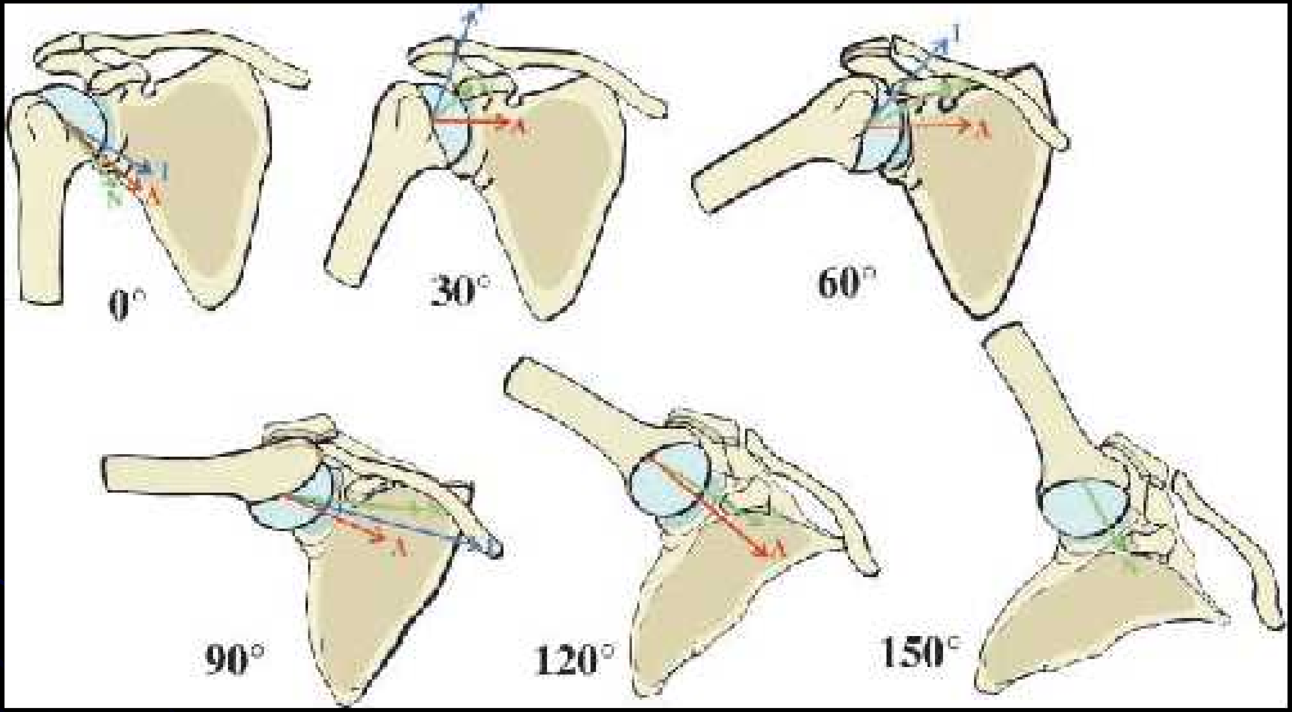
Composite Motion

The ratio GH : ST motion is termed scapulohumeral rhythm
For each 15 deg of abduction
10 deg G/H motion
5 deg S/T motion

- The clavicle elevates 4 deg at the S/C joint for each 10 deg of abduction
- 20 deg of motion occurs at the A/C joint

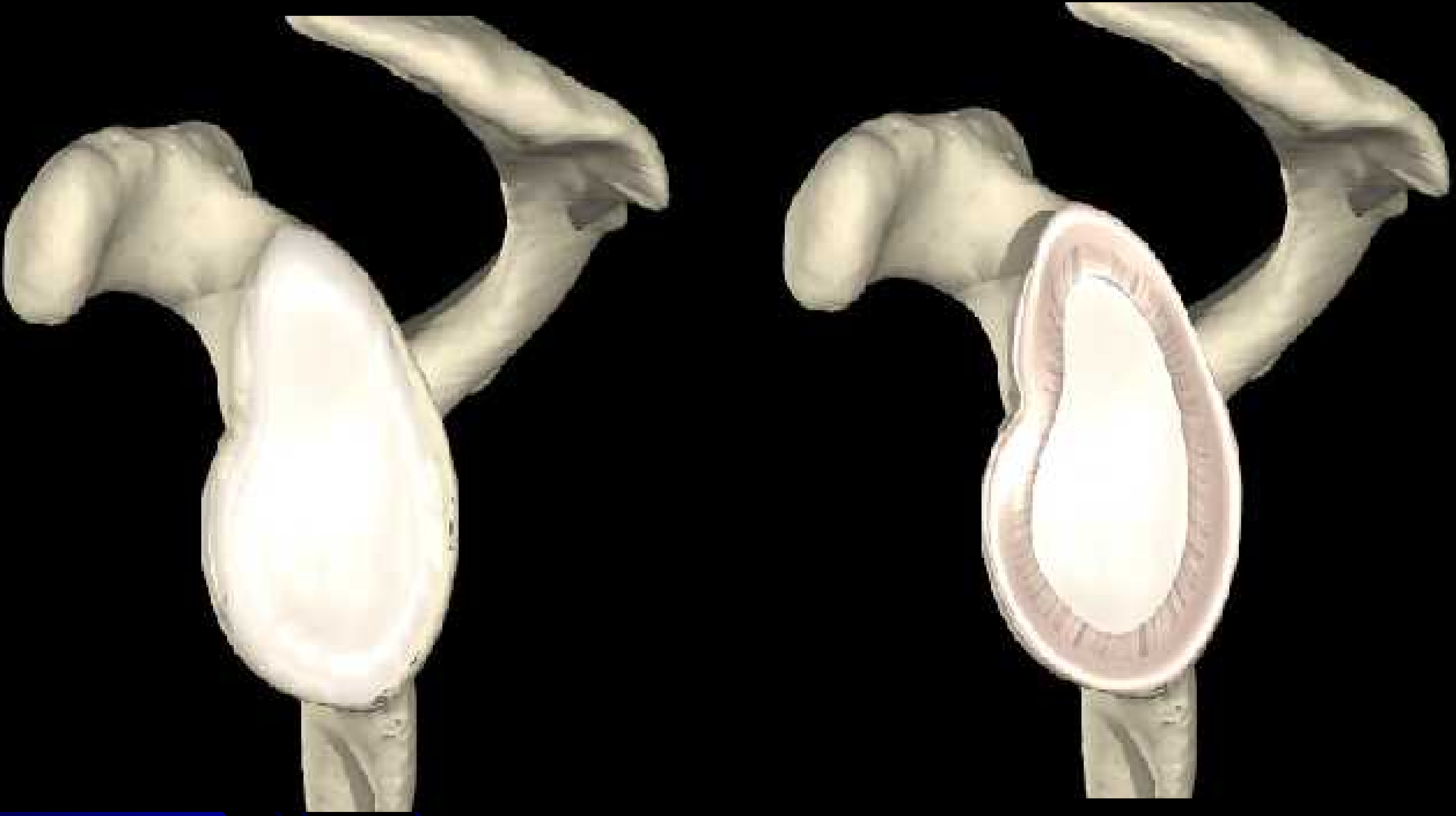
Biceps Tendon

Designed for rapid activity.



Force vectors in different degrees of abduction

Glenoid labrum



increases the depth of glenoid by 50%

Function of Ligaments

Limitation of movement extent (check rein-effect)

Break against supranormal translocation (barrier effect)

Glenohumeral ligaments are important at extremes of motion

The normal shoulder precisely constrains the humeral head to within 1 to 2 mm of the center of the glenoid cavity throughout most of the arc of motion.

Factors limiting shoulder internal rotation

Posterior capsule

Factors limiting shoulder external rotation

Coracohumeral ligament
3 Glenohumeral ligaments

Shoulder Stabilizing Mechanisms

Static stabilizers

Articular cartilage
Concavity of the glenoid fossa
Glenoid fossa retroversion and superior angulation
Glenoid labrum (50%)
Joint capsule
Glenohumeral ligaments

Dynamic Stabilizers

Rotator cuff and deltoid muscle compress the joint at rest and function.
vacuum effect from negative intra-articular pressure

Concavity of the glenoid fossa

Articular cartilage

Thin in the central bare area (1.2 mm av.) and thick around the periphery (3.8 mm av.).

the glenoid articular cartilage is thicker at the periphery, thus creating significant articular surface conformity

Adhesion and Cohesion

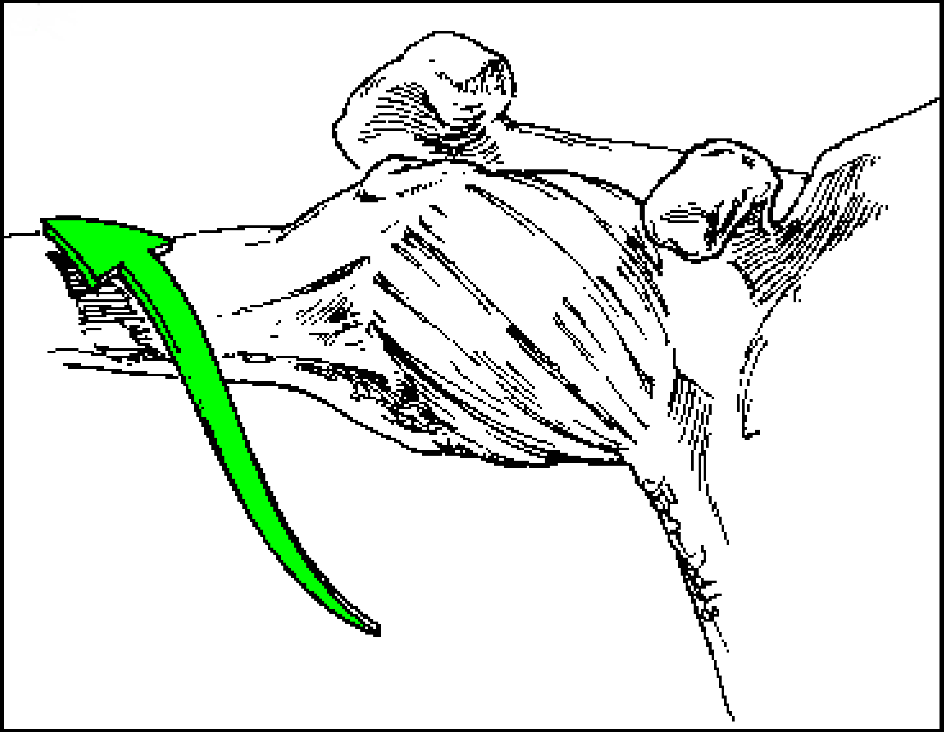
The normal glenohumeral joint is fully sealed by the capsule
normally contains less than 1 mL of joint fluid under slightly negative intra-articular pressure.
The result is a suction effect to resist humeral head translation.
Minor contribution at low loads.

Glenoid Labrum

Enhances stability by deepening the concavity of the glenoid socket.
9 mm and 5 mm in the superoinferior and anteroposterior planes.
Loss of the integrity of the labrum decreases resistance to translation by 20%.
The labrum also acts as an anchor point for the capsuloligamentous structures.

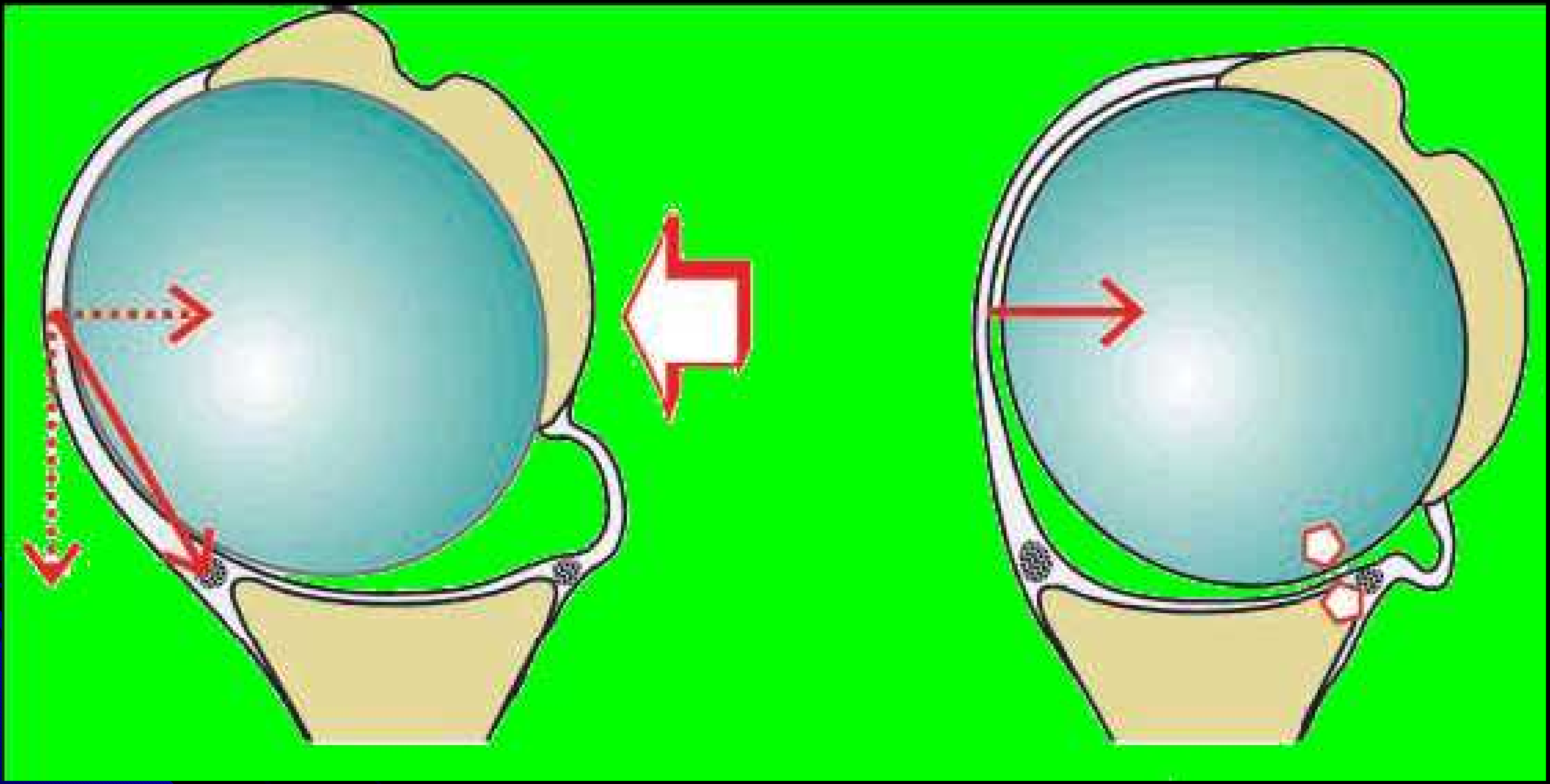
Bankart Lesion

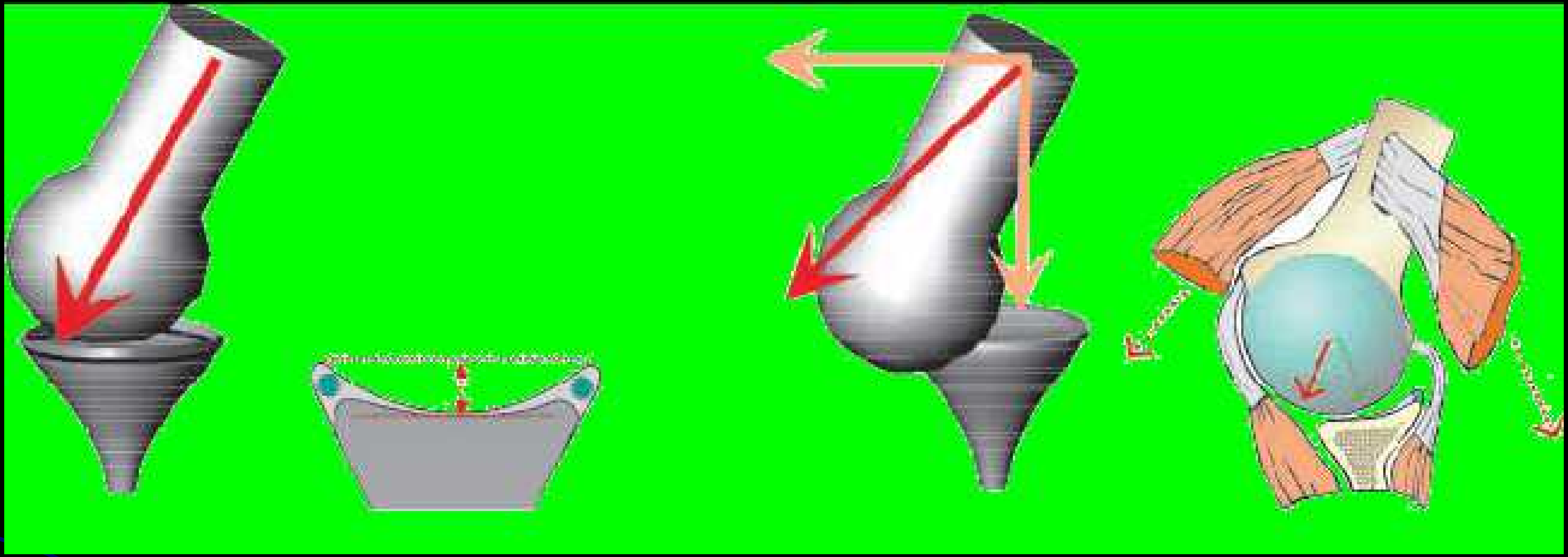
Joint Capsule



Surface area is twice that of the humeral head, allowing for extensive range of motion.

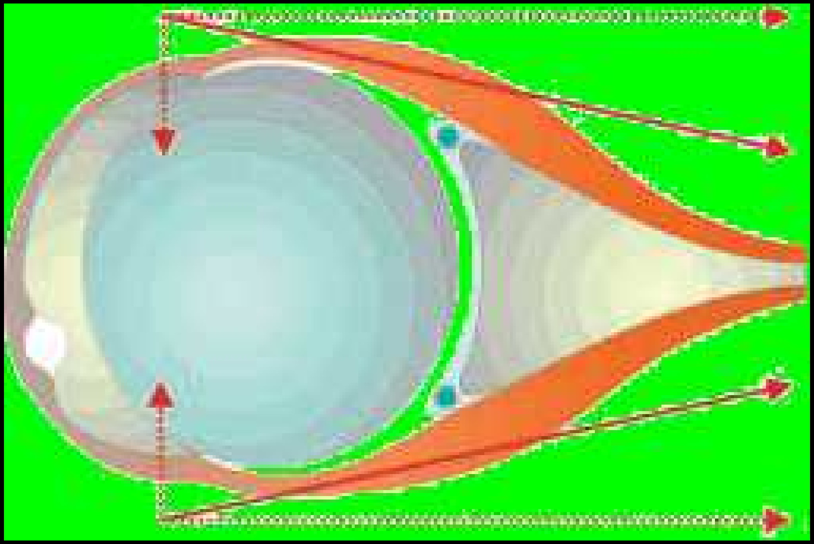
The capsule tightens in extreme abduction and extemal rotation, taking up the redundant capsule.





Stability depends on the action of several force vectors

Force Couples in the Shoulder Joint



The capsuloligamentous structures reciprocally tighten and loosen during rotation of the arm to limit translation.

In the midrange of motion, these structures are relatively lax, and stability is mainly provided by the actions of the rotator cuff and biceps through the concavity-compression effect.

At the extremes of motion, the ligaments tighten and become functional.

The anterior capsule is much thicker than the posterior capsule, which has no defined glenohumeral ligaments.

Stabilizers & Arm Position

- Neutral position - Intra-articular pressure & muscles
- Midrange - Increased role of rotator cuff
- Extremes of motion - GH ligaments

During upper extremity movement the effects of static stabilizers are minimized and dynamic stabilizers become the dominant forces.

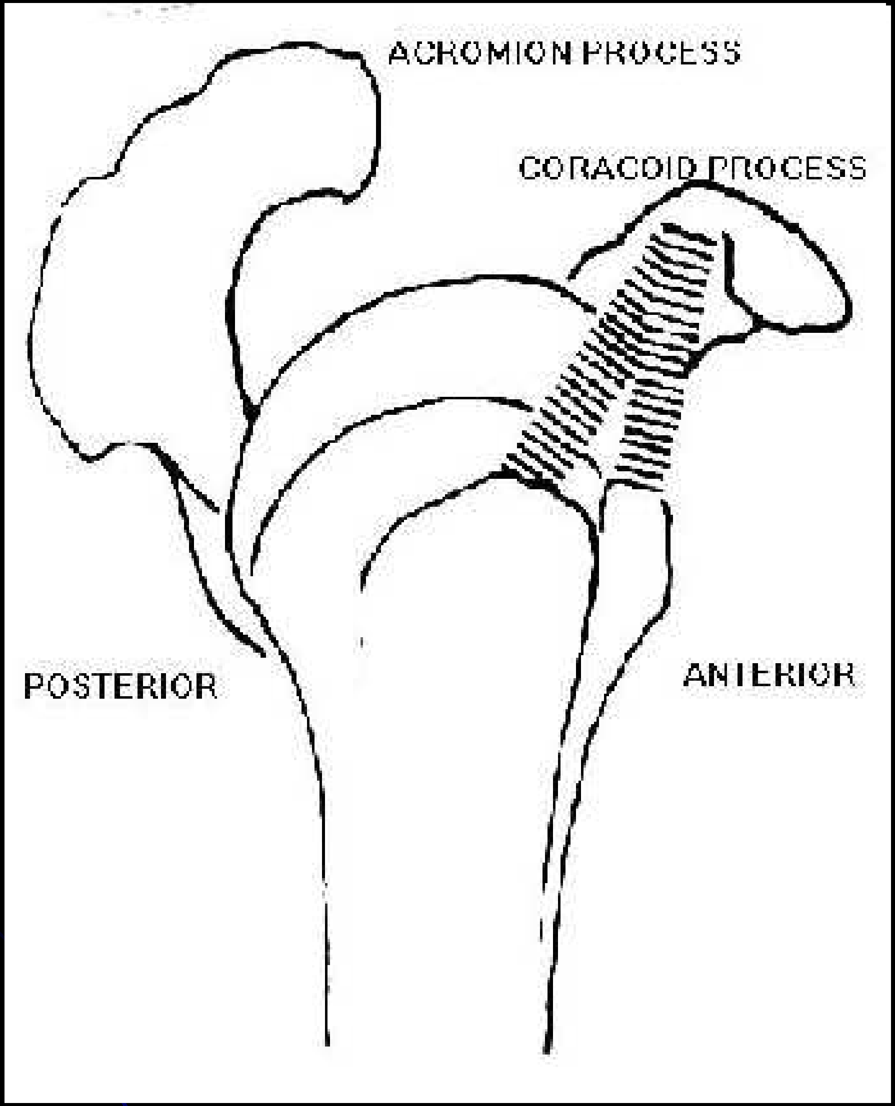
Concavity compression

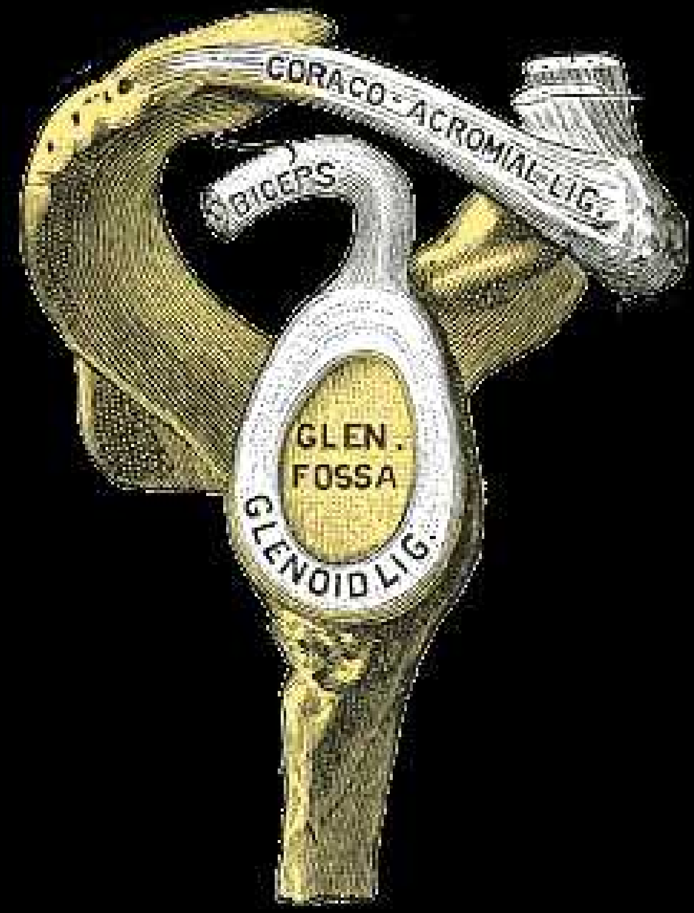
Dynamic stabilization is merely the coordinated contraction of the rotator cuff muscles that create forces that compress the articular surfaces of the humeral headinto the concave surface of the glenoid fossa.

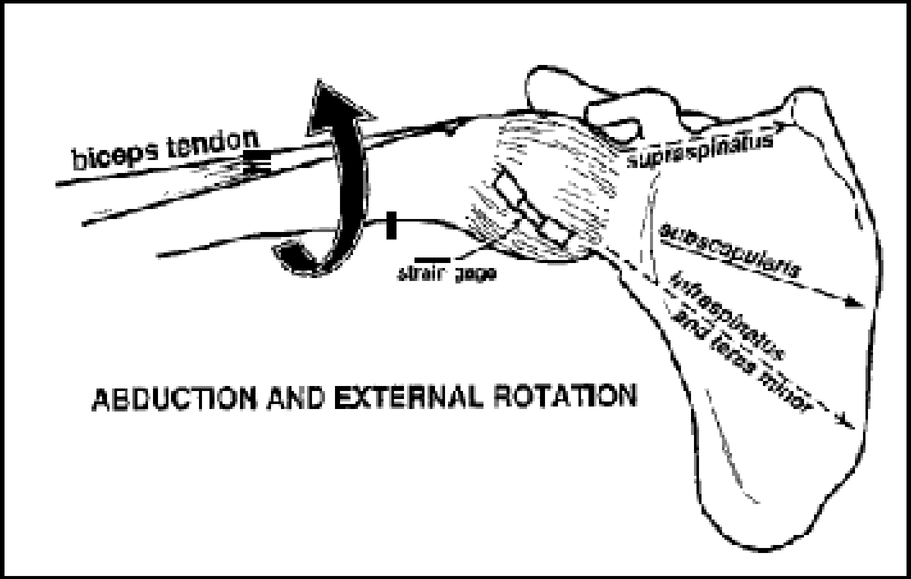
Stability

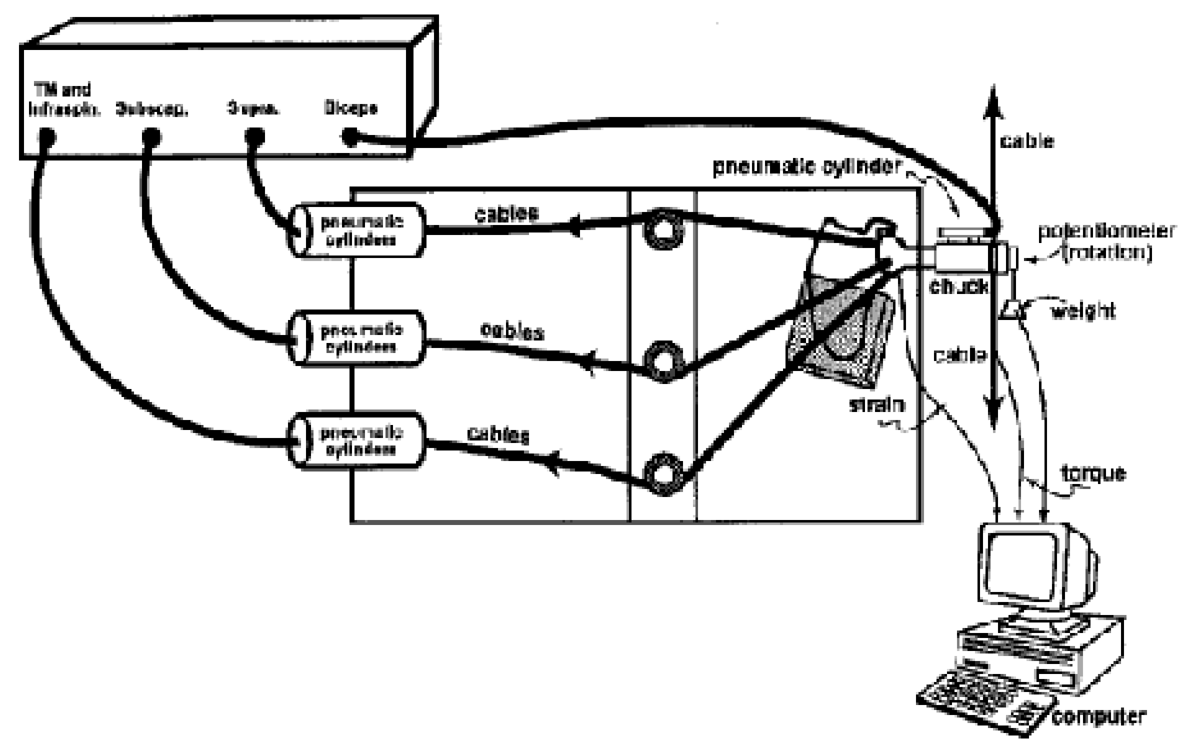
The vector of the acting forces passed through the glenoid.

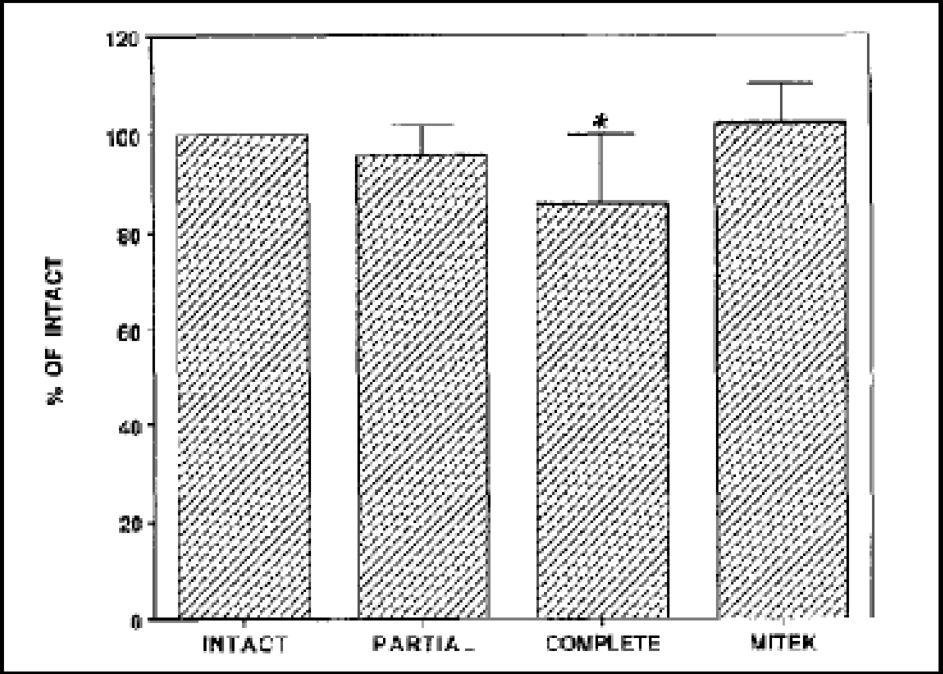
Coracohumeral Ligament

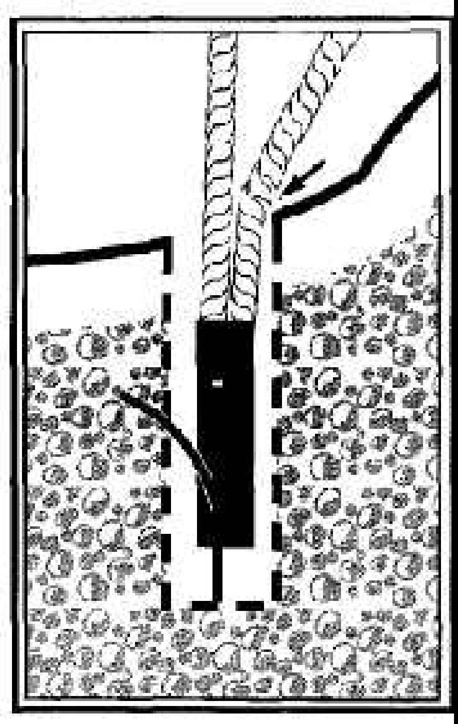



CORACO-ACROMIAL LIG.
BICEPS
GLEN. FOSSA
GLENOID LIG.


biceps tendon
strain gage
supraspinatus
subscapularis
infraspinatus and teres minor
ABDUCTION AND EXTERNAL ROTATION


TM and Infraspin.
Subscap.
Supra.
Biceps
pneumatic cylinders
cables
pneumatic cylinders
cables
pneumatic cylinders
cables
pneumatic cylinder
cable
potentiometer (rotation)
chuck
weight
cable
strain
torque
computer


% OF INTACT
120
100
80
60
40
20
0
*
INTACT
PARTIAL
COMPLETE
MITEK



Shoulder Instability

Biomechanics

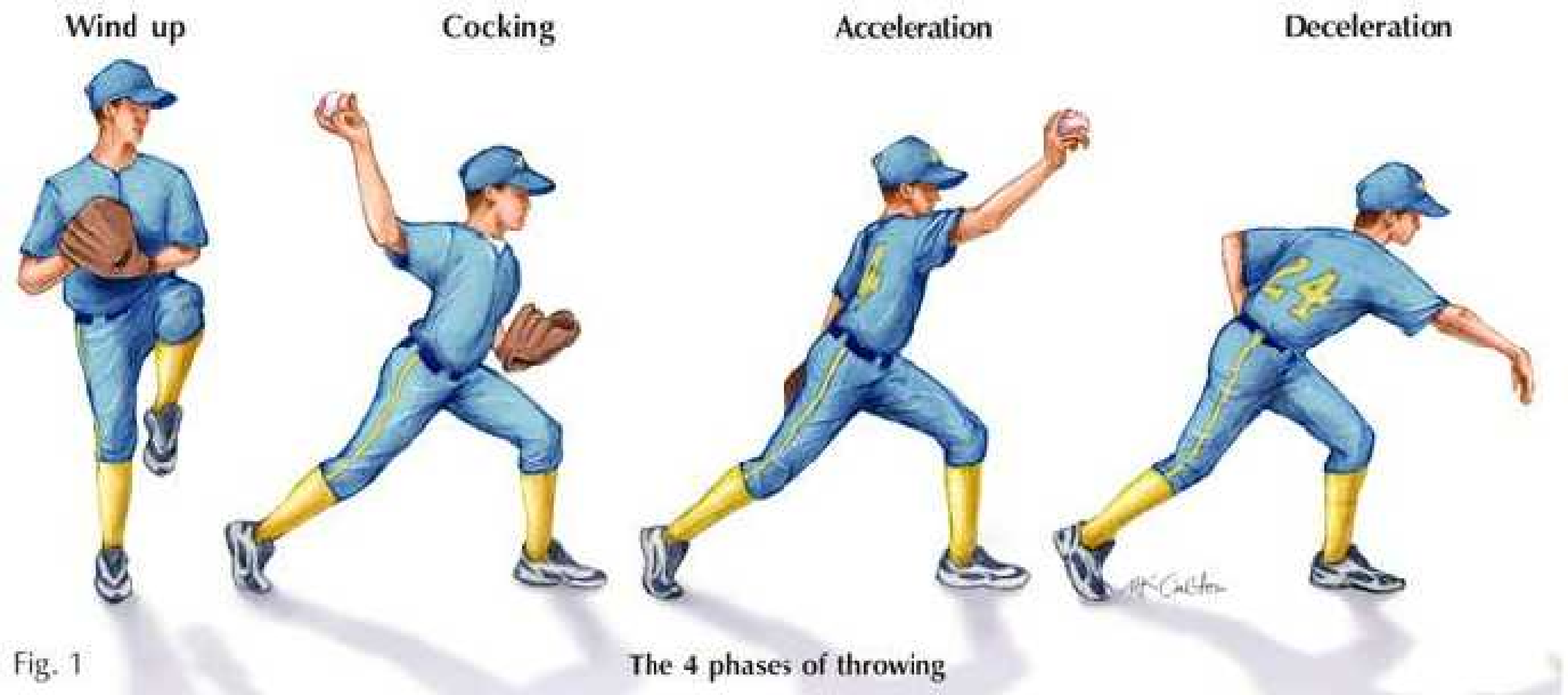


Fig. 1 The 4 phases of throwing

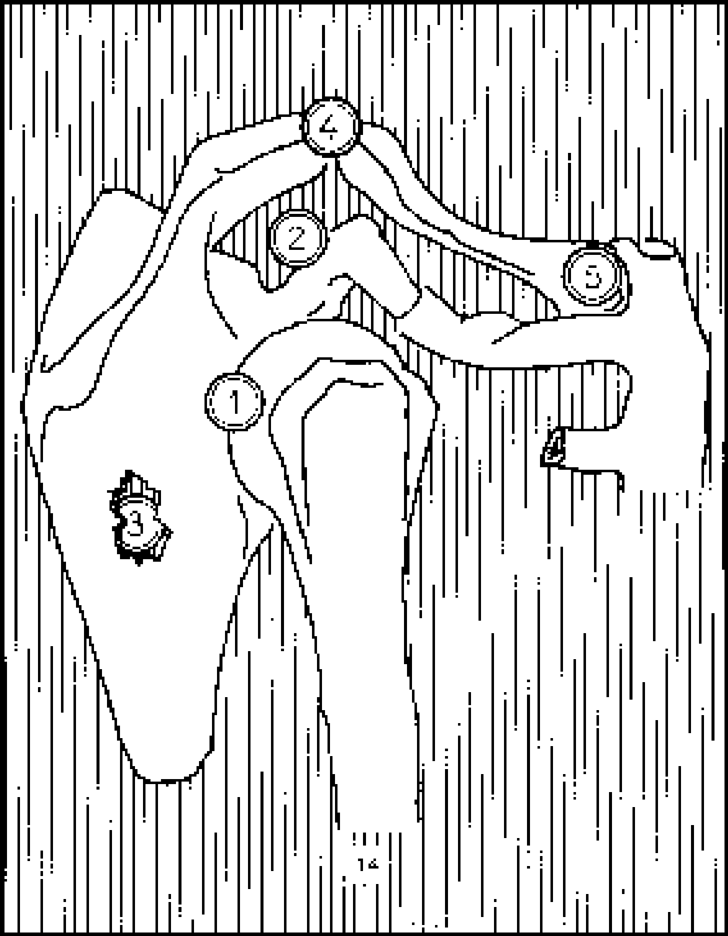
Instability

- Stability relies on ligaments and rotator cuff action
- Inferior glenohumeral ligament
  - Maximally stretched in external rotation
  - Chronic stretching can cause functional incompetence
  - Causes rotator cuff to work harder – can fatigue or tear

Shoulder Girdle

Includes:

- G-H joint
- A-C joint
- S-C joint
- S-T joint
- Subacromial space



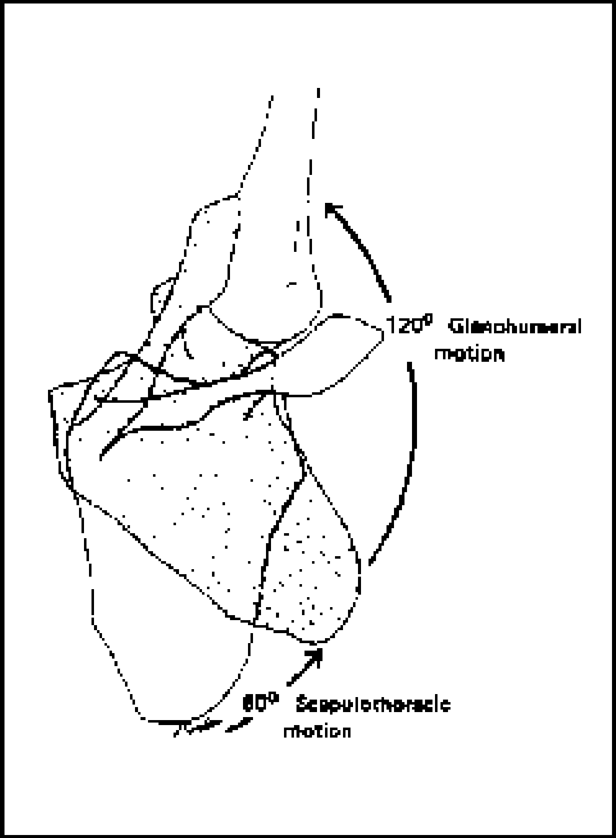
Shoulder Motion

Combined Movements:

- Flexion - 150 - 180^0
- Extension - 50 - 60^0
- Abduction - 150 - 180^0
- External rotation - 90^0
- Internal rotation - 70 - 90^0
- Horizontal abduction
- Horizontal adduction

Scapulohumeral Rhythm

- Total elevation:
    - 120^0 at G-H joint
    - 60^0 at S-T joint



Glenohumeral Motion

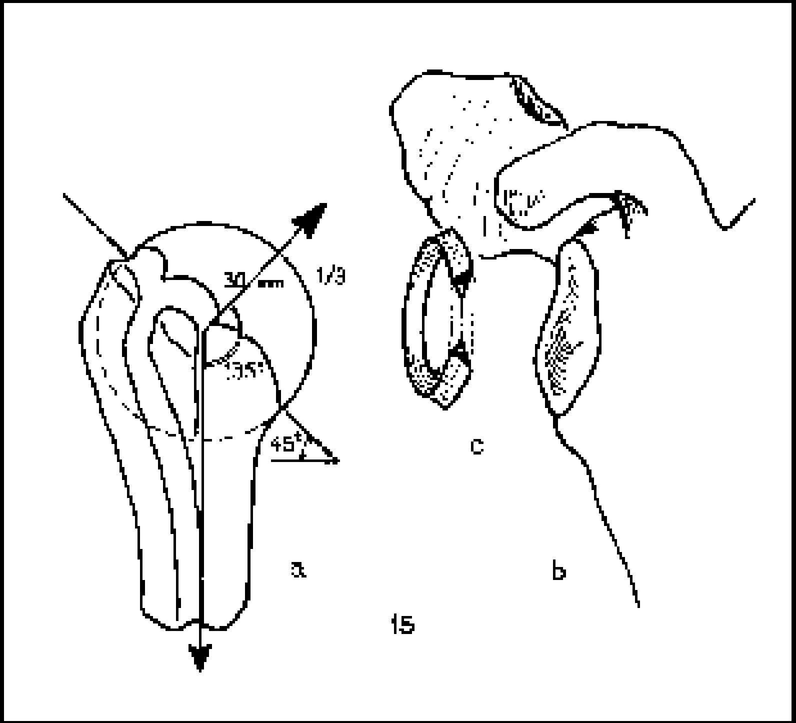
Controlled by:

- Passive restraints
- Active restraints

Glenohumeral Motion

Passive Restraints:

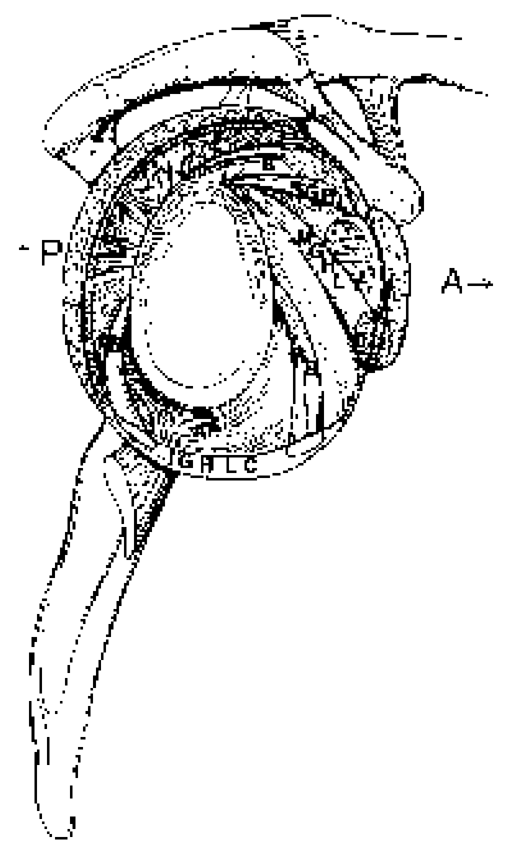
- Bony geometry
- Labrum
- Capsuloligamentous structures
- Negative intra-articular pressure



Capsuloligamentous Structures

Glenohumeral ligaments:

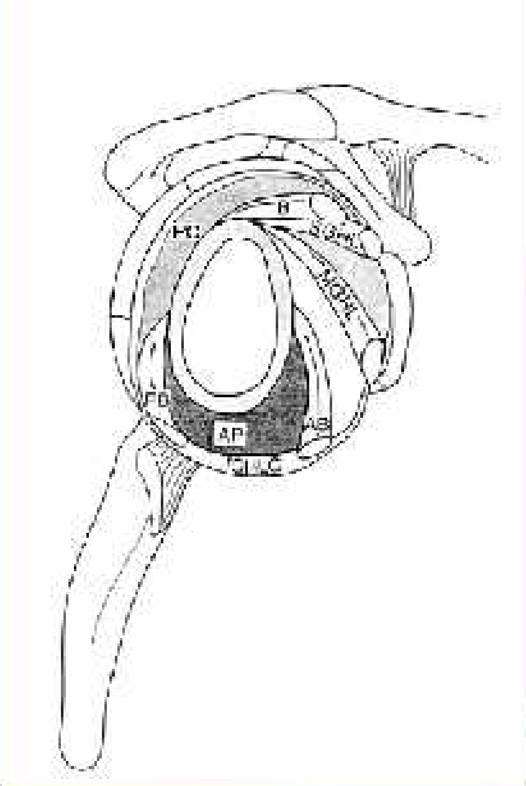
- SGHL
- MGHL
- IGHL complex
  - anterior band
  - posterior band
  - axillary pouch



Stabilizing Anatomy – Multifactorial

- Glenohumeral ligaments – more important toward functional end range
  - CH
  - SGHL

  Head suspenders
  - MGHL-low and mid range abduction (+ subscapularis)
  - IGHL-45º abduction and higher
- Glenoid labrum
  - Adds depth
  - "Break stop"/centers humeral head
  - Attachment for GH ligaments /biceps tendon

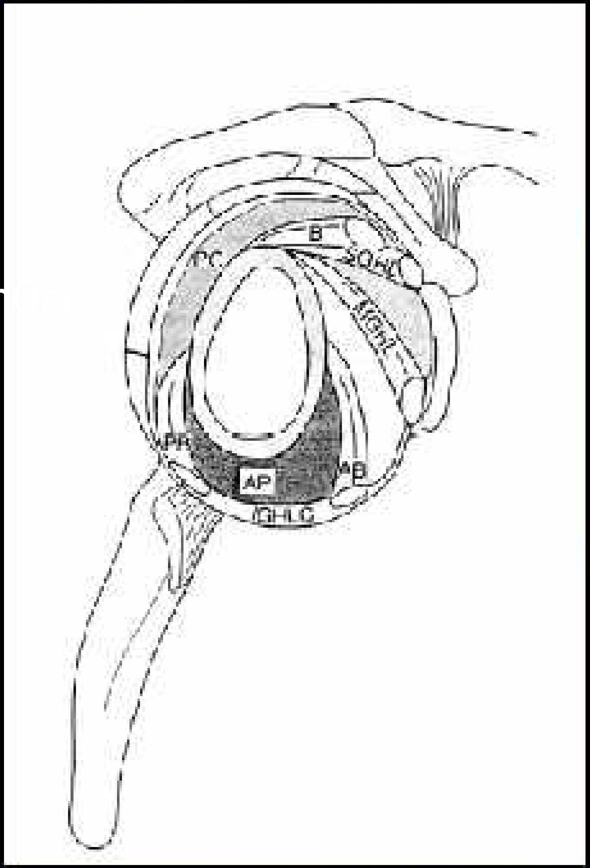


Stabilizing Anatomy – Multifactorial

- Glenoid articulation – "articular arc"
  - Glenoid normally "pear-shaped"
  - Permits high degree of rotation and translation
  - Low "containment"

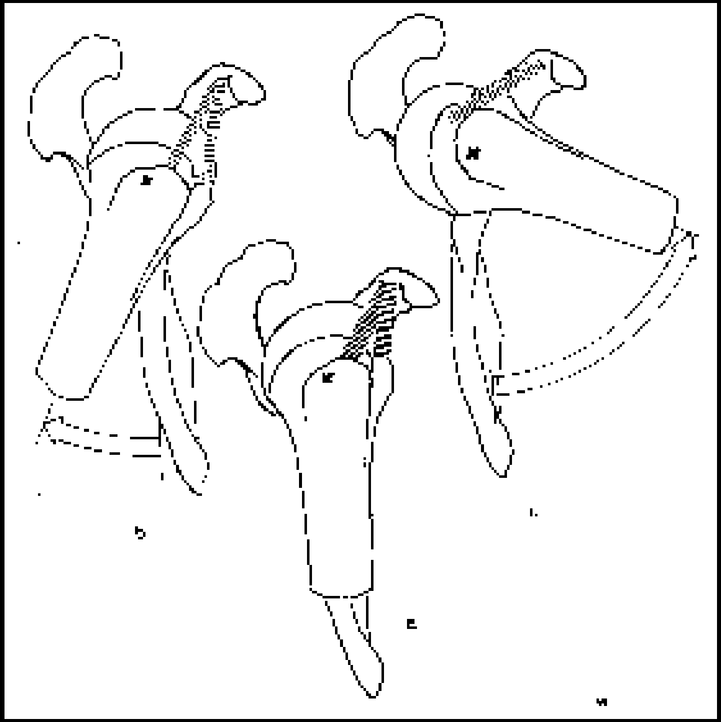
πραγματοποιη

- Rotator cuff & scapular musculature (dynamic)
  - Prime stabilizer during mid-range glenohumeral motion
  - GH compression/head depressor/GH "balance



Capsuloligamentous Structures

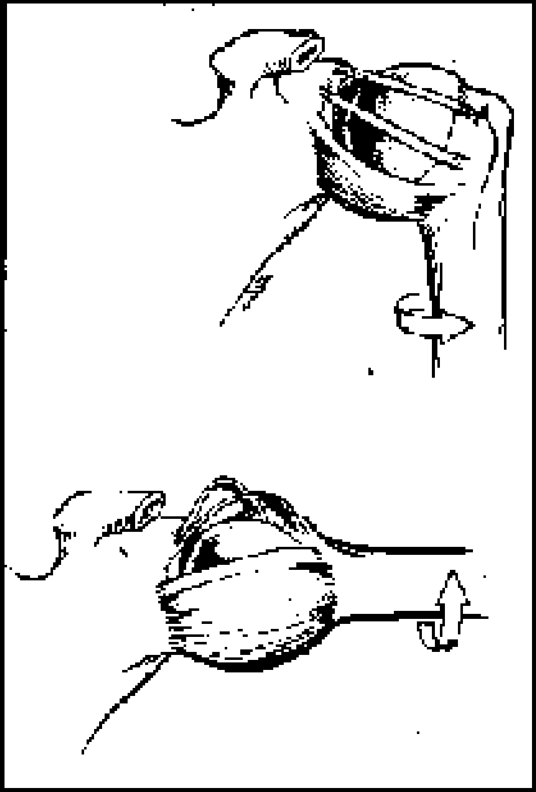
- Coracohumeral ligament
  - anterior band
  - posterior band



Restraints to External Rotation

Dependent on arm position:

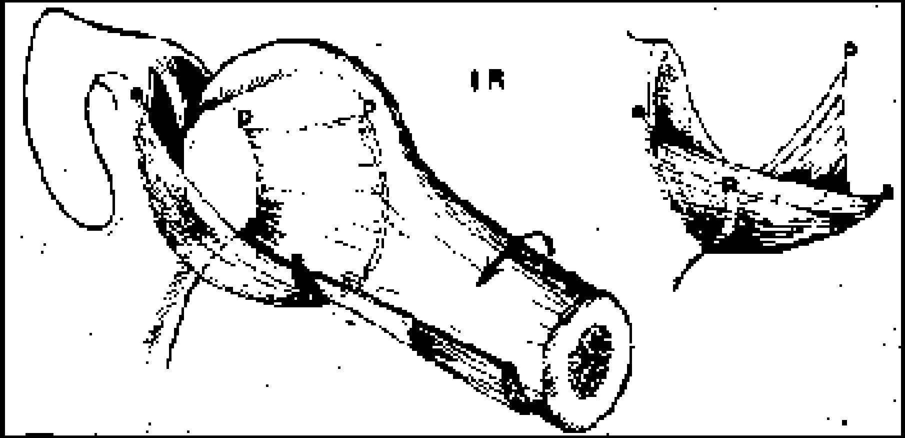
- 0^0 - SGHL, C-H & subscapularis
- 45^0 - SGHL & MGHL
- 90^0 - anterior band IGHLC



Restraints to Internal Rotation

Dependent on arm position:

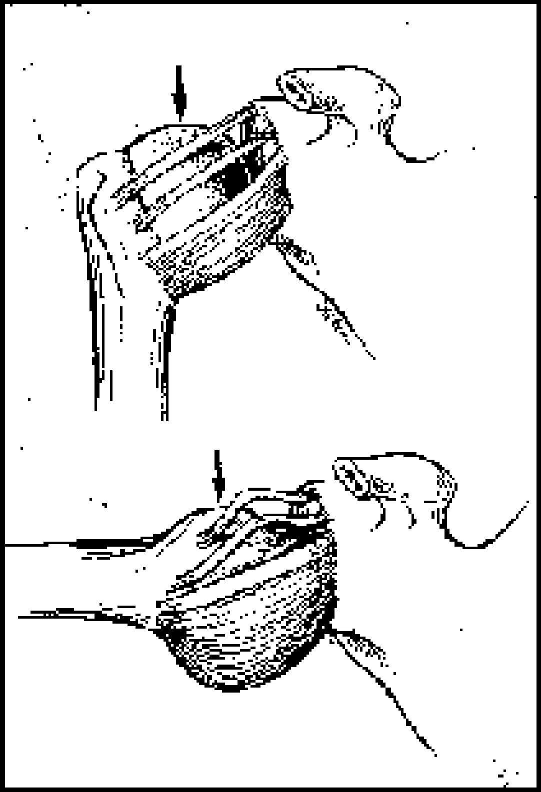
- 0^0 - posterior band IGHLC
- 45^0 - anterior & posterior band IGHLC
- 90^0 - anterior & posterior band IGHLC



Restraints to Inferior Translation

Dependent on arm position:

- 0^0 - SGHL & C-H
- 90^0 - IGHLC



Glenohumeral Motion

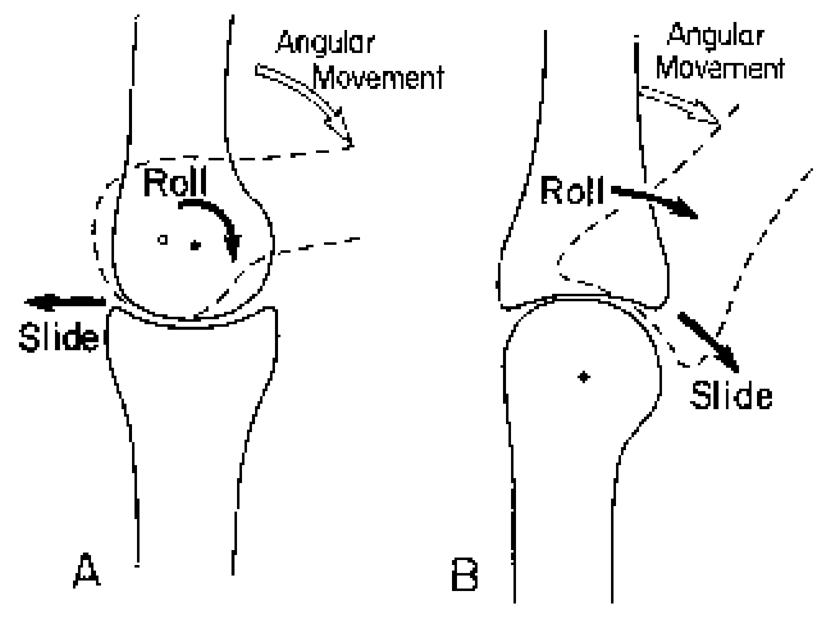
Scapular Plane:

- Flexion/extension - 120^0
- Abduction/adduction - 120^0
- External/internal rotation
- Horizontal abduction/ adduction

Arthrokinematics of Glenohumeral Joint

Glenohumeral Motion

Convex - Concave Rule:



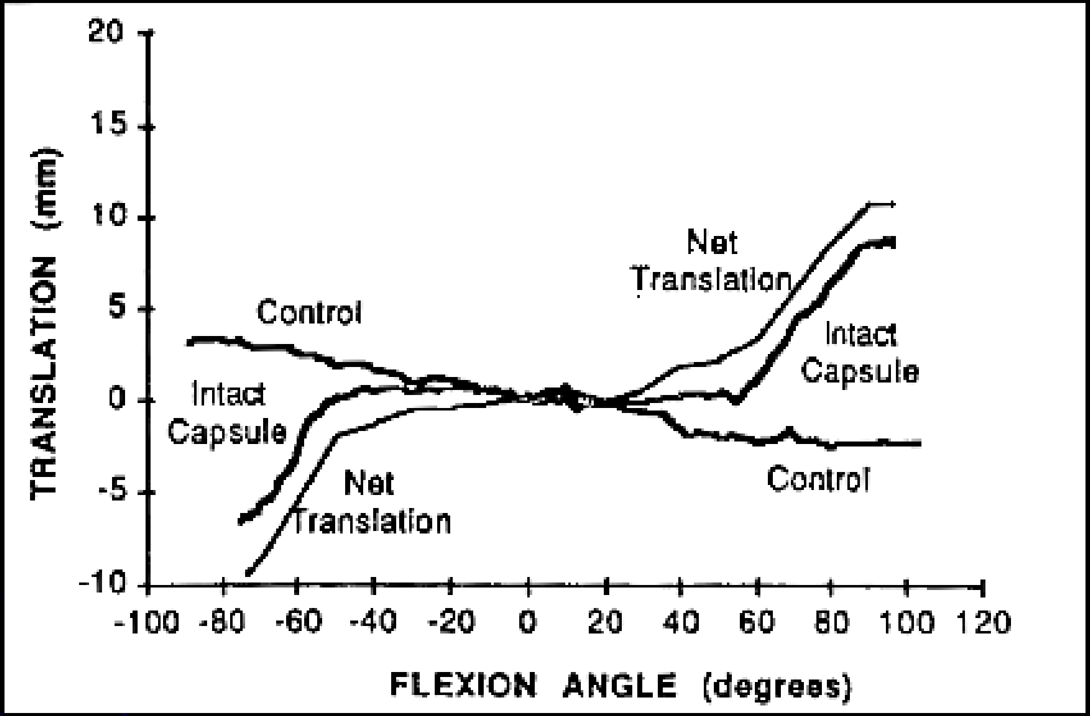
Glenohumeral Motion

Arthrokinematics:

- Abduction
- Flexion
- Extension
- External rotation
- Internal rotation

Glenohumeral Motion

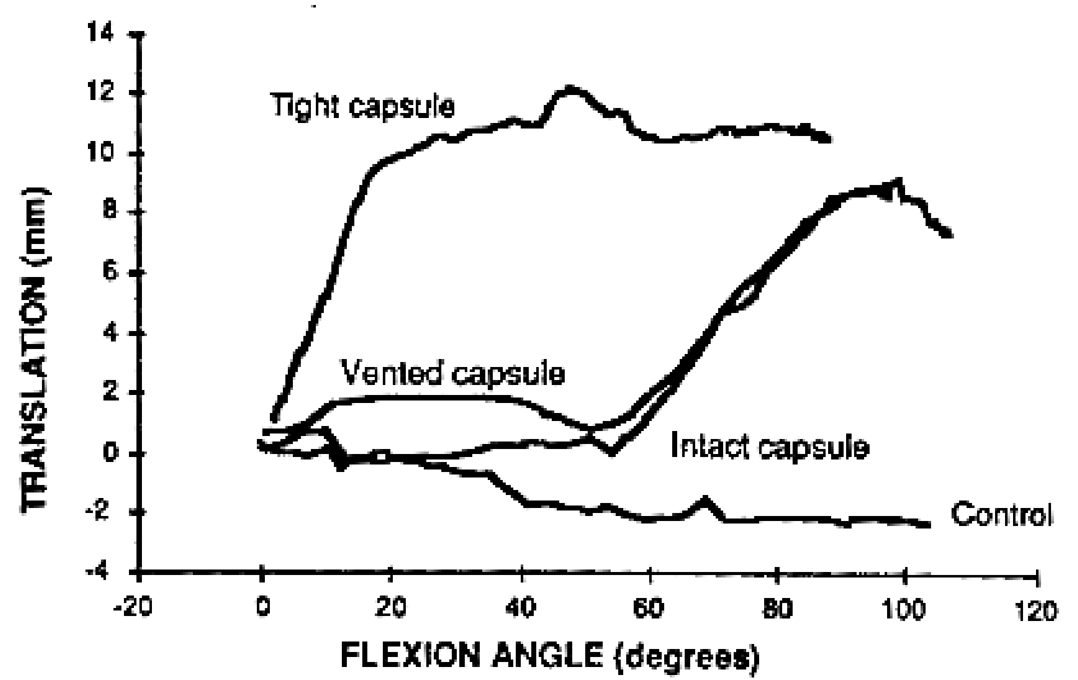
Arthrokinematics:



Harryman et. al. 1990

Glenohumeral Motion

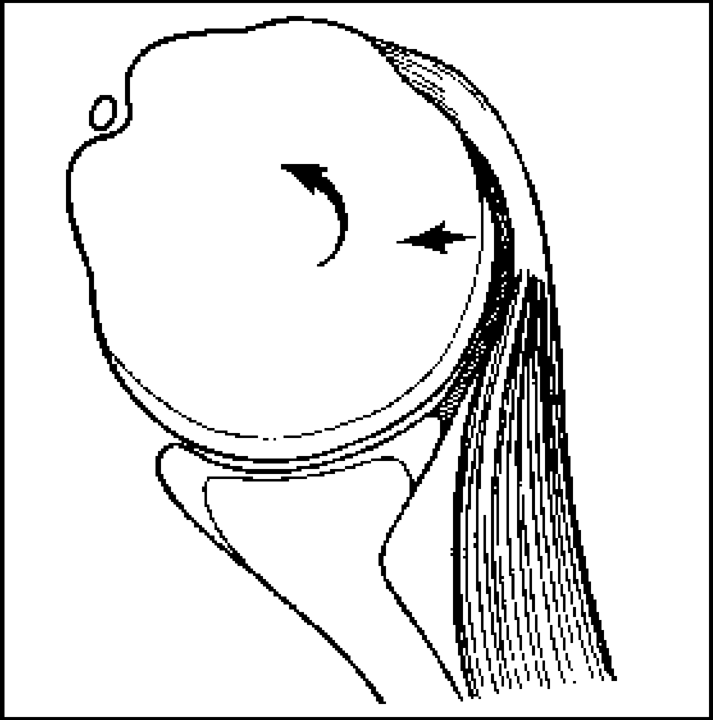
Arthrokinematics:



Harryman et. al. 1990

Glenohumeral Motion

Arthrokinematics:



Harryman et. al. 1990

Glenohumeral Motion

Capsular Tightness:

Results in Abnormal Arthrokinematics

Glenohumeral Motion

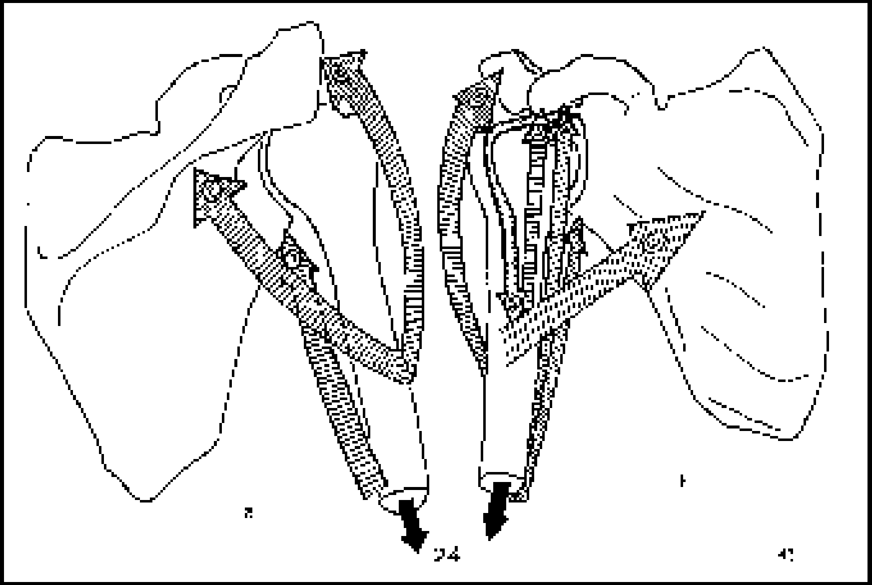
Normal Arthrokinematics:

- Combines rotation & translation to keep humeral head centered on glenoid

Scapulohumeral Muscles

Prime Movers:

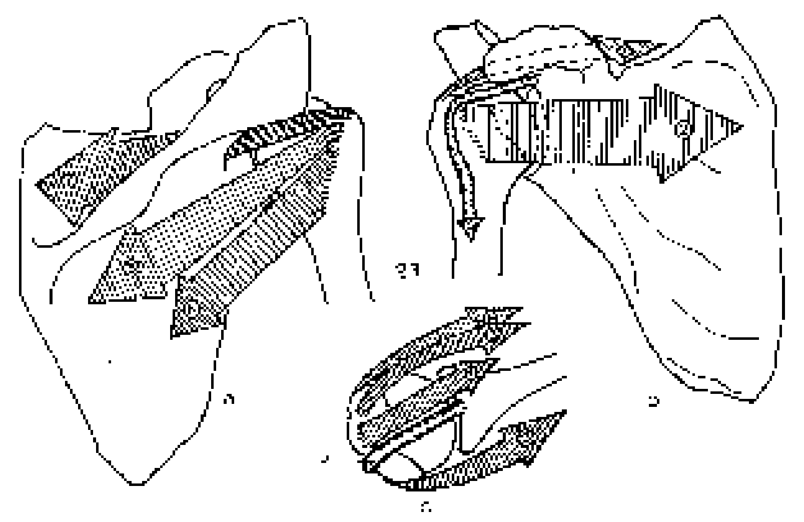
- Deltoid
- Pectoralis major
- Latissimus dorsi
- Teres major
- Biceps
- Coracobrachialis
- Triceps



Scapulohumeral Muscles

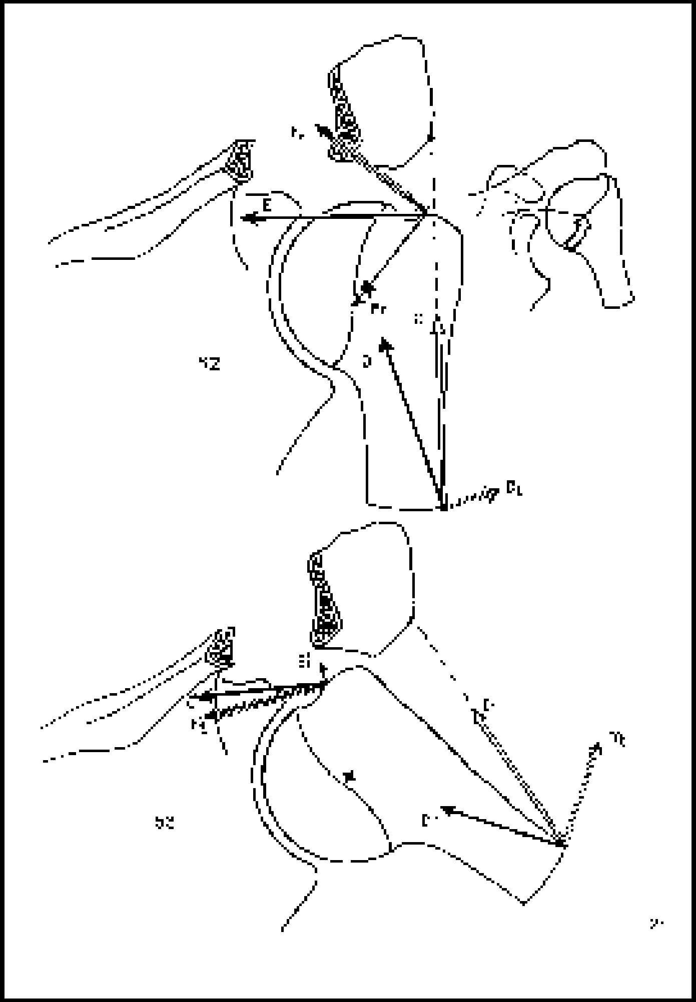
Rotator Cuff:

- Subscapularis
- Supraspinatus
- Infraspinatus
- Teres Minor



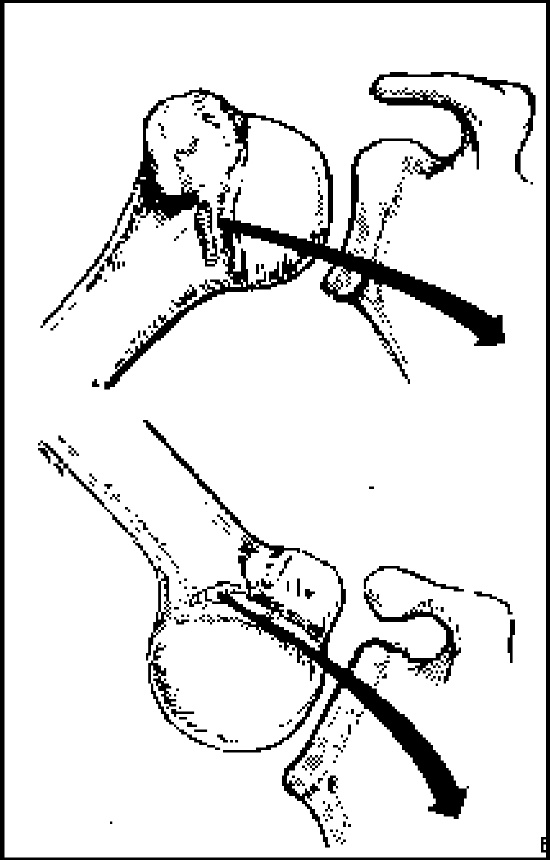
Rotator Cuff Function

- Approximates humerus to function
- Supraspinatus assists deltoid in abduction
- Subscapularis, infraspinatus & teres minor depress humeral head



Subscapularis

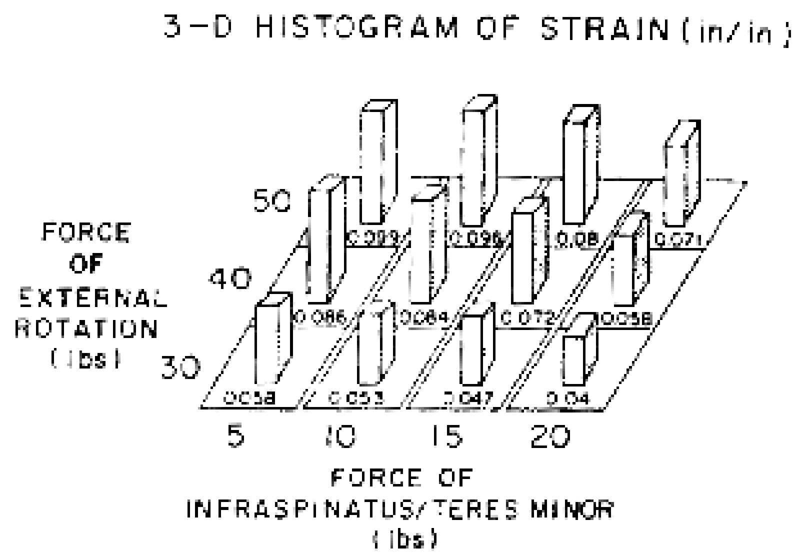
- Effective restraint to ER with arm at side
- Ineffective restraint to ER with arm abducted to 90^0



Turkel et. al. JBJS 1981

Infraspinatus/Teres Minor

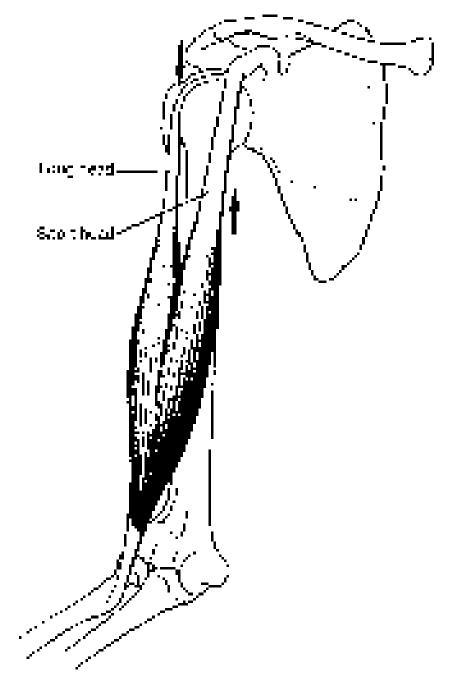
- Reduces strain on anterior band of IGHLC
- “Hamstrings” of glenohumeral joint



Cain et. al. AJSM 1987

Long Head of Biceps

- Biceps tendon force increases torsional rigidity to ER
- No effect on strain of IGHLC
- Effect lost with SLAP lesion



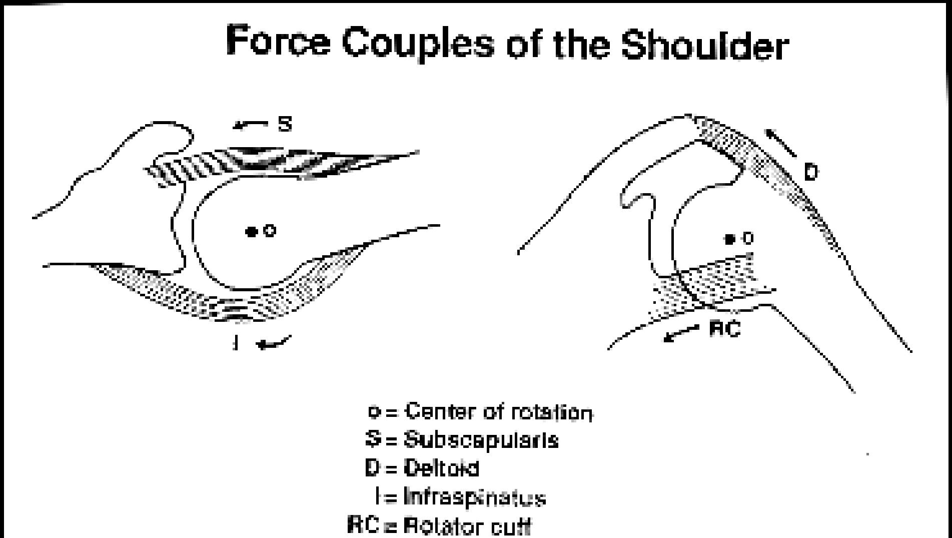
Rodosky et. al. AJSM 1994

Biceps Becomes More Important Anterior Stabilizer as Capsuloligamentous Stability Decreases

Itoi et. al. JBJS 1994 & Glousman et. al. 1988

Force Couples Acting on Glenohumeral Joint

- Transverse plane - anterior vs. posterior RC
- Coronal plane - deltoid vs. inferior RC

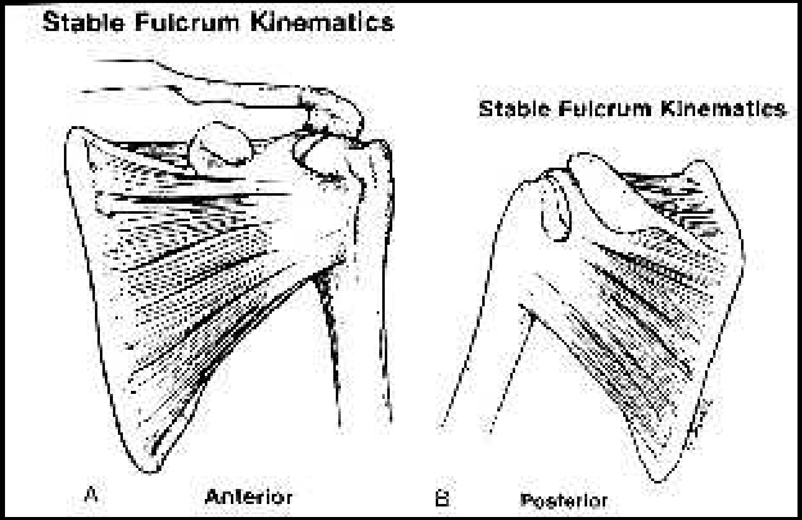

Force Couples of the Shoulder

o = Center of rotation
S = Subscapularis
D = Deltoid
I = Infraspinatus
RC = Rotator cuff

Rotator Cuff Tear

Supraspinatus:

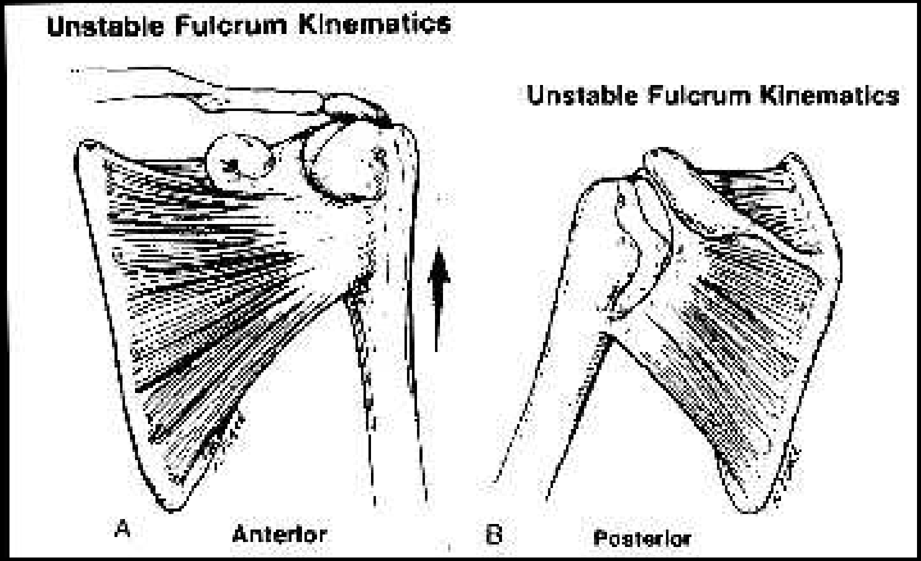
- Essential force couples maintained
- Normal strength & function possible



Rotator Cuff Tear

Supraspinatus/Posterior Cuff:

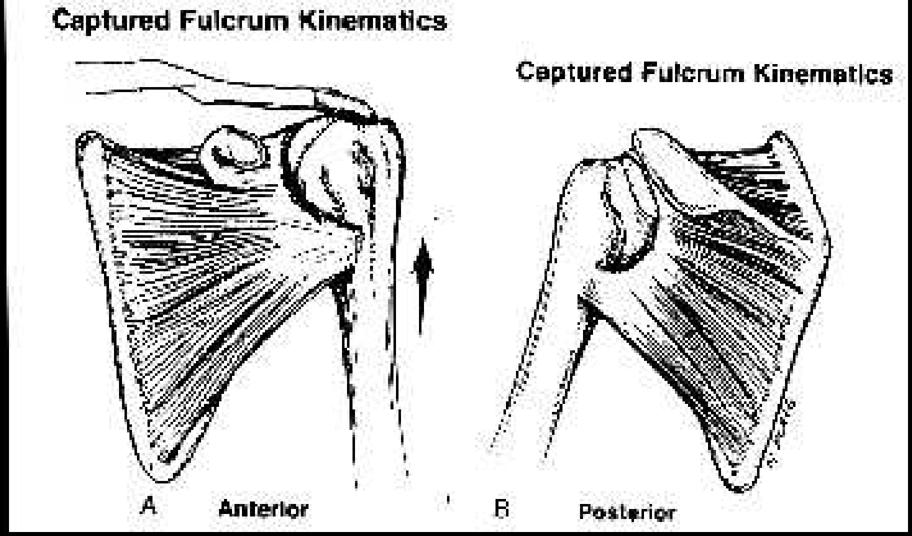
- Essential force couples disrupted
- Weakness with external rotation
- Little active elevation possible



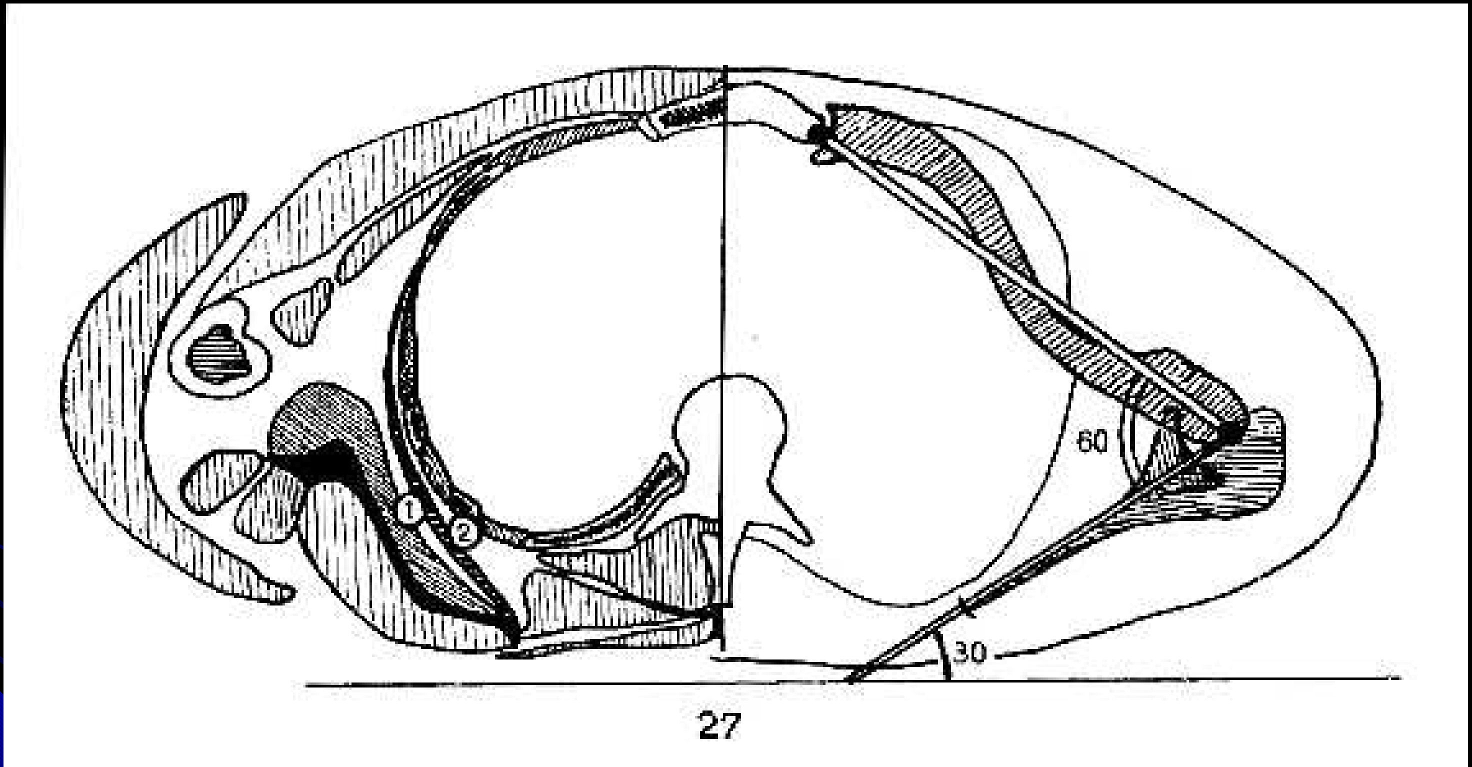
Rotator Cuff Tear

Massive Tear :

- Essential force couples disrupted
- Weakness with internal & external rotation
- Little active elevation possible

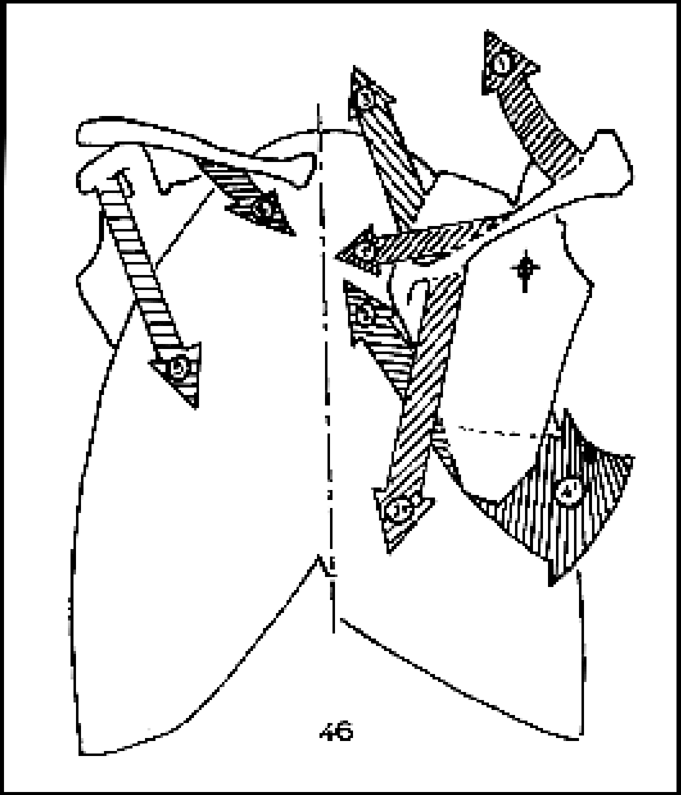


Scapulothoracic Joint



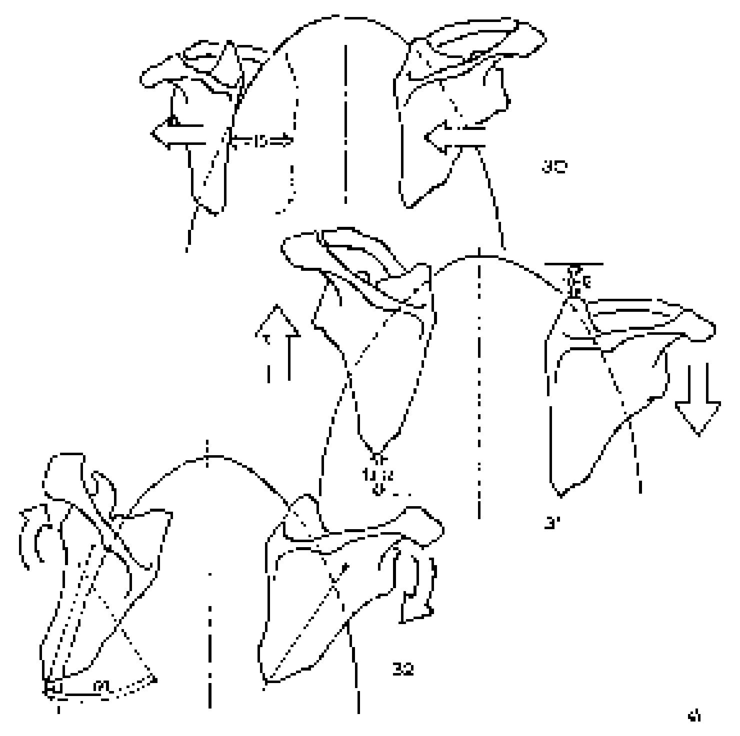
Scapulothoracic Muscles

- Trapezius
- Serratus anterior
- Rhomboids
- Levator scapulae
- Pectoralis minor
- Subclavius



Scapulothoracic Motion

- Elevation/depression
- Protraction/retraction
- Upward/downward rotation



Force Couple at Scapulothoracic Joint

- Serratus anterior produces anterio-lateral movement of inferior angle
- Upper trapezius pulls scapula medially

Force Couple at Scapulothoracic Joint

- Serratus anterior produces anterio-lateral movement of inferior angle
- Upper trapezius pulls scapula medially

Σταθερότητα γληνοβραχιόνιας α.

Στατικοί

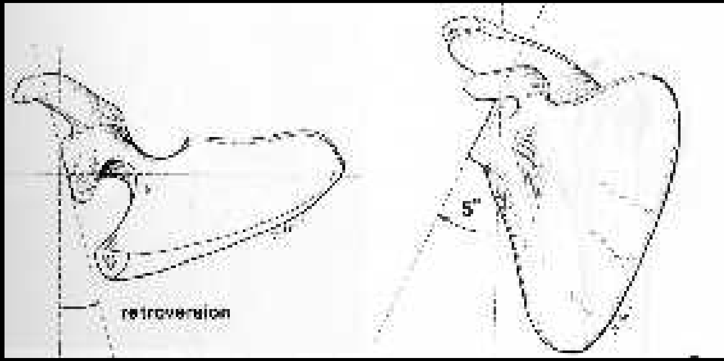
- Προσανατολισμός
- Γλην/βραχ.επιφάνεια και αρθρική επαφή
- Επιχείλιος χόνδρος
- Θυλακοσυνδεσμικές δομές
- Άνω γληνοβραχιόνιος σ.και κορακοβραχιόνιος σ. στο rotator interval
- Μέσος και κάτω γληνοβραχ.σ.
- Οπίσθιος θύλακος
- Ιδιότητες υλικών
- Μάζα του τενοντίου πετάλου των στροφέων

Δυναμικοί

- Συνδυασμένη σύσπαση μυών τενοντίου πετάλου
- Σύσπαση τ.μακράς κεφ.δικεφάλου
- Δυναμοποίηση των συνδέσμων
- Κινηματικοί παράγοντες (θωρακοωμοπλατιαία κ.)
- Αρνητική ενδαρθρική πίεση και προσκόλληση-συνοχή

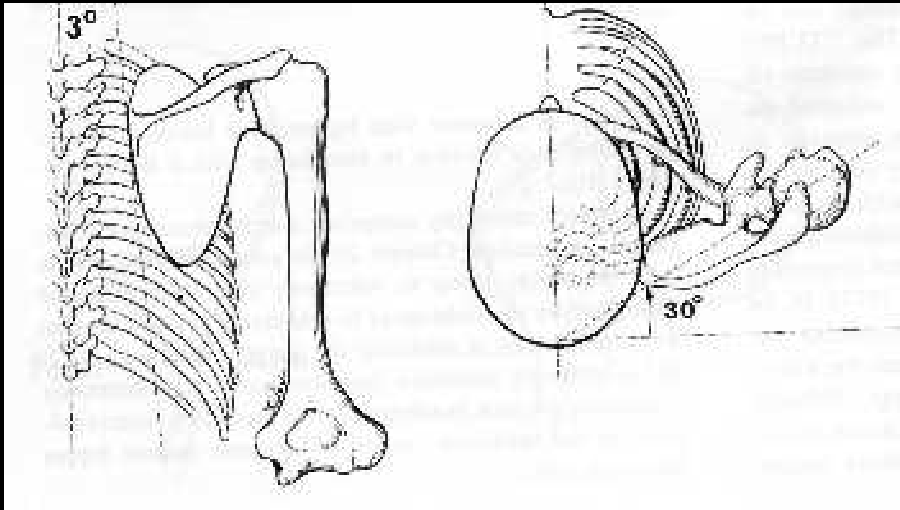
Προσανατολισμός αρθρικής επιφάνειας

- Ωμοπλάτη β έσω στροφή στο εγκαρσιο επ.30^{o} , 3^{o} απαγωγή στο μετωπιαίο επ.και 20^{o} πρ.κλίση στο οβελιαίο επ.

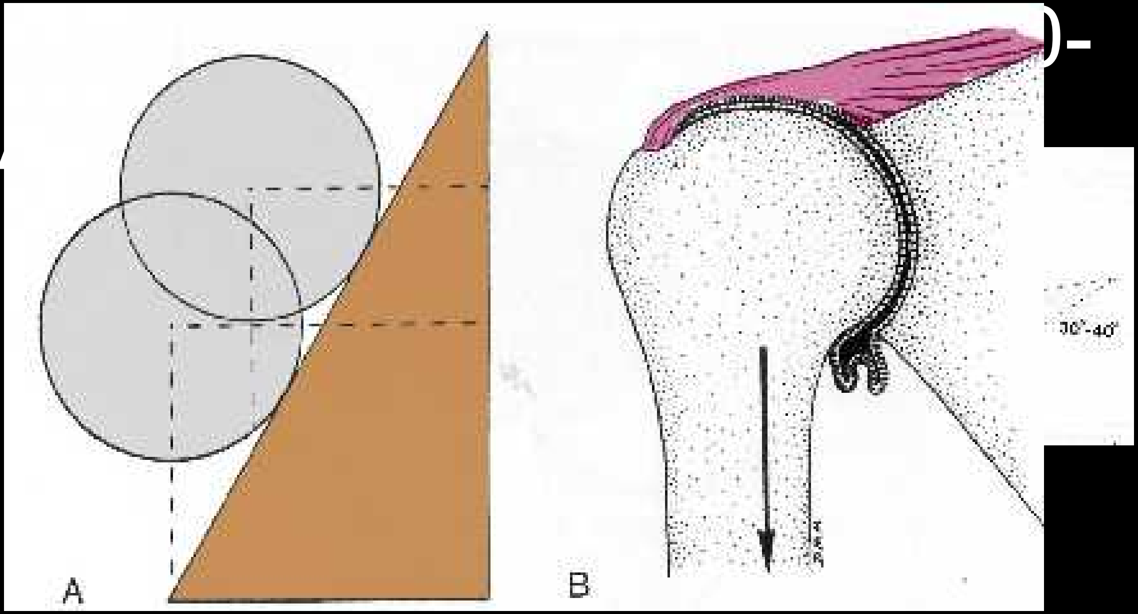


•Ωμογλήνη β Saha 75%
οπ.κλίση 7^{o} 25%
πρ.κλίση 2-10^{o}

Άνω (κεφαλική) κλίση 5^{o}



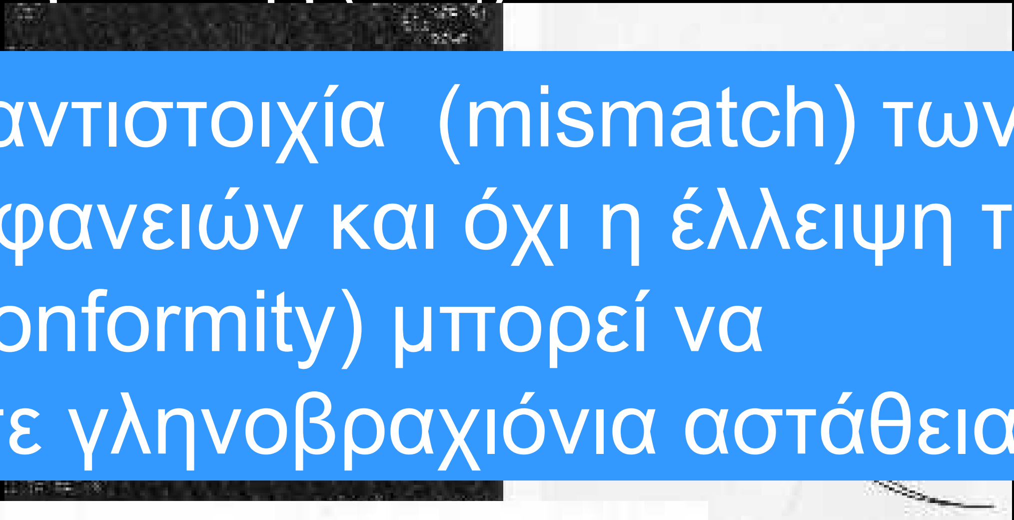
Βραχιόνιο 0-
140^o, οπ.κ



Η κλίση της ωμοπλάτης αποτελεί βασικό παράγοντα που συμβάλλει στην προς τα κάτω σταθερότητα της γληνοβραχιονίου άρθρωσης (Warren 1980,Matsen 1990)

Αρθρική επιφάνεια και επαφή

- Γληνοβραχιόνιος δείκτης (GH$_I$)=

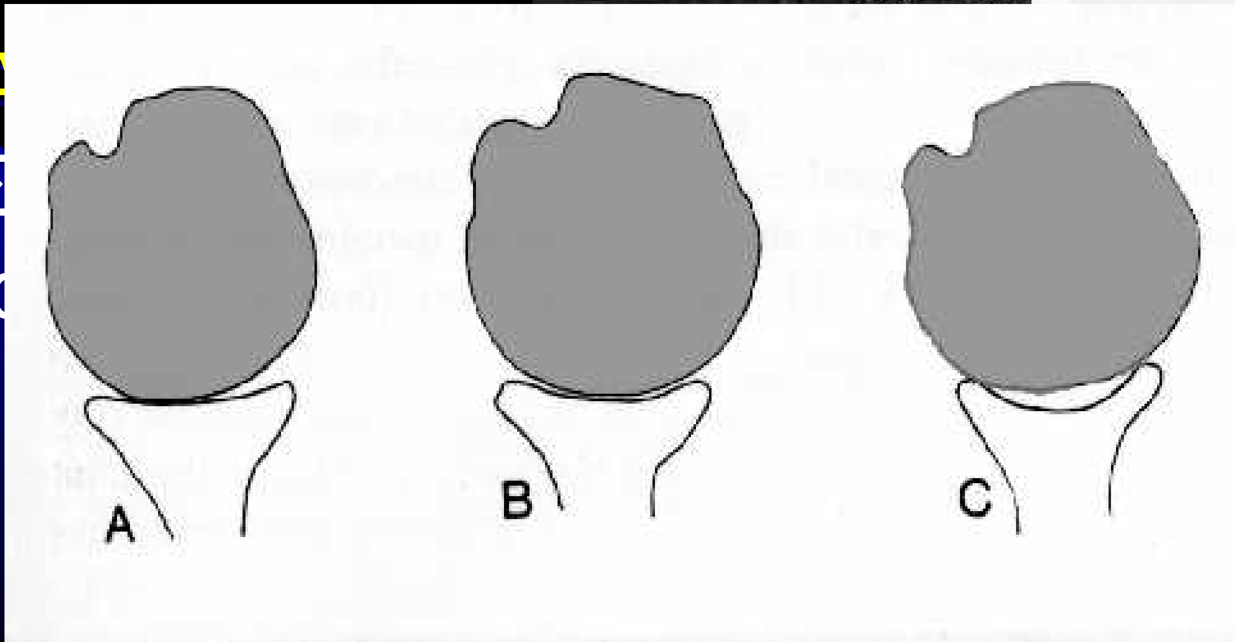


Πιθανώς η αναντιστοιχία (mismatch) των αρθρικών επιφανειών και όχι η έλλειψη της συμμετρίας (conformity) μπορεί να προδιαθέσει σε γληνοβραχιόνια αστάθεια

•A wski 1992)

Σ ακτ.

κ



είλιος χόνδρος

άθος τη %)

άλογο «

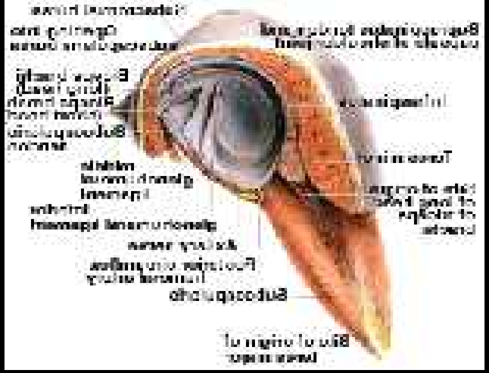
επαφής

στικά φο ς

νίου

Καλύτερη στερέωση κάτω από
ωμογλήνης.Συνεπώς αποκολλή
ισημερινού οδηγούν σε αστάθεια ενώ χαλαρή πρόσφυση του χόνδρου πάνω από τον ισημερινό πιθανότατα αντιπροσωπεύει φυσιολογική παραλλαγή

Συνδεσμοθυλακικά στοιχεία



- SGHL : παρών 90%, αναστολή της προς τα κάτω μετατόπισης (+ CHL)(Warner 1990)
- Περιορίζει έξω στροφή (ώμος σε προσαγωγή)

(πιθανώς οπίσθια σταθερότητα του ώμου βλάβες στο rotator interval β αστάθεια πολλαπλών κατευθύνσεων)

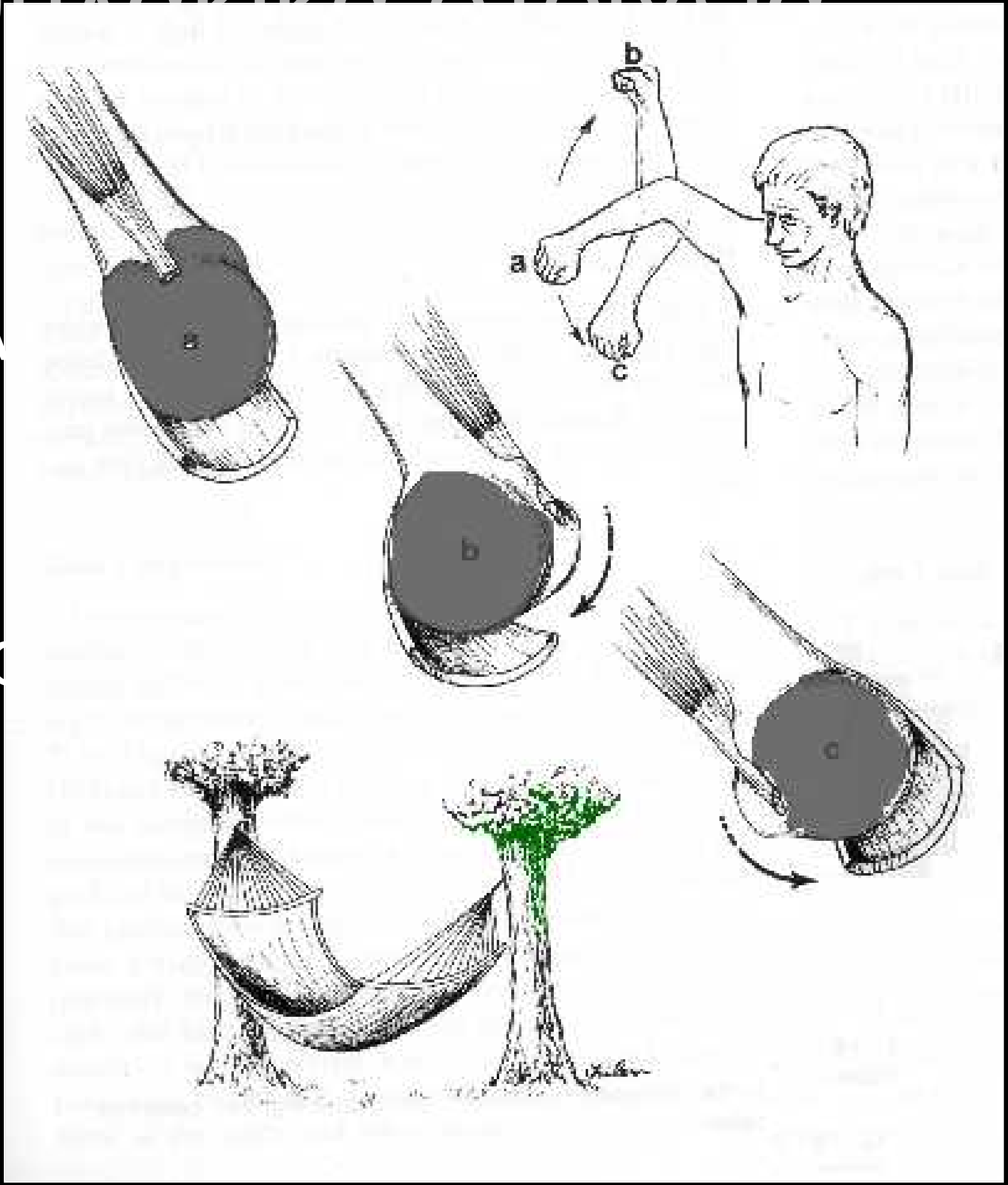
- MGHL : Δευτερογενής σταθεροποιητής σε πρόσθια και κάτω αστάθεια , μεγαλύτερη ποικιλομορφία, 30% απών

Συνδεσμοθυλακικά στοιχεία

IGHL complex

- Μηχανικό ανάλ
(υποστηρίζει σε

Περιορίζει την πρ
μετατόπιση σε



Εμβιομηχανικές ιδιότητες

IGHLcomplex

•Όριο θραύσης σε εφελκυσμό: 5.5 MPa

(γόνατο 35-80 Mpa)

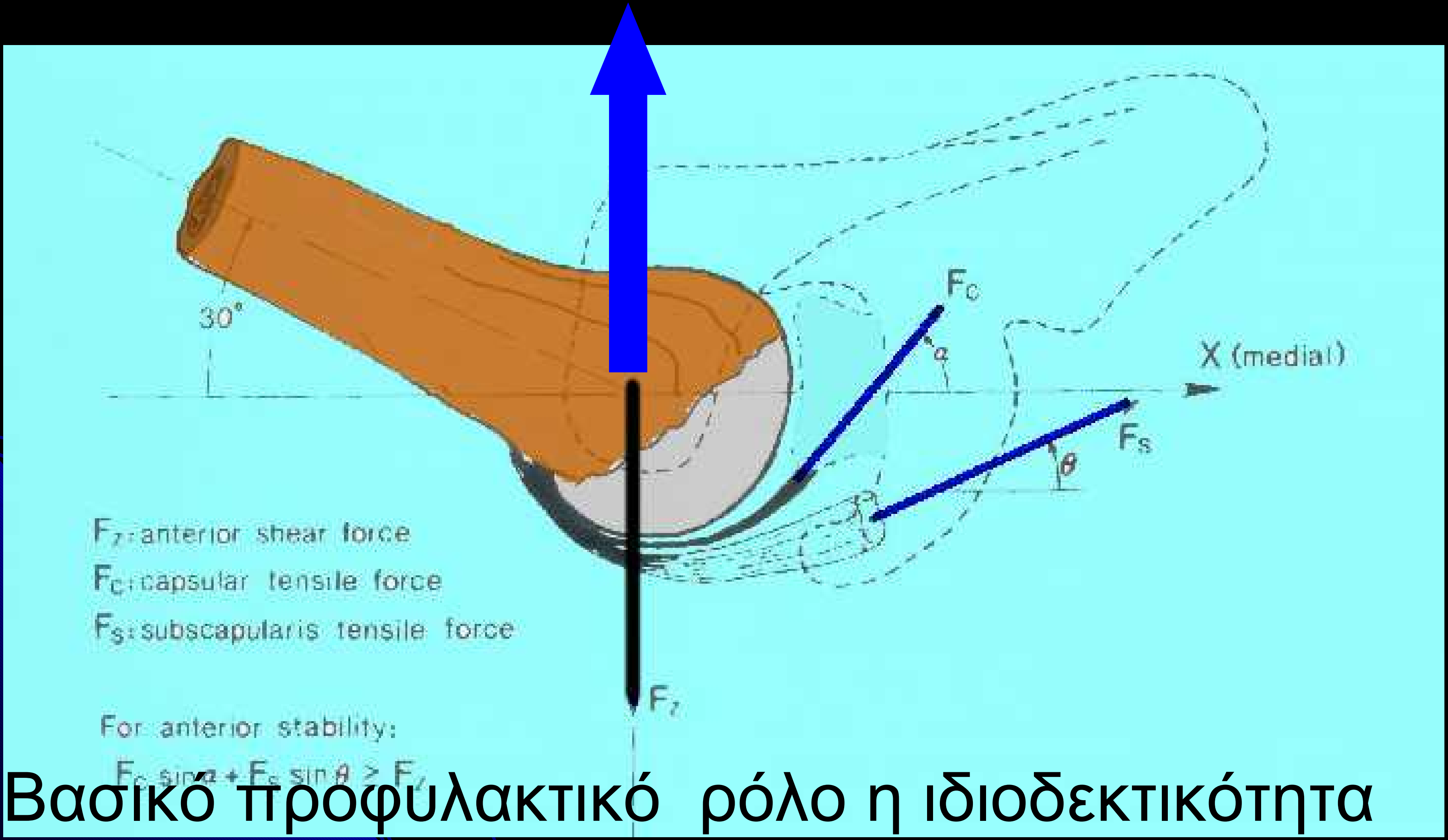
•(Θραύση συμβαίνει στην πρόσφυση στη γλήνη 40%,στο βραχιόνιο 25%,στη μάζα του συμπλέγματος 35%)

•Σημαντ.βαθμού πλαστική παραμόρφωση

•Συνεπώς μπορεί να υφίσταται σημαντικού βαθμού χαλάρωση χωρίς να υπάρχει απόσπαση

Bigliani 1992

Δύναμη τάσεως (εφελκυσμού) στο θύλακο



Βασικό προφυλακτικό ρόλο η ιδιοδεκτικότητα

Δυναμικοί σταθεροποιητές της γληνοβραχιονίου άρθρωσης

- Τεν.πέταλο στροφέων/μύες
- Τεν.της μακράς κεφ.του δικεφάλου/μύς (πρόσθια και άνω σταθερότητα)
- Δελτοειδής,ωμοραχιαίοι

Μηχανισμοί:

•Συμπίεση άρθρωσης

•Συνδυασμένη σύσπαση του τεν.πετάλου / επικέντρωση κεφαλής

•Δυναμοποίηση των γληνοβραχιονίων συνδ. μέσω συνδέσεων με το τεν.πέταλο

•Κινηματικοί παράγοντες (θωρακοωμοπλατ. κ.)

Συμπιεστικά φορτία στην άρθρωση

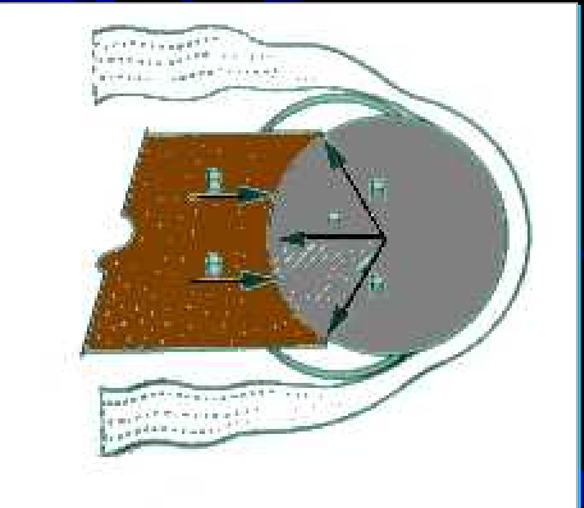
- Φορτία από ένέργεια του τ. πετάλου και του τ.του δικεφάλου γ σταθερότητα
- πολύ ισχ.από στατικούς σταθεροποιητές
- γ επικέντρωσης κεφ.του βραχιονίου
- συμμετρία της άρθρωσης και γ η τριβή

“Containment concept” (Howell-Galinat/1989)

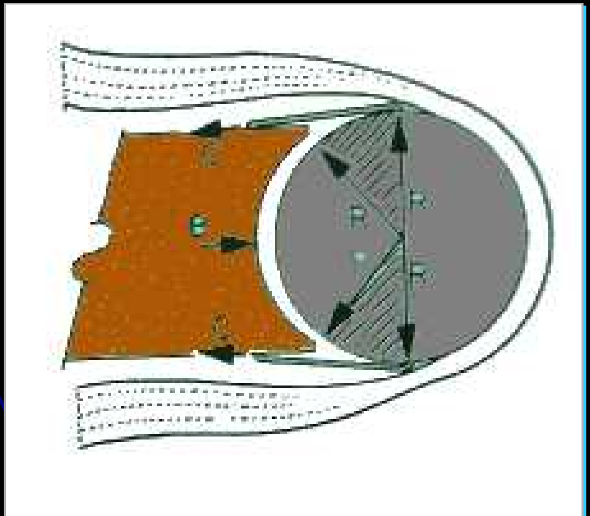
Συνδυασμένη σύσπαση μυών του τ.πετάλου και επικέντρωση της κεφαλής (steering effect)

Η συνισταμένη δύναμη μπορεί να κατευθύνεται :

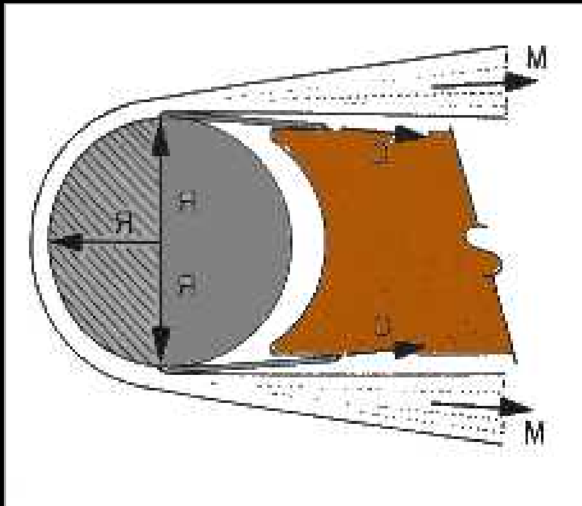
Μέσα στα όρια της γλήνης (στροφή του ώμου)



Έξω απο τη γλήνη (ακραίες θέσεις της άρθρωσης)



Μακριά από τη γλήνη(διάσταση της άρθρωσης π.χ follow-through φάση ρίψης)



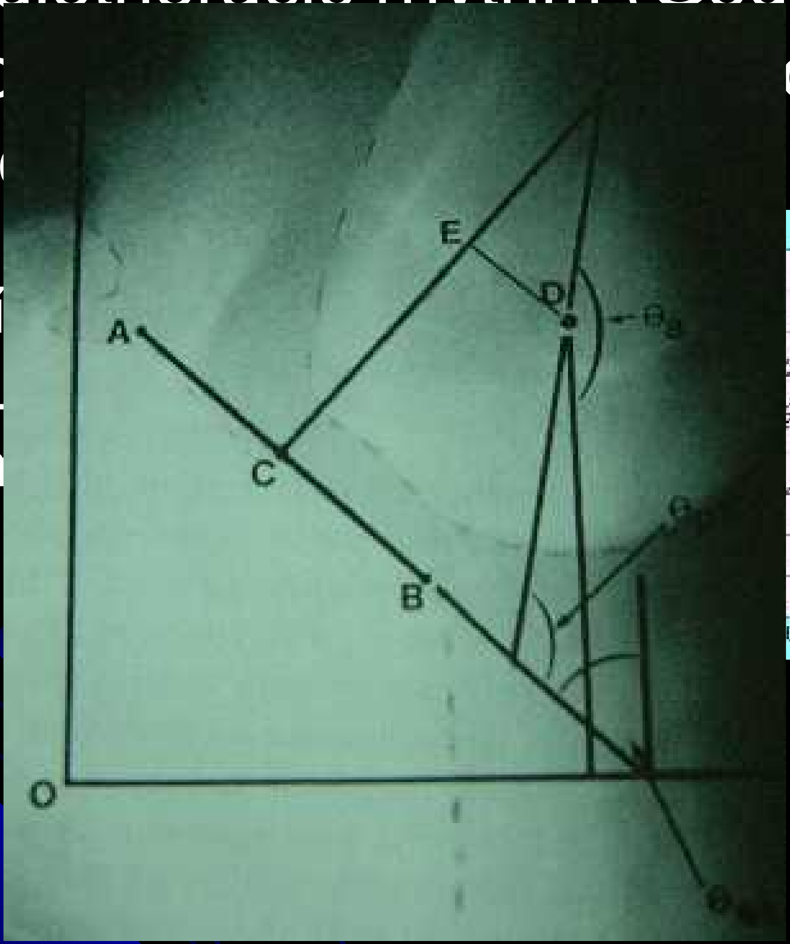
Δυναμοποίηση συνδέσμων

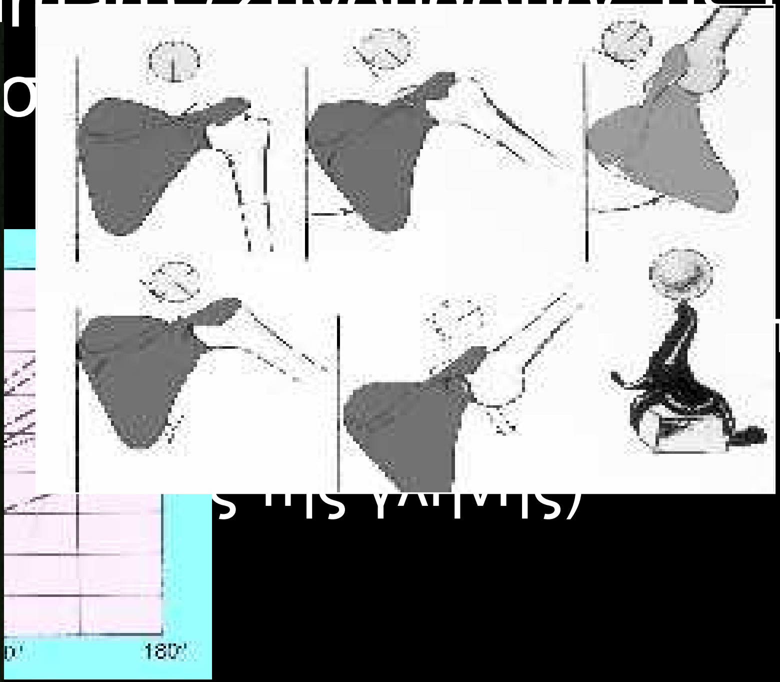
- Clark et al 1990 : Η κατάφυση του τενοντίου πετάλου στη κεφαλή β διαμέσου τμημάτων του θυλάκου και συνδέσμων β αυξάνουν τα φορτία τάσεως β δυναμοποίηση
- Στις ακραίες κινήσεις αναλαμβάνουν φορτία και προφυλάσσσουν απο υπερβολική μετατόπιση και στροφή
- Τένοντας του δικεφάλου μεγάλης σημασίας ιδίως όταν η σταθερότητα από τις θυλακοσυνδεσμικές δομές ελλατώνεται (σε ελλείμματα του θυλάκου ή κατά τη διάρκεια ρίψεων) Itoi,Morrey 1994

Θωρακοωμοπλατιαία κίνηση

- Scapulothoracic rhythm (Godman) /Συνδυασμός με τη γληνο… σ… στην (…

• ασθενεί… π. κίνηση (L… impingem… ς της γλήνης)





Επιπρόσθετοι μηχανισμοί γληνοβραχιόνιας σταθερότητας (save energy mechanisms)

1)Φαινόμενο προσκόλλησης-συνοχής Simkin 1988

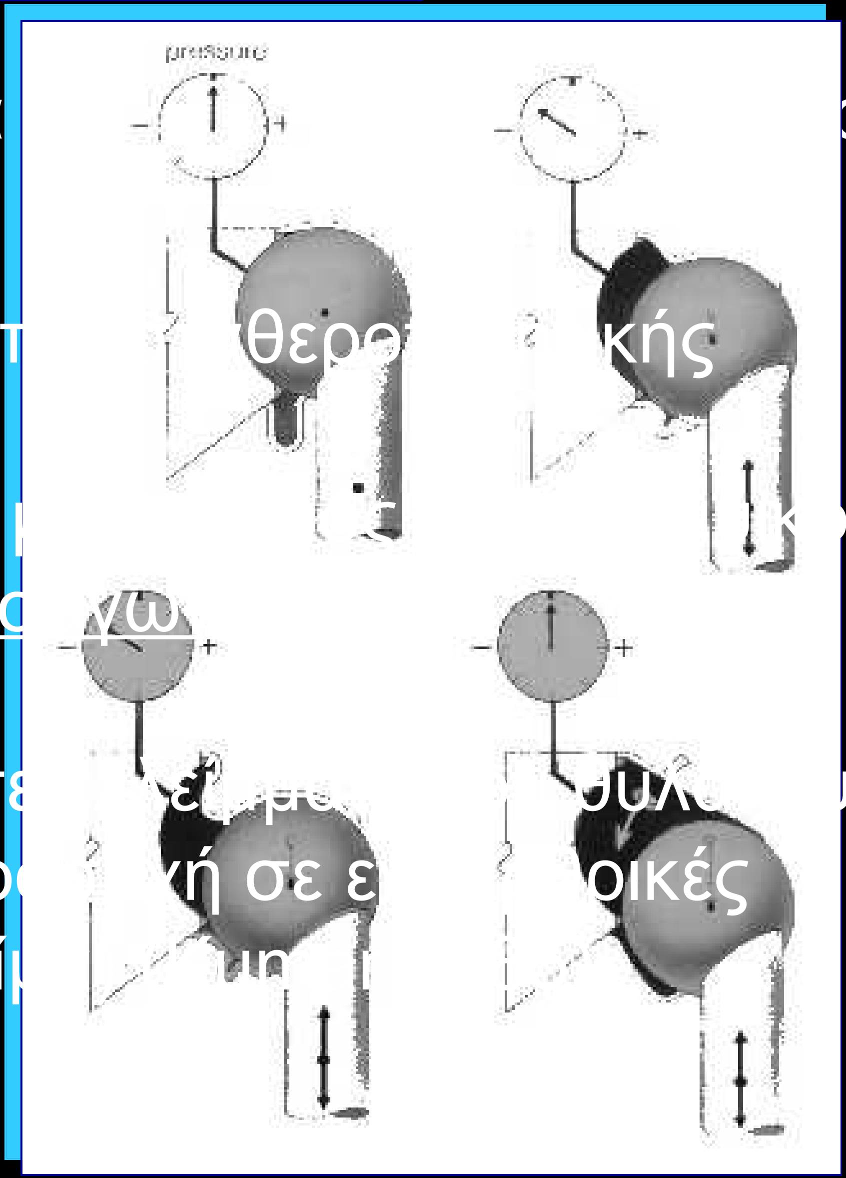
- Αρθρικές επιφάνειες με αρθρικό υγρό δ ποσότητας, διατηρούνται σε επαφή με δυνάμεις συνάφειας
- Η σταθεροποιητική δύναμη εξαρτάται απο την έκταση της αρθρικής επιφάνειας και τις ιδιότητες του υγρού.(αρθρικό υγρό ιδανικό λόγω υψηλού tensile και χαμηλού shear strength)

2)Φαινόμενο αρνητικής πίεσης

«σφραγισμένο» διαμέρισμα ct”

- Σχετικά μικρό το μέγεθος τ θερο κής δύναμης
- Κύριος σταθεροποιητικός κο τόνο στον χαλαρό σε προσ γω

- Κατάργηση μηχανισμού σε υλε υ π.χ στο rotator interval (πρ κή σε ε οικές εγχύσεις,σκιαστικό,ορός,αί



Συμπεράσματα

- Σταθερότητα στη γληνοβραχιόνιο άρθρωση πολυπαραγοντικό φαινόμενο με στατικούς και δυναμικούς παράγοντες
- Η σύσπαση των μυών του τενοντίου πετάλου β ιδίως κατά τη μεσότητα της κίνησης σταθεροποιούν την άρθρωση.
- Αρνητική ενδαρθρική πίεση β χαλαρωμένος και σε προσαγωγή ώμος
- Θυλακοσυνδεσμικά στοιχεία σα «χαλινάρια» στις ακραίες θέσεις της άρθρωσης σε υπερβολική στροφή ή μετατόπιση.

Causes of poor scapulothoracic rhythm

- Long thoracic nerve palsy

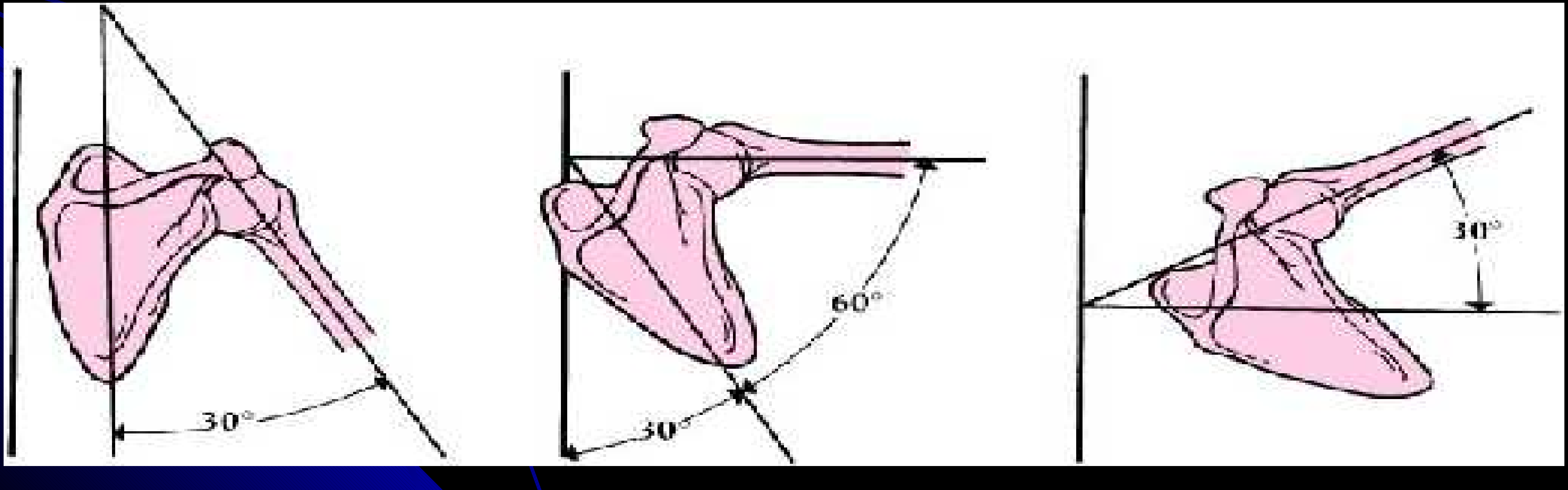
- Brachial plexopathies

Scapulohumeral Rhythm

- Initially believed to be 2:1.
- More recent proposal of three distinct patterns (each with different ratio).
- Middle phase (80–140 degrees abduction) – Scapular rotation provides greater contribution to arm elevation than GH motion.

Shoulder Evaluation (Observation)

- Scapulohumeral Rhythm
  - Movement of scapula relative to the humerus
  - Initial 30 degrees of glenohumeral abduction does not incorporate scapular motion (setting phase)
  - 30 to 90 degrees the scapula abducts and upwardly rotates 1 degree for every 2 degrees of humeral elevation
  - Above 90 degrees the scapula and humerus move in 1:1 ratio



Scapulothoracic Joint

- Not a typical articulation--does not connect bone to bone
- It is a physiologic joint
  - Scapula rests on 2 muscles which attach to it
    - Serratus Anterior
    - Subscapularis
- Deep to these is the thorax

Scapulothoracic Joint

- Scapula will move across thorax as a result of motions at S-C and A-C joints
- Approx 65% of this ROM occurs b/c of motion at S-C
- Approx 35% occurs b/c of motion at A-C
- Total ROM of motion for scapulothoracic joint is approx. 60° for 180° of arm abduction or flexion

Glenohumeral Joint

- This is the true shoulder joint
- Ball and socket joint
- Largest ROM and movement potential in the body
  - Reasons for this characteristic include:
    - Shallow joint
    - Lax joint capsule
    - Limited Ligamentous support

Glenohumeral Joint

- Glenoid shallow socket on scapula--faces slightly anterior--consequences???
  - Glenoid labrum--rim of fibrocartilage
    - Deepens socket--increases contact area up to 75%
  - Joint Capsule
- Ligamentous Stability
  - Anterior--glenohumeral ligaments
  - Posterior--only joint capsule

Glenohumeral Joint

- Motions
  - Flexion & Extension--180° flex, 60° ext
    - Flexion limited to 30° when internally rotated
  - Abduction & Adduction--180 ° abd, 75 ° hyperadd
    - Abduction limited to 60 ° when internally rotated
  - Internal and External Rotation--neutral=180 °
    - In abduction, limited to 90 °
  - Horizontal Flexion & Extension--135 ° flex, 45 ° ext

Joint Stability

- When arm is neutral, ligaments are loose, allowing IR and ER
- As arm is externally rotated, the the capsule becomes tighter
- When arm is abducted inferior ligamentous tissue becomes tighter, more so with ER
- In extreme abduction and ER, ligaments become tight around joint, giving stability

Muscular Stabilizers

- Muscles are arranged to provide large stabilizing components
- Prime stabilizers--Rotator Cuff
  - Pull head of humerus into the fossa
- Deltoid
  - Large stabilizing component, regardless of position of humerus

Muscular Stabilizers

- Long head of biceps
  - Effective because of proximity to joint
    - Most effective when shoulder is extended
- Long head of triceps
  - Effective because of proximity to joint
    - Most effective when shoulder is flexed

Prime Movers

- Abduction
    - Deltoid
        - Supraspinatus
- Adduction
    - Pectoralis Major
    - Latissumus Dorsi
- Flexion
    - Anterior Deltoid, Pec Major
    - Biceps
- Extension
    - Posterior Deltoid, Lats, Triceps

Prime Movers

- Internal Rotation
  - Lats, Subscapularis
- External Rotation
  - Infraspinatus, Teres Minor
- Horizontal Flexion
  - Pec Major
- Horizontal Extension
  - Posterior Deltoid, Triceps

Scapulohumeral Rhythm

- When the arm moves, the shoulder girdle moves as well
- The arm can only move in the first 30 deg. of abduction before scapula moves
- After 30 degrees, the g-h/scapula ROM occurs at a ratio of 2:1
- For every 2 deg. of abduction, the scapula will move laterally, anteriorly and superiorly 1 deg.

Mechanics of Abduction

- Supraspinatus initiates first few degrees of abduction
  - (first class lever gives better angle of pull than deltoid
- At this point stabilizing component of deltoid is actually a dislocating component
- Pulls humerus up away from glenoid and against the acromion

Mechanics of Abduction

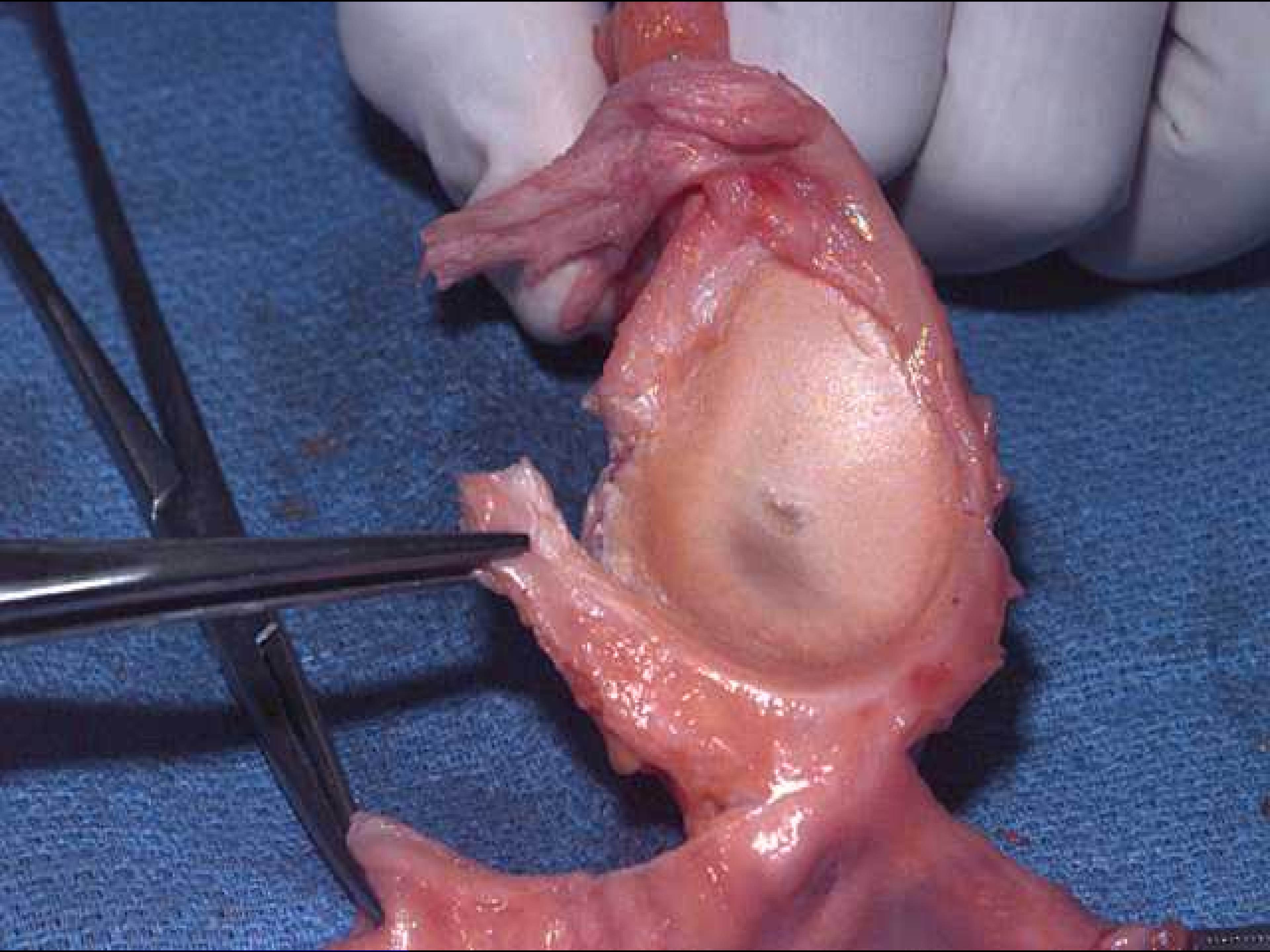
- Rotator cuff pull humeral head against glenoid to counteract deltoid
  - Supraspinatus pulls into fossa
  - Infraspinatus, Teres minor, and Subscap have downward components
- Deltoid takes over after first few degrees

Mechanics of Abduction

- As angle approaches 90, greater tuberosity abuts the coracoacromial arch--acromion and coracoacromial ligament
- Soft tissue becomes compressed
- If arm is externally rotated, greater tuberosity can clear arch
- 30 deg ROM becomes available

Physiological Considerations

- Superior migration of humeral head due to rotator cuff weakness
- Any activity that narrows the space
  - Overhead activities
- Rotator cuff tendonitis
- Subacromial bursitis
- Supraspinatus zone of hypovascularity
  - Wringing out effect



Apprehension Test

- Start with abduction, no rotation. Gently add External Rotation

Traumatic Instability

- >98% are anterior (dislocated with arm in some combination of abduction/external rotation)
- Neurovascular injury is rare
- Initial tx: shoulder immobilizer (4weeks), refer to Ortho and PT
- Beware patients > 50 yo (RCT is common)
- Surgery if recurrent

Where does ‘velocity’ come from

Atraumatic Instability

- Repetitive microtrauma in a position of instability (ABD/ER): swimmers, throwers, weight lifters. “Secondary impingement”
- Anterior capsule is slowly being stretched.
- Tx: PT to strengthen anterior rotator cuff (subscapularis) for “muscle repair” and restrict offending activities

Glenohumeral Joint

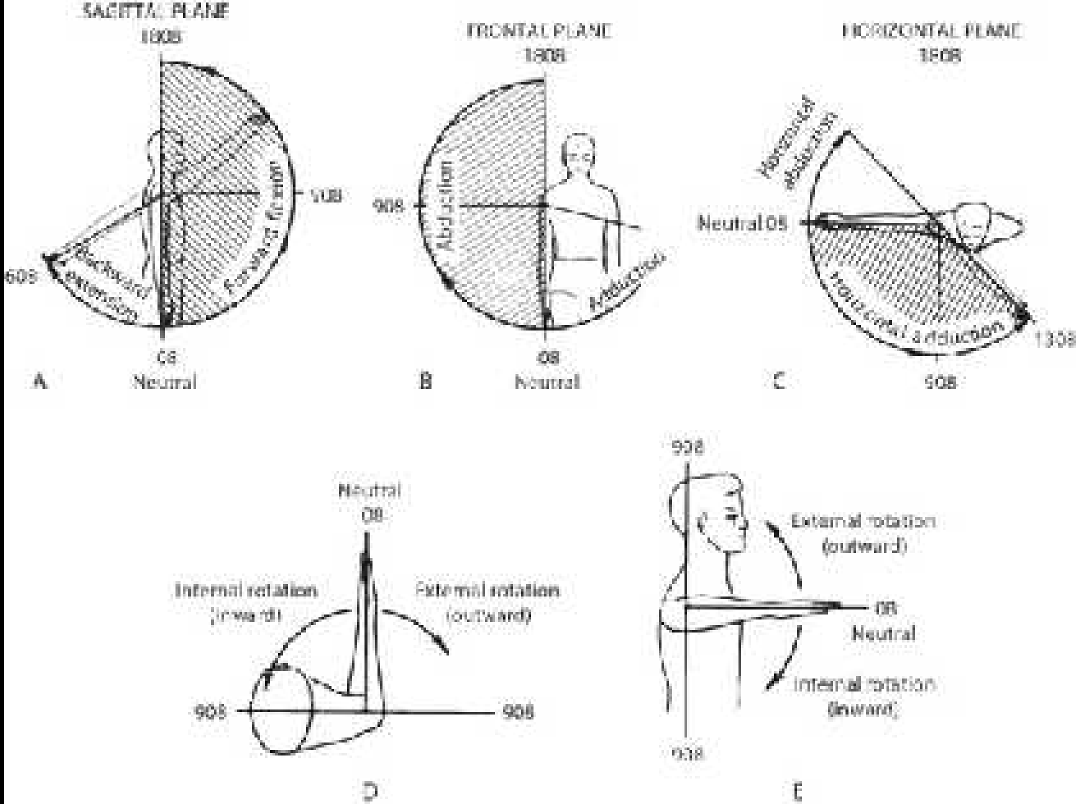
- Frequently injured due to anatomical design
  - shallowness of glenoid fossa
  - laxity of ligamentous structures
  - lack of strength & endurance in muscles
  - anterior or anteroinferior glenohumeral subluxations & dislocations – common
  - posterior dislocations – rare
  - posterior instability problems somewhat common

The Shoulder Joint

- Wide range of motion of the shoulder joint in many different planes requires a significant amount of laxity
- Common to have instability problems
  - Rotator cuff impingement
  - Subluxations & dislocations
- The price of mobility is reduced stability
- The more mobile a joint is, the less stable it is & the more stable it is, the less mobile

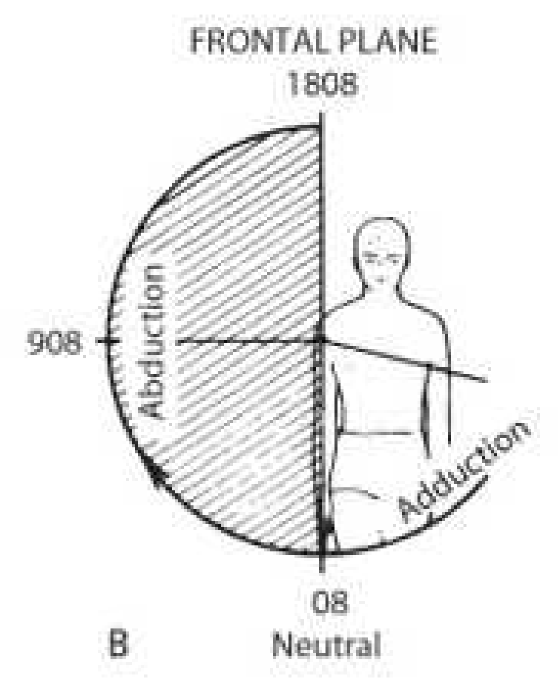
Glenohumeral Joint Range of Motion

- Determining exact range of each movement is difficult due to accompanying shoulder girdle movement



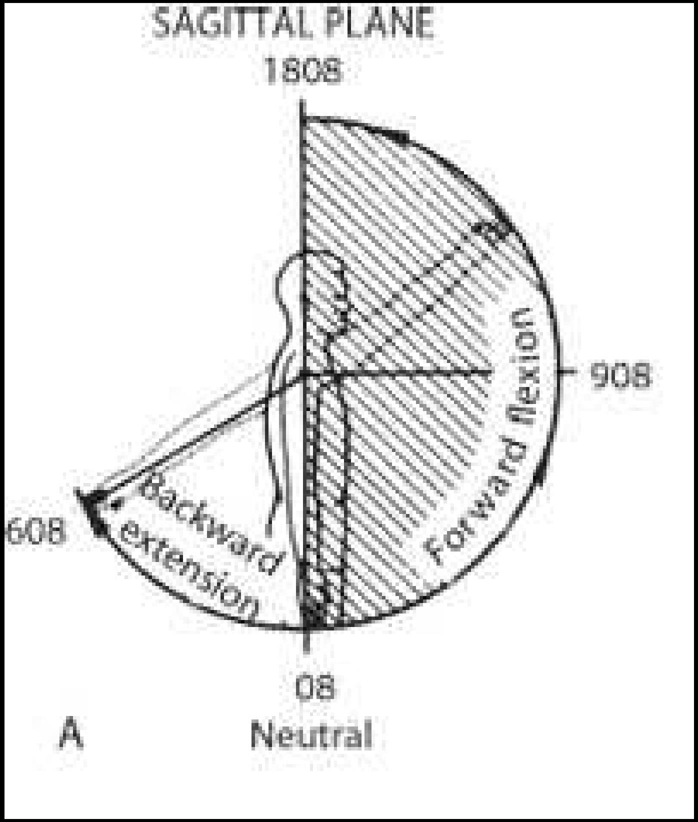
Glenohumeral Joint

- 90 to 95 degrees abduction
- 0 degrees adduction, 75 degrees anterior to trunk



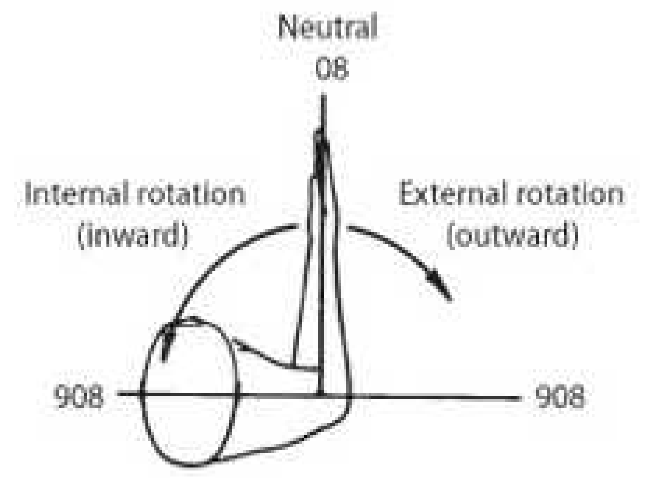
Glenohumeral Joint

- 40 to 60 degrees of extension
- 90 to 100 degrees of flexion

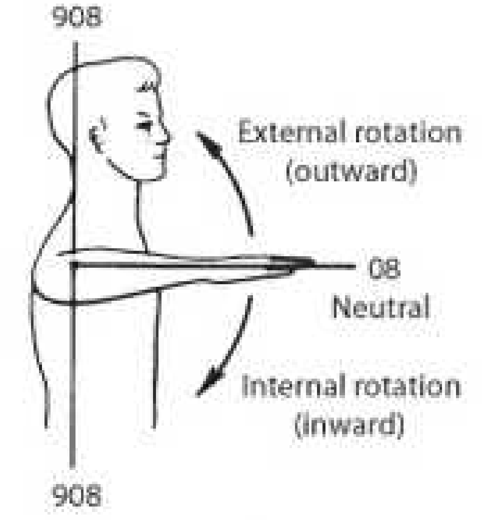


Glenohumeral Joint

- 70 to 90 degrees of internal & external rotation



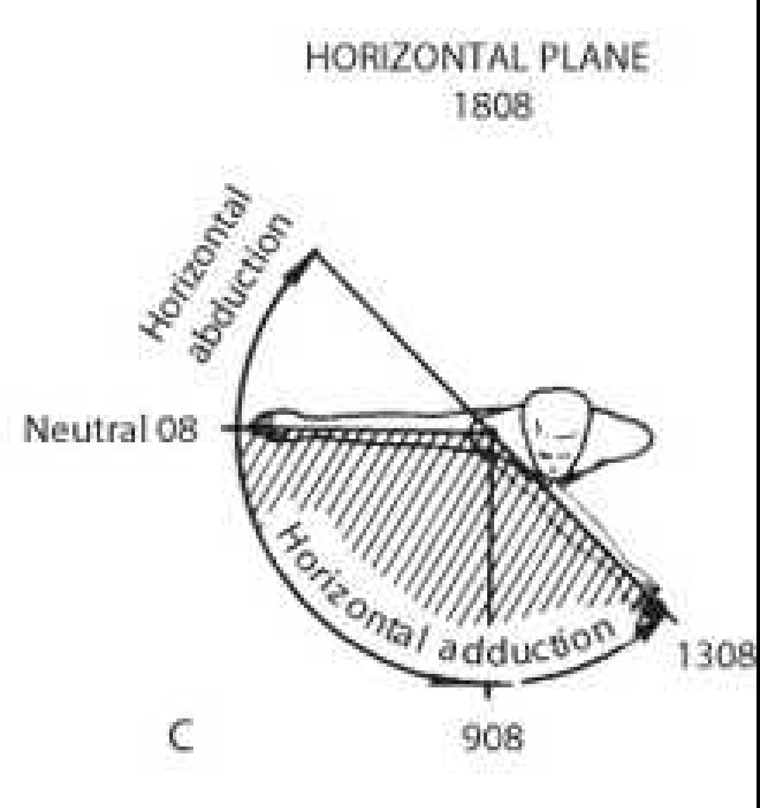
D

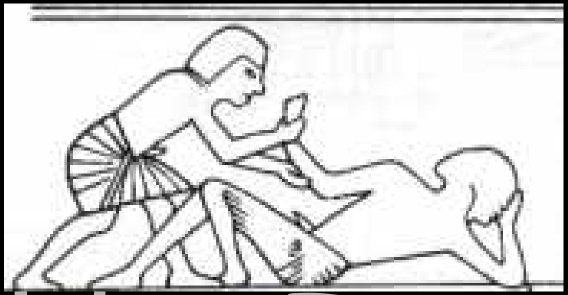


E

Glenohumeral Joint

- 45 degrees of horizontal abduction
- 135 degrees of horizontal adduction





Shoulder Instability

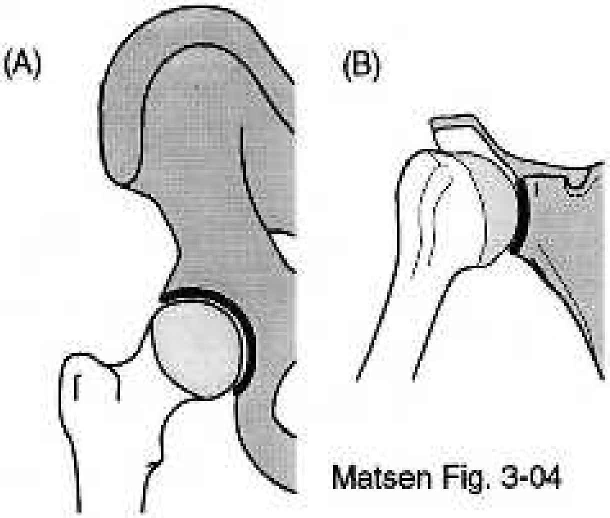
"It deserves to be known how a shoulder which is subject to frequent dislocations should be treated… I have never known any physician treat the case properly."

Hippocrates, 400 BC

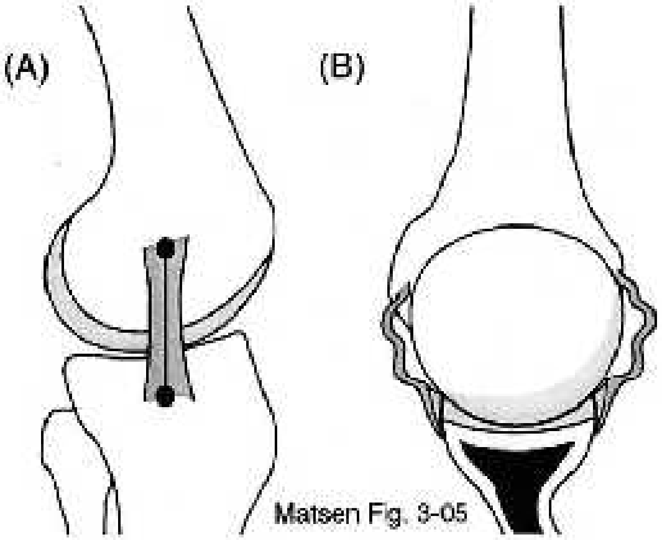
Instability vs. Laxity

- Instability -
    - symptomatic inability to maintain the humeral head centred in the glenoid fossa
- Laxity -
    - humeral head can be passively translated across glenoid fossa more than normal

Anatomy of the GH joint

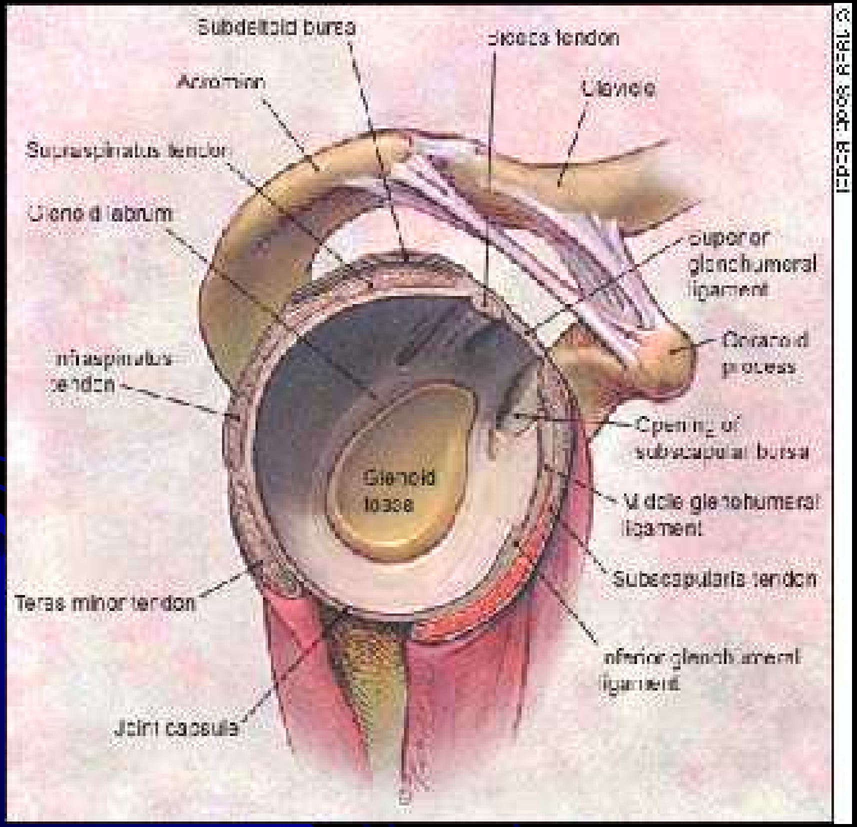


Matsen Fig. 3-04



Matsen Fig. 3-05

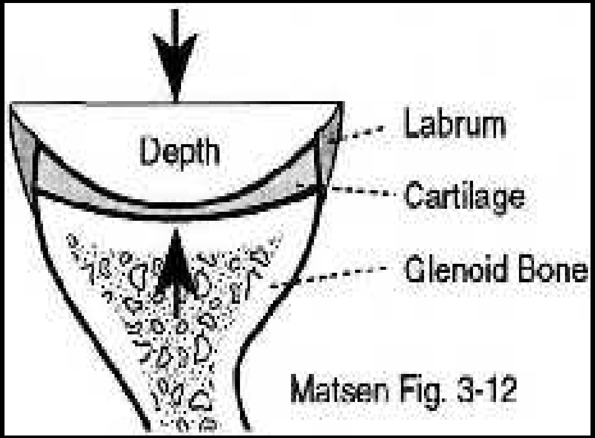
Stabilisers



- Rotator Cuff-
  - dynamic stabiliser
  - passive muscle tension
  - ligament tightening
  - compression of articular surface
- GHL-
  - static stabiliser

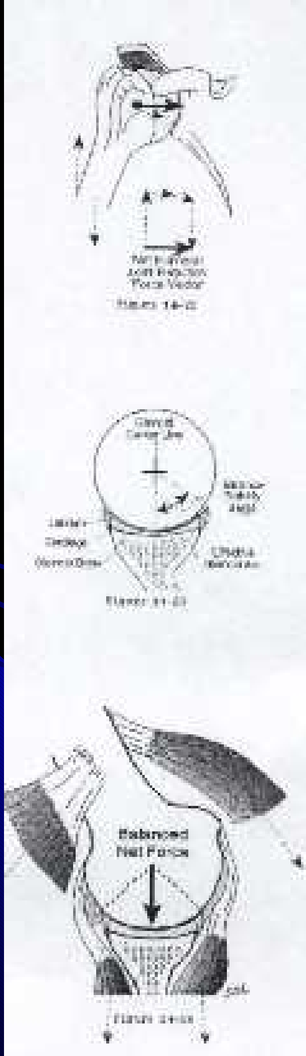
Contributors to stability

- Passive
  - Jt conformity
  - Jt pressure
  - adhesion/cohesion
  - ligament

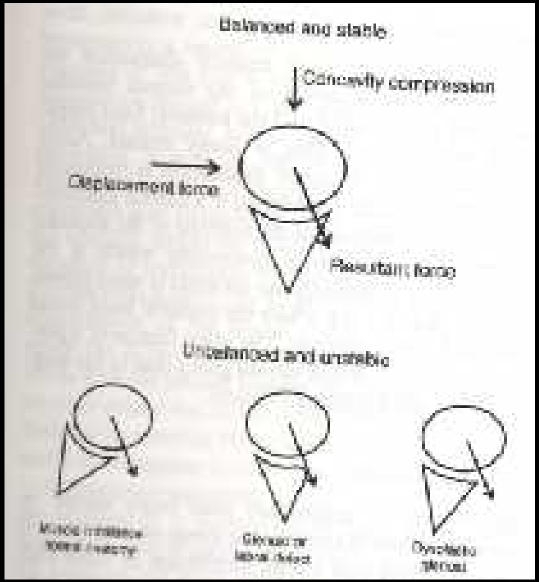


Matsen Fig. 3-12

Biomechanics of instability



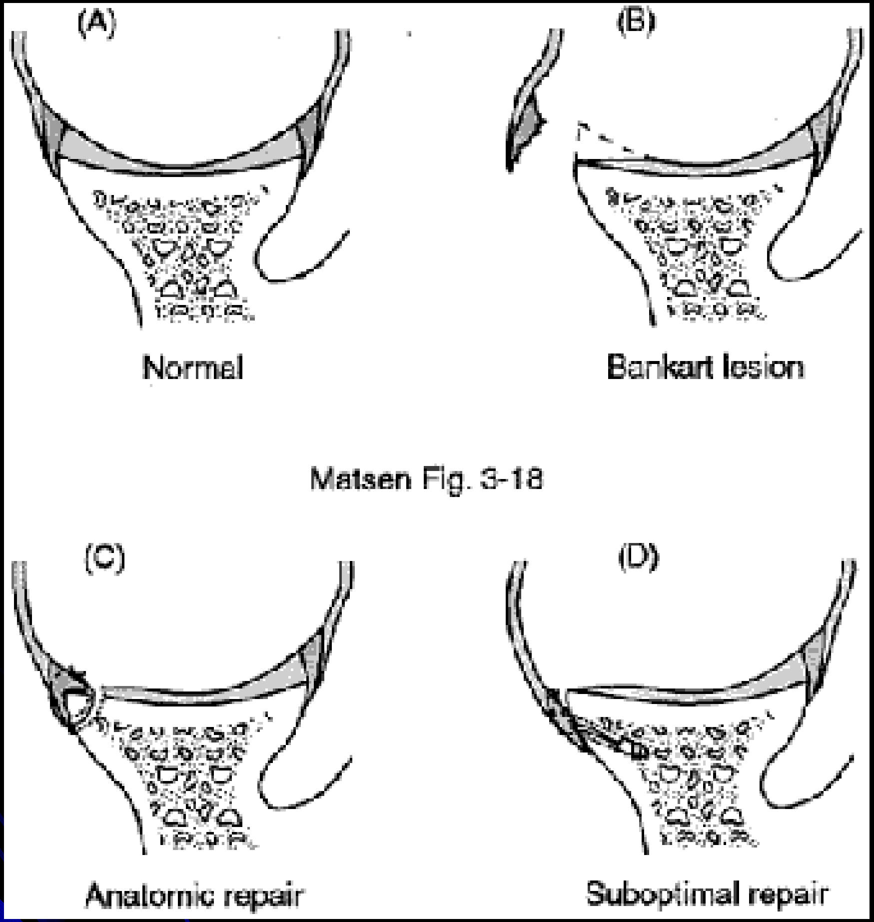
- Net humeral joint reaction force
- Effective glenoid arc



Pathology

- Injury to Inferior Gleno-humeral ligament
  - may fail at glenoid rim (Bankart lesion)
  - ? not sufficient alone to produce instability
  - fail at midsubstance (attenuation)

Biomechanics of Bankart repair



Forces Acting on the Shoulder

- During the later stages of abduction, the Rotator Cuff muscles provide a downward pull on the humeral head
  - *Allows for the humeral head to pass under the acromion unimpeded*
  - *Deceleration of the humerus in throwing is assisted by eccentric contractions of the infraspinatus & teres minor*

Forces Acting on the Shoulder

- Force Couple – during abduction a force couple exists between the line o pull between the supraspinatus & th deltoid m. group

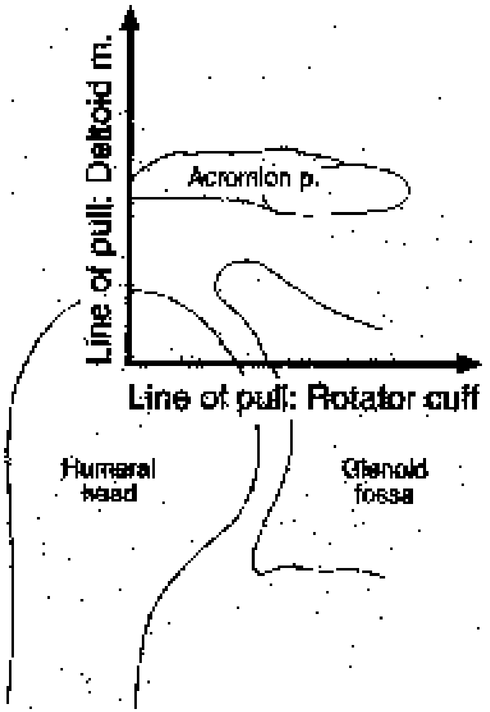


FIGURE 13–15. Scapulohumeral force couple. Contraction of the deltoid muscle pulls the humeral head upward. To prevent contact between the humeral head and the acromion process during abduction, the rotator cuff must hold the humeral head close to the glenoid fossa and, when the humerus approaches 90° of abduction, must serve to glide the humerus inferiorly.

Scapulothoracic Rhythm (Scapulohumeral)

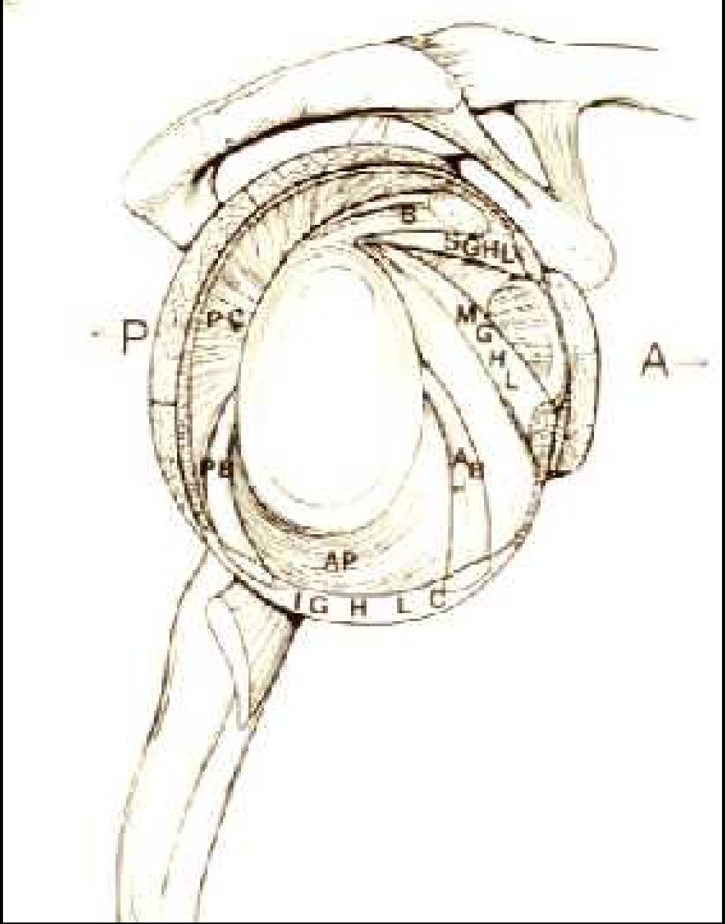
- 0-30° All humerus movement – setting phase
- 30-90° 2:1 humerus abduction: scapula abduct
- 90°-full abduction 1:1 ratio

Important ligaments

- Glenohumeral ligament (4 sections)
    - **Superior Glenohumeral (SGHL)**
    - **Middle Glenohumeral (MGHL)**
    - **Anterior Inferior Glenohumeral (AIGHL)**
    - **Inferior glenoid ligament (IGHL):**Main static stabilizer of the glenohumeral joint

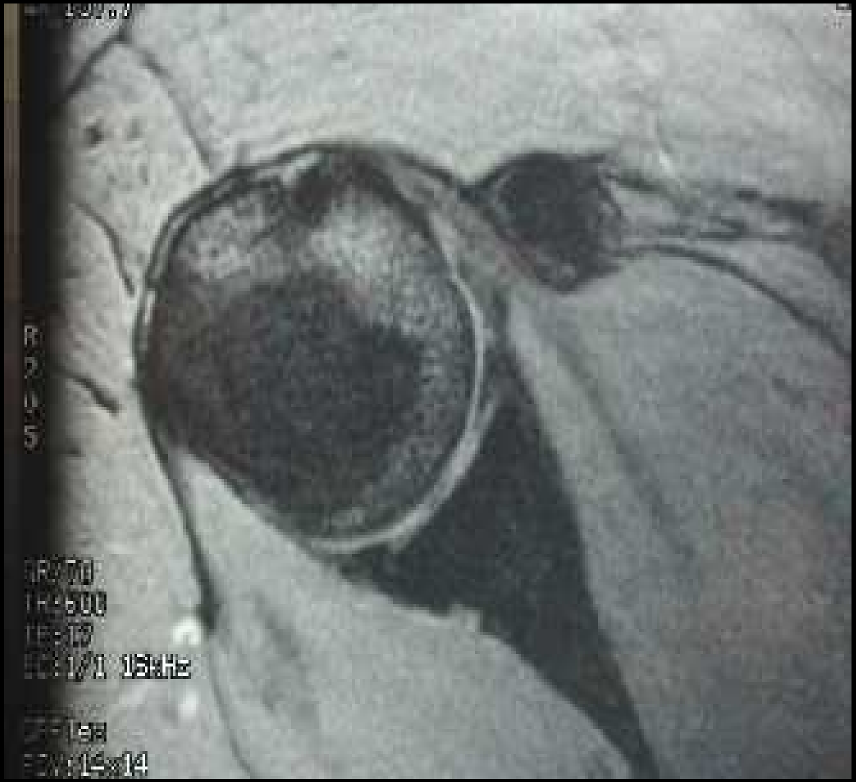
Ligaments

- Thickened bands within the capsule
- SGHL
- MGHL
- IGHL
  - AIGHL
  - PIGHL



Labrum

- Deepens socket
- Ligament attachment



Rotator Interval

- Between Subscapularis and Supraspinatus
- Widening allows increased inferior translation of humeral head
- Normally tightens with external rotation

Basic Concepts

- Spectrum
  - Minor instability with activity related pain
  - Recurrent subluxation
  - Recurrent dislocation
  - Locked dislocation with loss of motion

Basic Concepts

- Multifactorial
  - Ligamentous laxity
  - Repetitive micro-trauma
  - Macro-trauma
  - Combination

The Most Important Factors In Treating Instability Are Recognizing It And Defining It.

Defining Instability

- Direction
  - Anterior/Inferior – most common
  - Posterior
  - Multidirectional
- Frequency

Defining Instability

- Degree
  - Pain
  - Subluxation
  - Dislocation
- Volition
  - The voluntary dislocator – be afraid, be very afraid.

Voluntary Posterior Subluxation

Ligamentous Laxity

Anterior Capsule

- Subscapularis Tendon
- Labrum
- Anterior Capsular Ligaments
  - Coraco Humeral, GH, Inferior GH Ligament
  - *Inferior may be the most important ligament in the shoulder*
- Anterior Synovial pouches and bursae

Rotator Cuff Muscles

- Supraspinatus - abduction
- Infraspinatus - external rotation
- Teres Minor - depression, external rotation, extension

Spells SIT

- Subscapularis - internal rotation

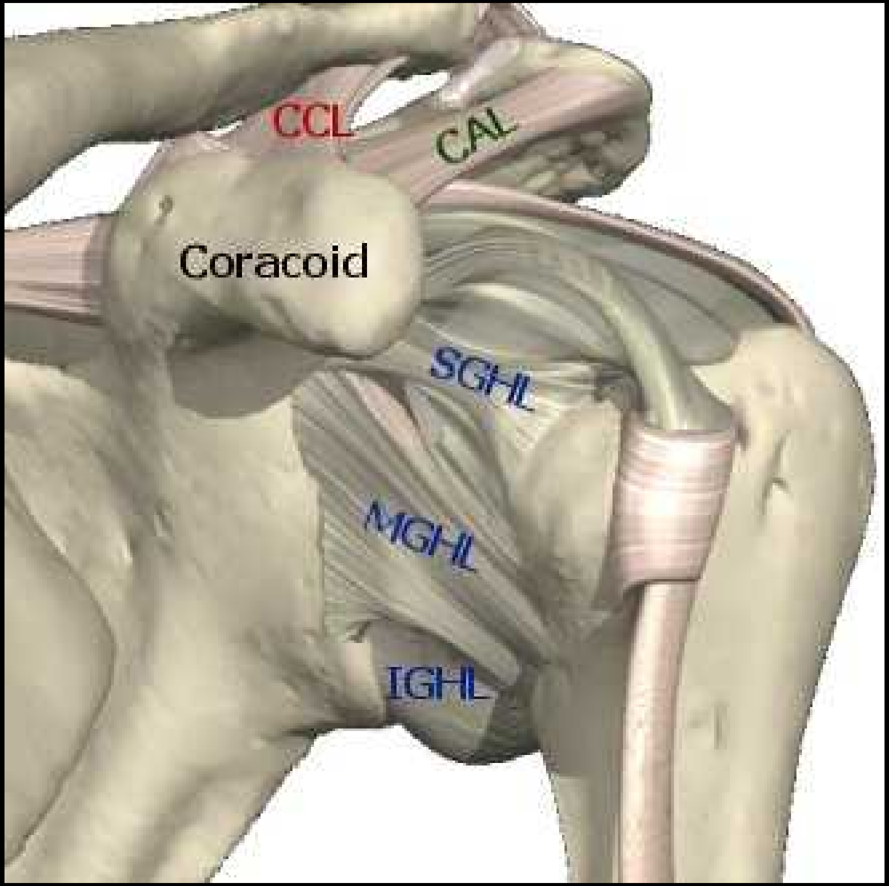
Cuff Functions

- Anterior Posterior Stability
- Internal and External Rotation
  - eccentrically and concentrically
- Elevation - Depression
- Protraction
- Retraction
- Joint Translation

- Fine Tuners
- Stabilizers
- Maintain joint contact areas

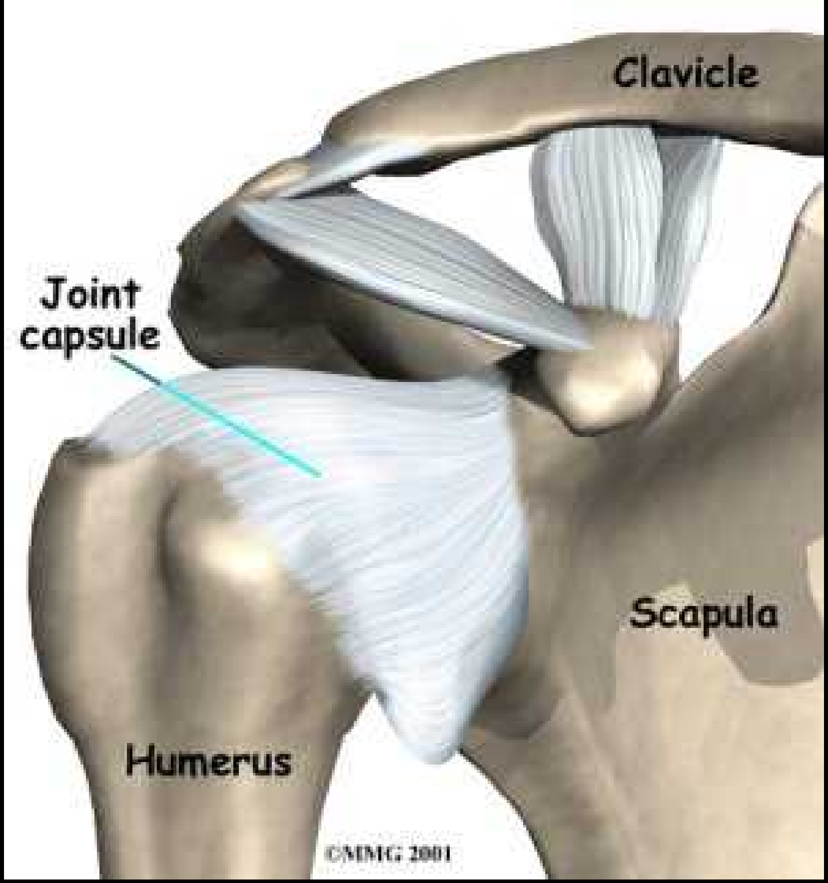
Anatomy of the Shoulder

- Ligaments
  - Where?
  - What?
  - Glenohumeral



Anatomy of the Shoulder

- Joint Capsule
  - Loose
  - Unrestricted ROM
  - Reinforced



Anatomy of the Shoulder

- Glenoid Labrum
  - Dense, fibrous structure
  - Oval
  - Deepens glenoid fossa
  - Stability

Shoulder, Lateral View
(Humerus Removed)

Shoulder Dislocation

- Fast Facts
  - 50 % of ALL dislocations
  - 95 % anterior
  - 85 % caused by trauma recur

Shoulder Dislocations

- Mechanism?
  - Anterior vs. posterior
    - Forced abduction, external rotation, extension
    - Forced adduction, internal rotation; FOOSHA

Shoulder Dislocations

- Defects following dislocation?
  - Hill-Sachs
  - SLAP
  - Bankart

Instability

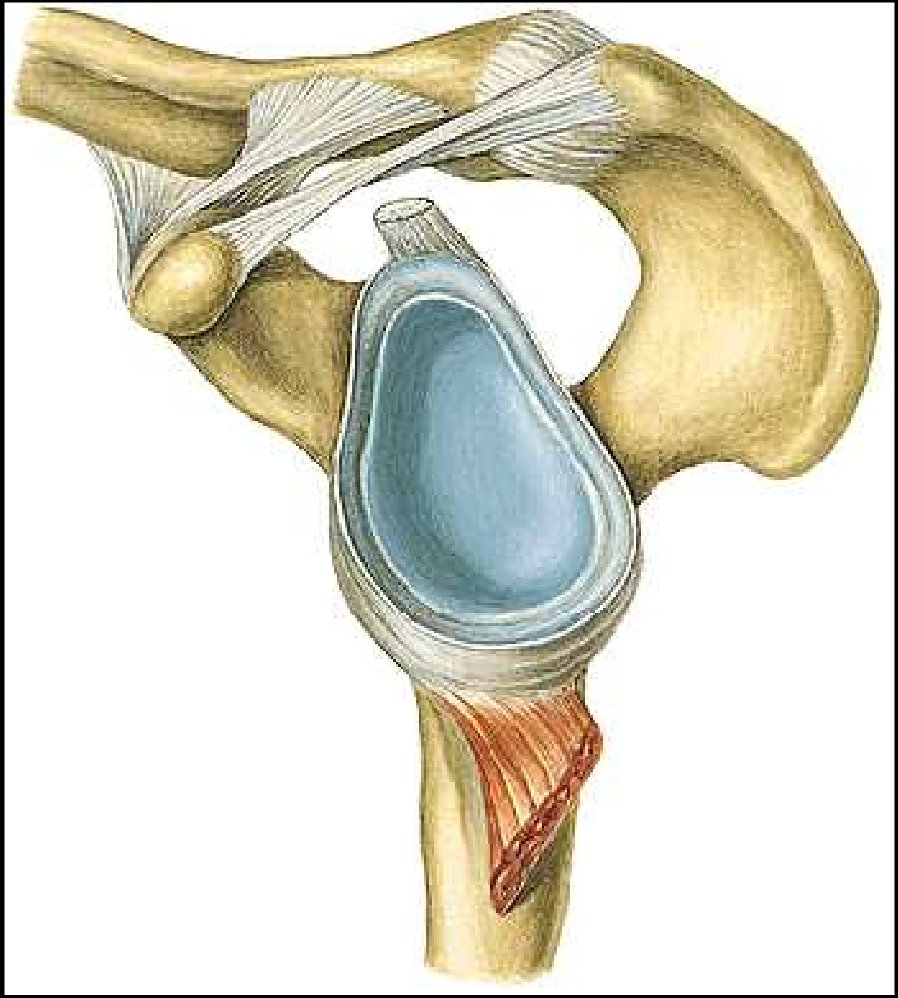
- Stability relies on ligaments and rotator cuff action
- Inferior glenohumeral ligament
  - Maximally stretched in external rotation
  - Chronic stretching can cause functional incompetence
  - Causes rotator cuff to work harder – can fatigue or tear

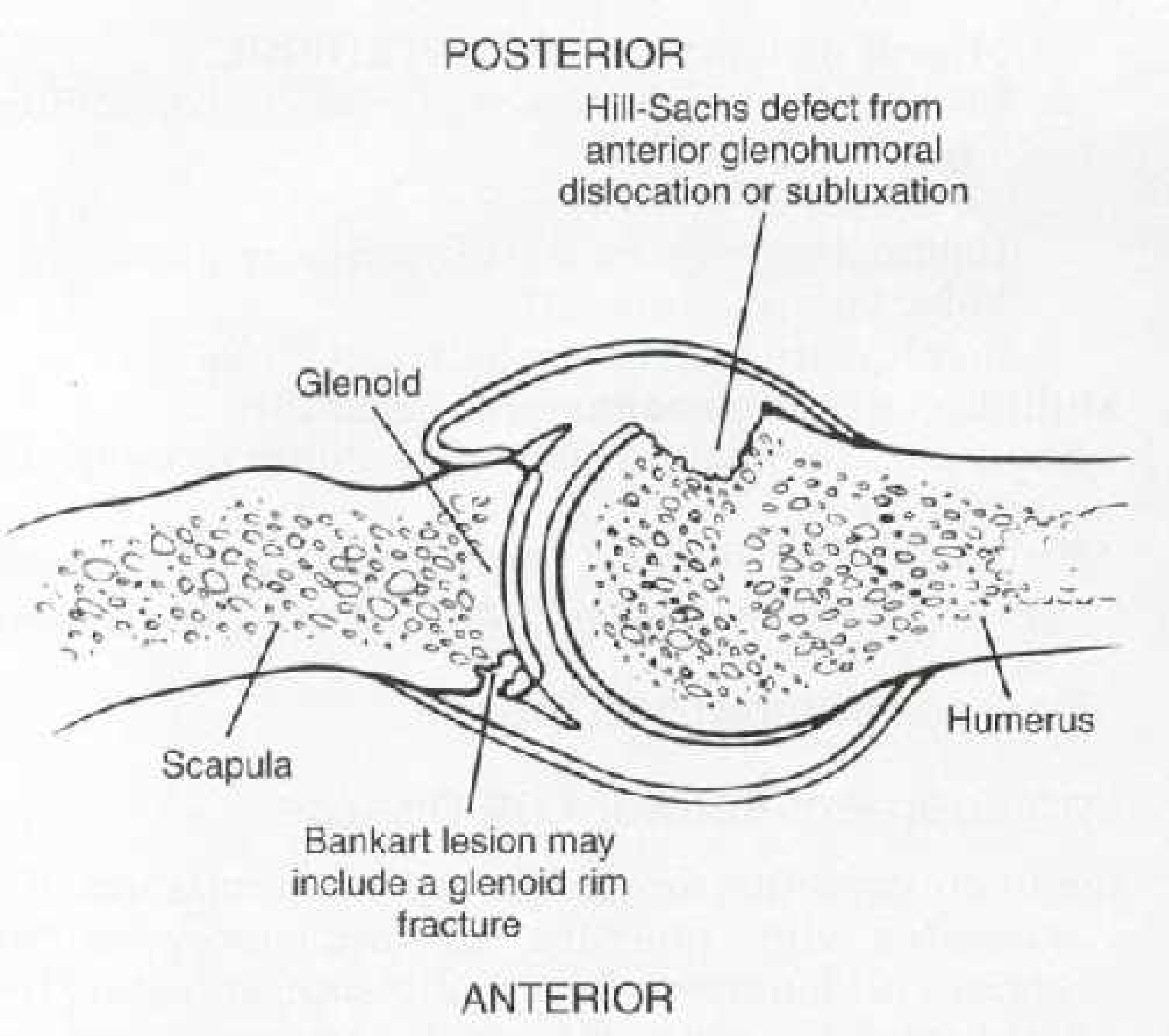
Instability

- Stability relies on ligaments and rotator cuff action
- Inferior glenohumeral ligament
  - Maximally stretched in external rotation
  - Chronic stretching can cause functional incompetence
  - Causes rotator cuff to work harder – can fatigue or tear

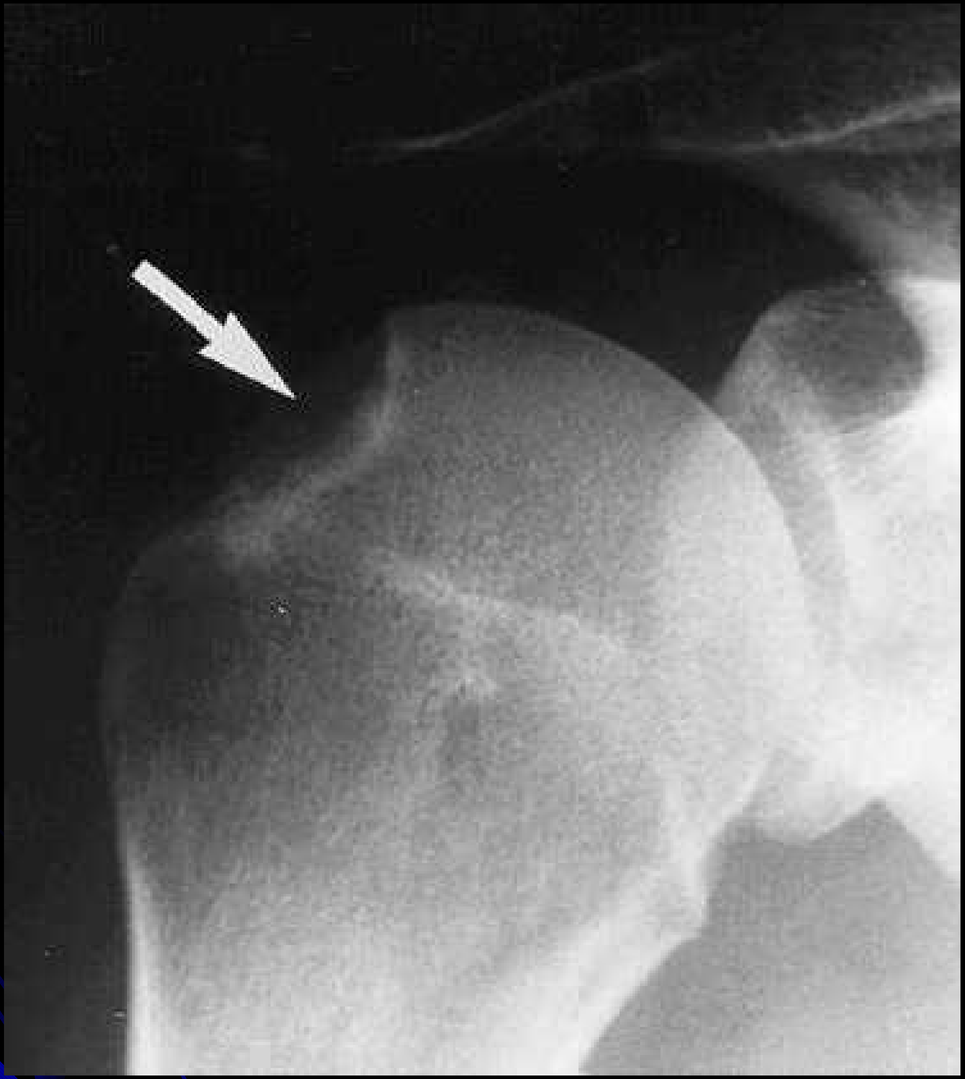
A-C Joint

- Ligaments
    - A-C
    - C-C

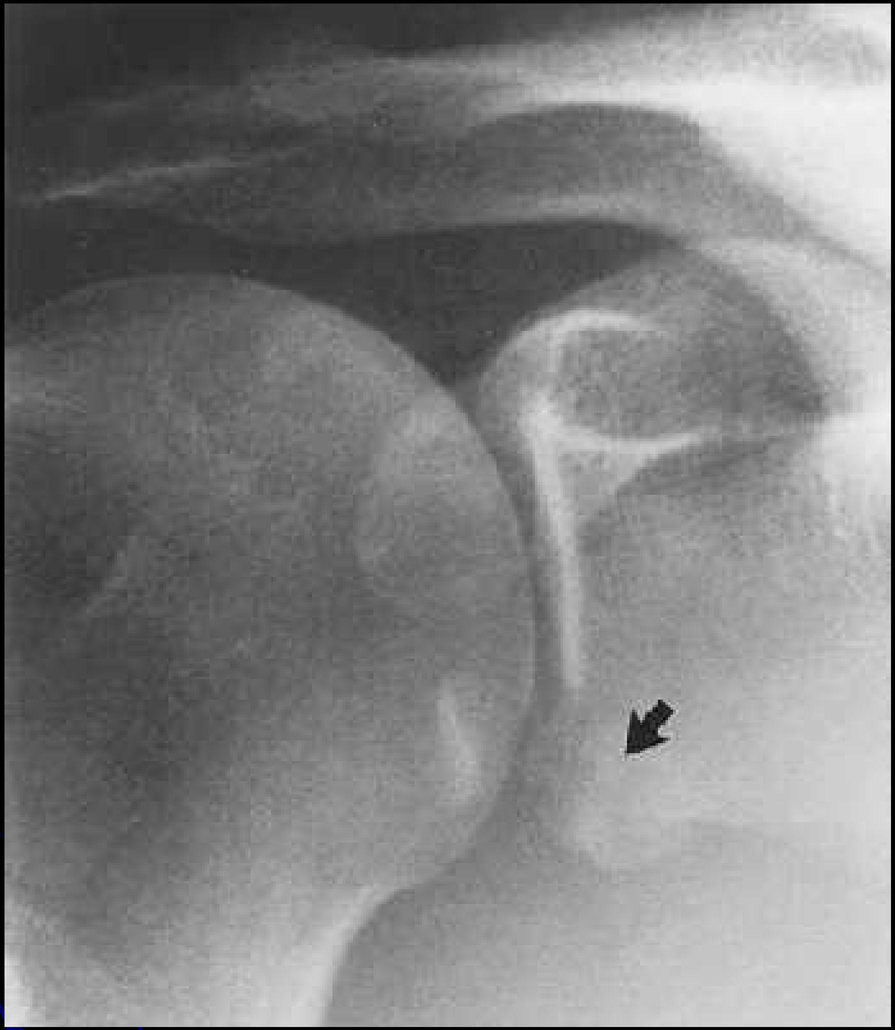



POSTERIOR
Hill-Sachs defect from anterior glenohumoral dislocation or subluxation
Glenoid
Scapula
Humerus
Bankart lesion may include a glenoid rim fracture
ANTERIOR

Hill – Sachs Lesion

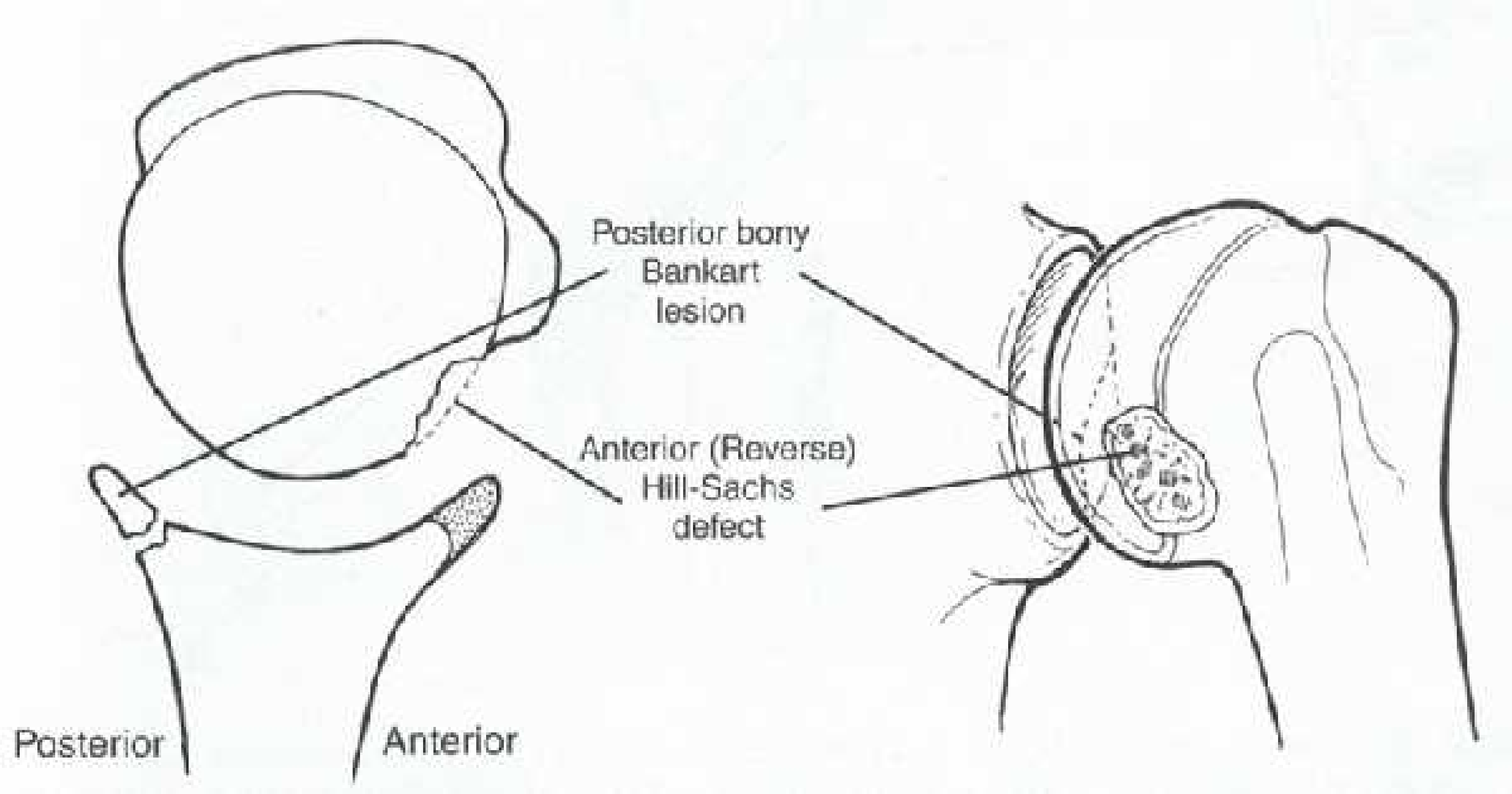


Bony Bankhart Lesion



Associated Injuries

- Associated fractures:
  - Reverse Hill - Sachs defect (hatchet - shaped anterior humeral head impression fracture)
  - Reverse Bankart lesion (posterior glenoid rim)
  - Lesser tuberosity fracture


Posterior bony
Bankart
lesion
Anterior (Reverse)
Hill-Sachs
defect
Posterior
Anterior

Continuum of Shoulder Stability

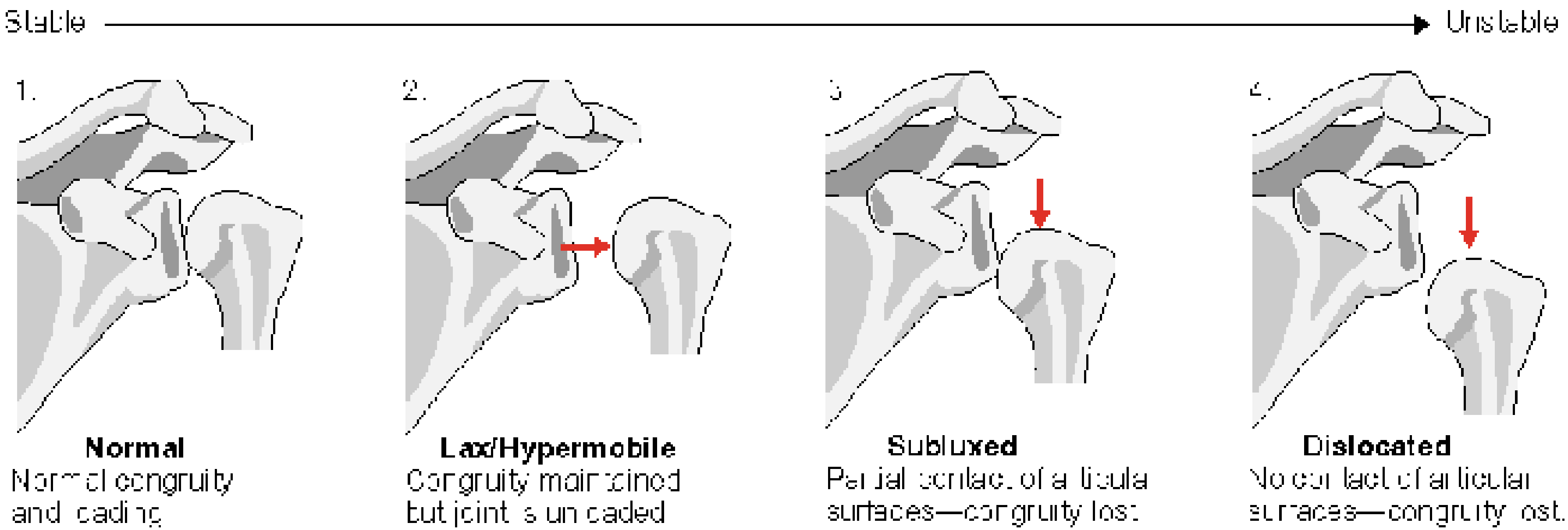


FIGURE 26-25. Continuum of shoulder stability. (Adapted from Strauss MB, Wrobel LJ, Neff RS, Cady GW. The shrugged-off shoulder: a comparison of patients with recurrent shoulder subluxations and dislocations. Physician Sports Med 1983;11:96.)

Hall & Brody. Therapeutic Exercise: Moving Toward Function, 2nd Edition

Contribution of Shoulder Musculature to Joint Stability

- Passive muscle tension from bulk effect of rotator cuff.
- Rotator cuff contraction – Compression of articular surfaces.
- Joint motion that secondarily tightens passive ligamentous restraints.
- Barrier or restrain effect of contracted rotator cuff muscle.
- Redirection of joint force to center of glenoid surface by coordination of forces from GH and ST joints.

Scapulothoracic Muscle Balance

- Efficient forces depend on stability of origins on scapula.
- Scapular position affects length-tension properties of rotator cuff.
- Scapular upward rotation, posterior tilt, lateral rotation – <u>necessary to maximize subacromial space</u>.

Contact forces in the joint

[illegible]

[illegible]

Runc

Runcima

Runciman

Runciman

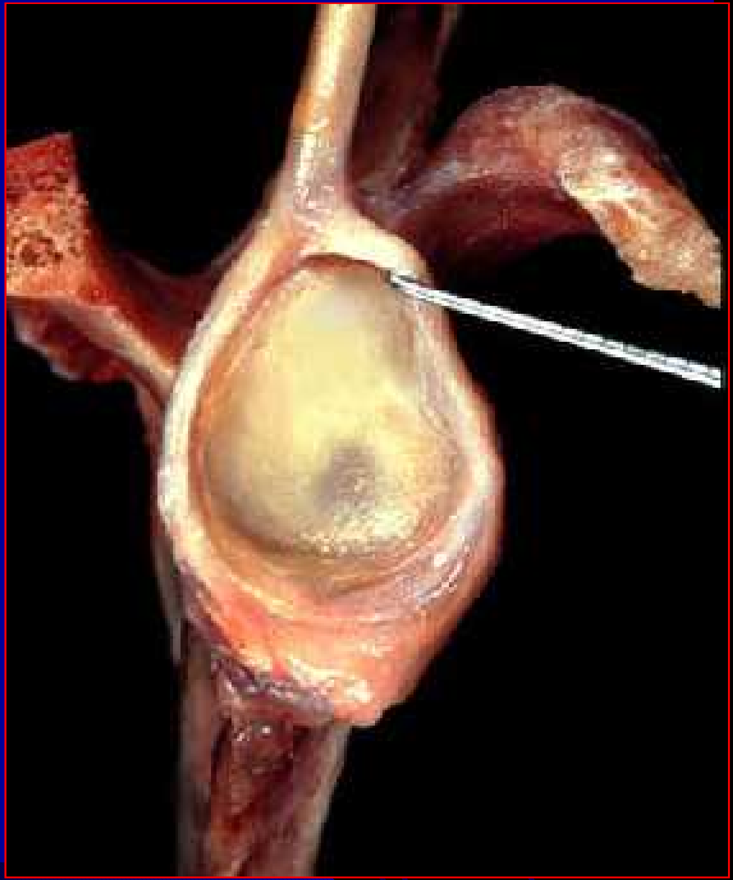
Karlsson and Peters

Karlsson

---

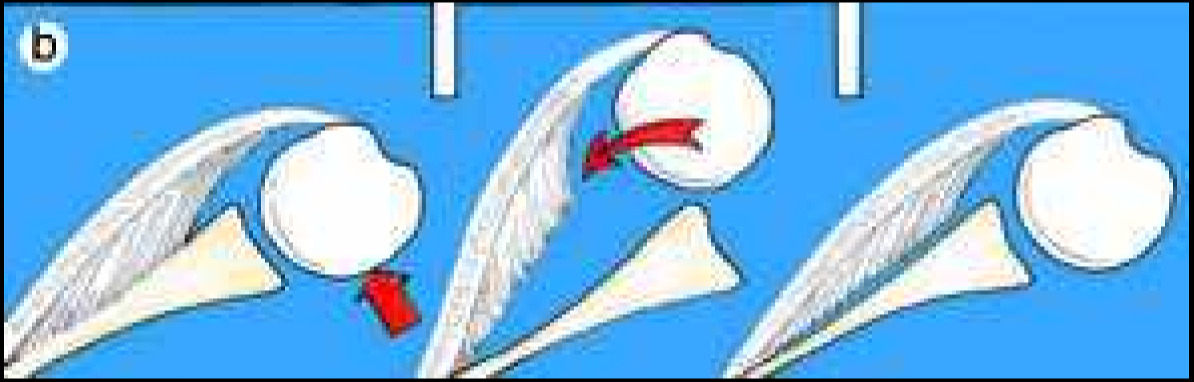
* Patients lifted themselves

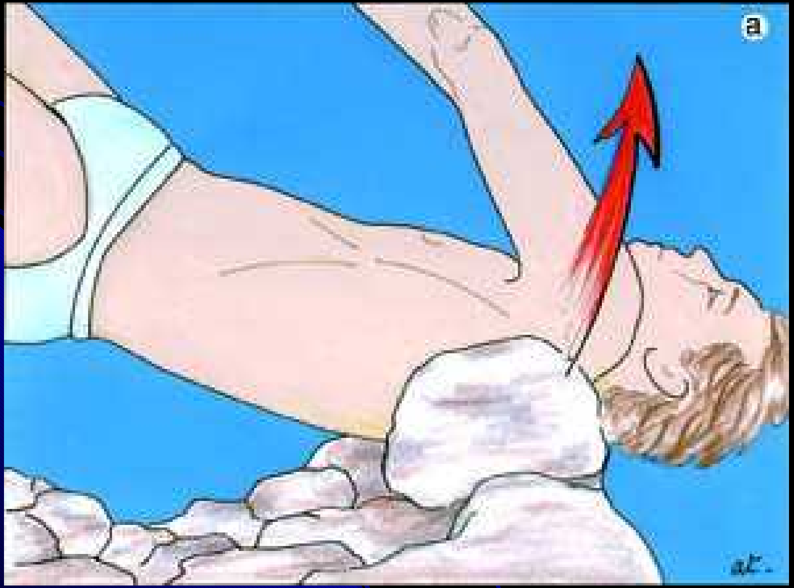
ΛΕΙΤΟΥΡΓΙΚΗ ΑΝΑΤΟΜΙΚΗ ΤΟΥ ΩΜΟΥ



- Βάθος ωμογλήνης 2.5 mm
- Ύψος επιχειλίου 2.5 mm
- Αρνητική ενδαρθρική πίεση 146 N
- Γληνοβραχιόνιοι σύνδεσμοι
- Μυικό περίβλημα

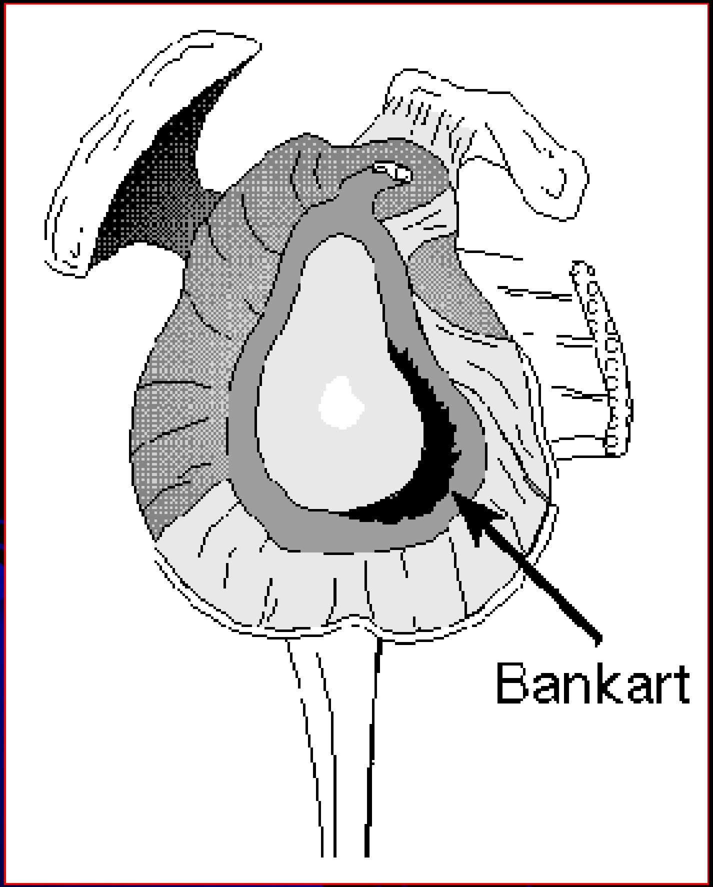
ΜΗΧΑΝΙΣΜΟΙ ΤΡΑΥΜΑΤΙΣΜΟΥ

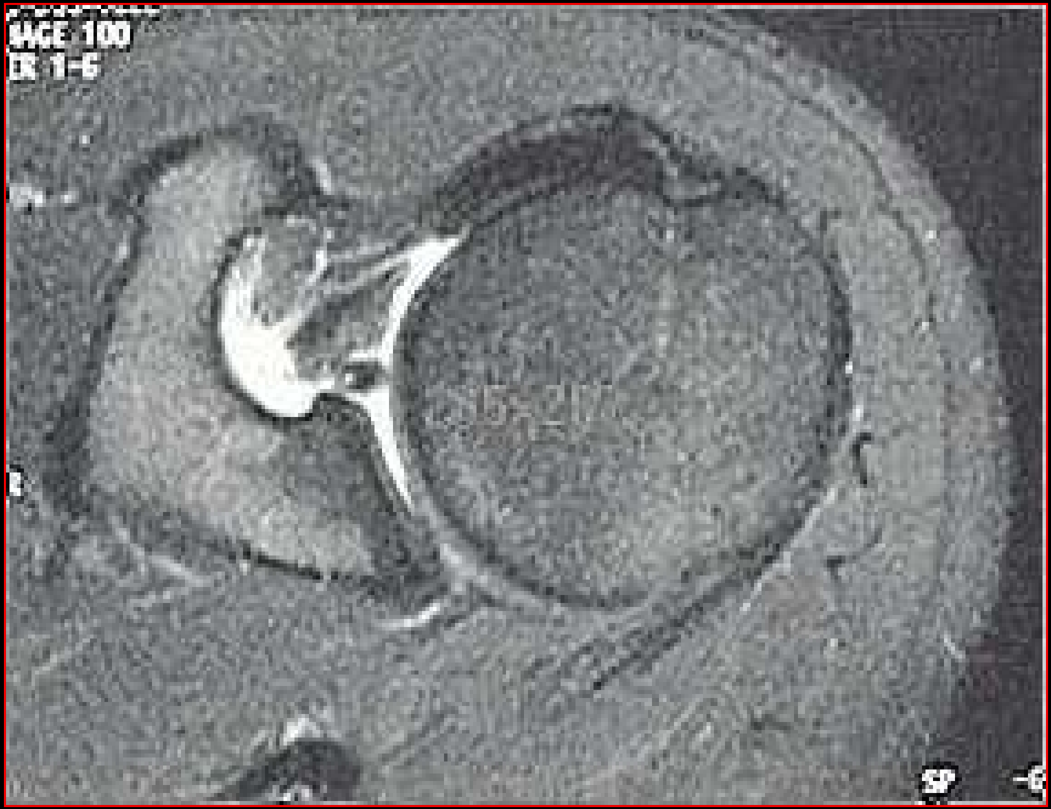




Πρόσθιο Εξάρθρημα του Ώμου

Βλάβη Bankart 80 - 90%





Μαγνητική Τομογραφία

Τύποι Αστάθειας

T.U.B.S.

Traumatic
Unidirectional
Bankart
Surgery

A.M.B.R.I.

Atraumatic
Multidirectional
Bilateral
Rehabilitation
Inferior capsular shift

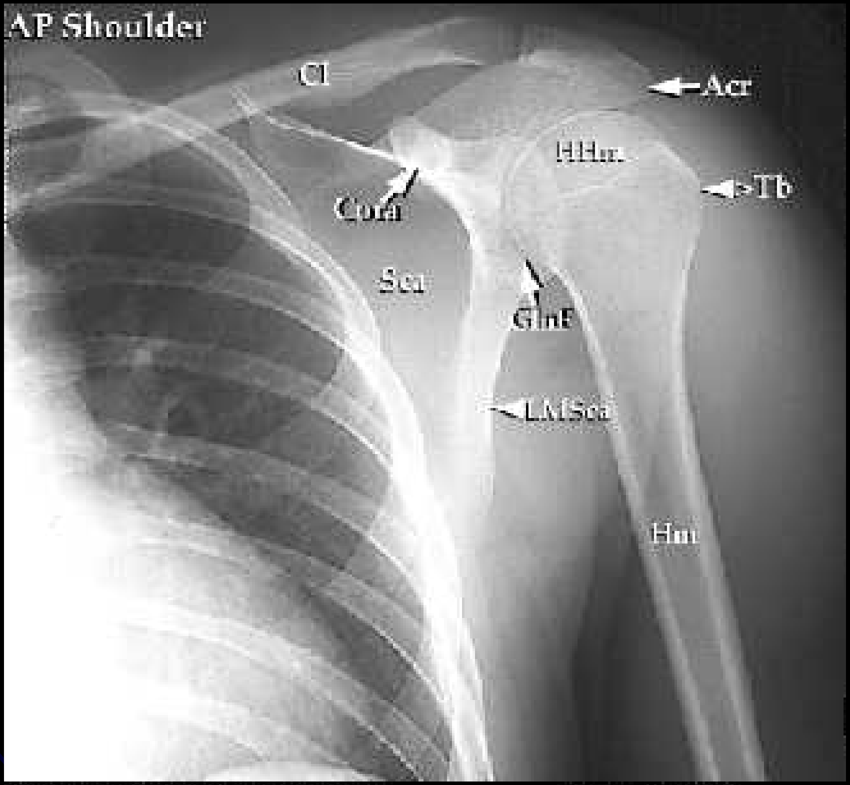
A.I.O.S.

Acquired
Instability
Overstress
Surgery

Shoulder Instability

- DEFINITION:
  - Glenohumeral instability is the inability to maintain the humeral head in the glenoid fossa.

Bony Anatomy



LMSca=Lateral Margin of Scapula
Cl=Clavicle
Acr=Acromion
Cora=Coracoid Process
Sca=Scapula

Hm=Humerus
HHm=Humeral Head
>Tb=Greater Tuberosity
GlnF=Glenoid Fossa

Shoulder Girdle

- Sternum
  - pivot/anchor
- clavicle
  - strut
- scapula
  - lever & pulley
- humerus

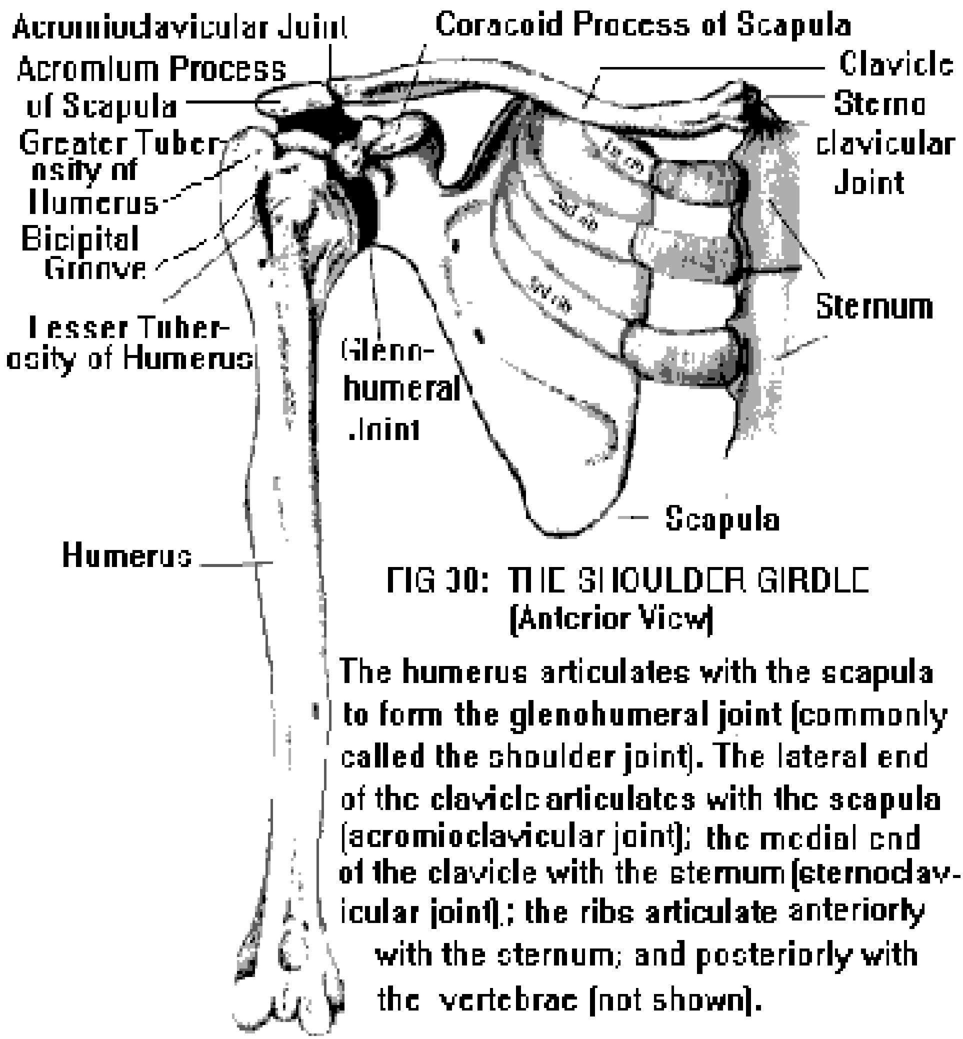


FIG 30: THE SHOULDER GIRDLE (Anterior View)

The humerus articulates with the scapula to form the glenohumeral joint (commonly called the shoulder joint). The lateral end of the clavicle articulates with the scapula (acromioclavicular joint); the medial end of the clavicle with the sternum (sternoclavicular joint).; the ribs articulate anteriorly with the sternum; and posteriorly with the vertebrae (not shown).

Scapula

- Glenoid fossa
  - poorly shaped
  - 7 deg. of retroversion
  - 5 deg. of sup tilt
- Acromium
- Coracoid
- Plane of the scapula - 30-45 deg to coronal

Joints

- SC
  - only bony attachment to the axial skeleton
- AC
  - 3 degres of freedom
    - scapular rotation
    - scapular winging
    - scapular tipping
  - ligaments: AC and CC ligs

Glenohumeral joint

- Humeral head 3x larger than glenoid fossa
- Ball and socket with translation
- 3 degrees of freedom
  - flex/ext
  - abd/add
  - int/ext rot
  - plus
    - horizontal flex/ext
    - horizontal abd/add

Scapulothoracic Articulation

- Elevation/Depression
- Pro/retraction
- up/downward rotation
  - scapular rotation is necessary to keep GH joint in position of max stability

Musculature

Rotator cuff muscles (S.I.T.S.)

Biceps tendon, long head

- secondary stabilizer head depressor

Deltoid

- primary mover of shoulder in flexion and abduction

Periscapular muscles

- help position scapula and orient glenohumeral joint
- contributes compressive force across joint

Periscapular muscles

- help position scapula and orient glenohumeral joint
- contributes compressive force across joint

Pectoralis major
Pectoralis minor
Latissimus
Teres major
Coracobrachialis
Levator scapulae
Trapezius
Subclavius
Rhomboid major
Rhomboid minor
Serratus anterior
Triceps brachii, long head

Ligaments and capsule

- Coracoacromial ligament
  - secondary stabilizer as it forms part of the coracoacromial arch

- **Coracohumeral ligament**
- Origin: anterolateral coracoid process Insertion: greater and lesser tuberosities, blends with capsule in rotator interval
- Unclear role in providing stability; may contribute to restraining inferior subluxation with arm at side, Becomes taut with external rotation

- Capsule
  - attached medially to margin of glenoid fossa
  - laterally to circumfrence of anatomical neck of humarus
  - ant cap thicker than post cap
  - 3 types
    - anterior labrial attachment
    - just medial to labrum
    - further medially on glenoid

- Allows for 2-3 mm of distraction
- little contribution to joint stability
- strengthened by GH ligs and RC tendons
- rotator interval
    - between SGHL and MGHL

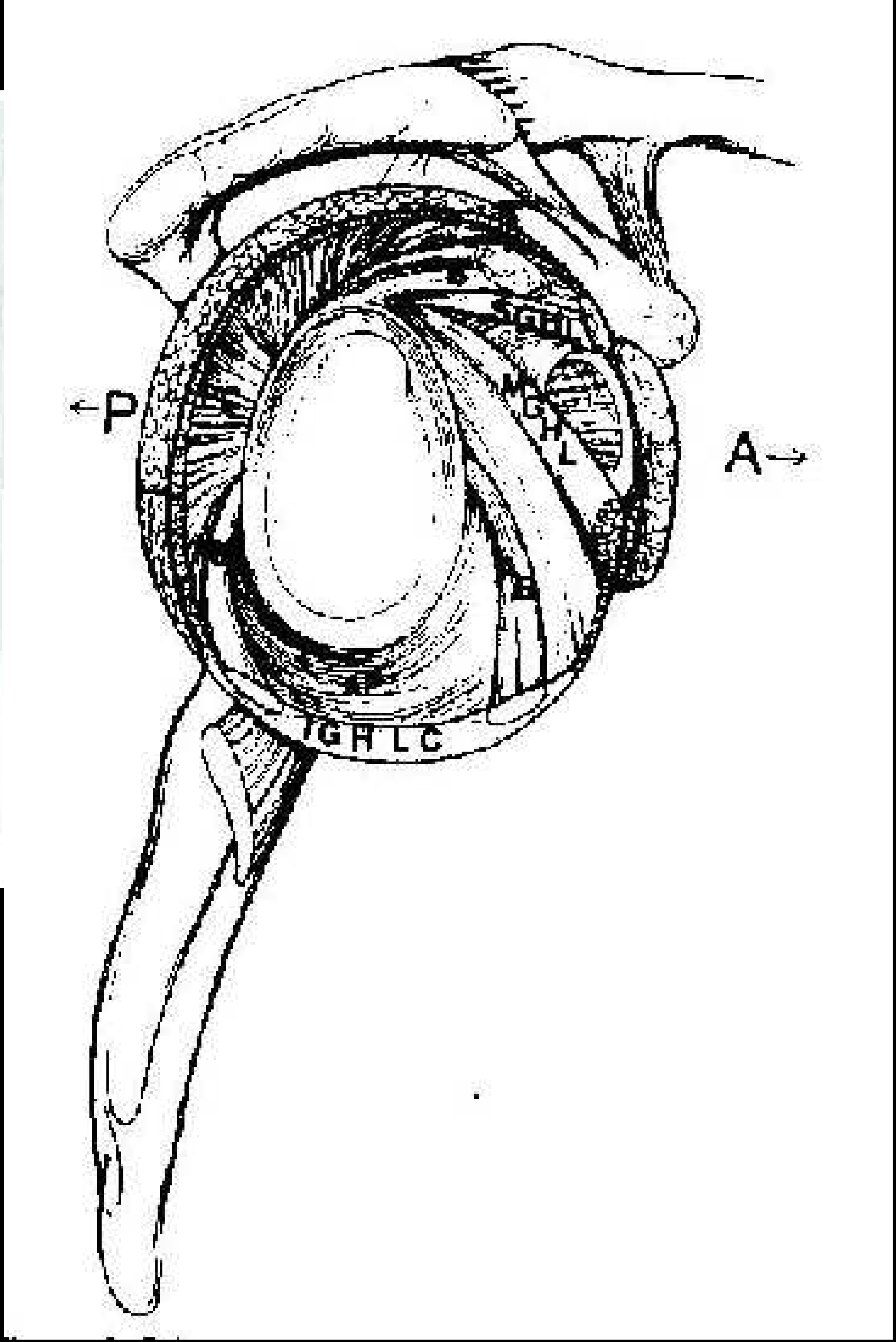
Glenohumeral ligaments (superior, middle , inferior)

- SGHL
  - O = tubercle on glenoid just post to long head biceps
  - I = humeral head near upper end of lesser tubercle
  - Resists inf subluxation and contributes to stability in post and inf directions

- MGHL
  - O= sup glenoid and labrum
  - I= blends with subscapularis tendon
  - Limits ant excursion instability especially with arm in 45 deg abd position
  - limits ext rotation

- IGHL
  - O= ant glenoid rim and labrum
  - I= inf aspect of humeral articular surface and anatomic neck
  - 3 bands, anterior, axillary and posterior
  - IGHL complex acts like a sling and when is the most important single ligamentous stabilizer in the shoulder.
  - Primary restraint is at 45-90 deg abd.


BT
SST
M
I


←P
A→
SGHL
MGHL
B
IGHLC

Glenoid Labrum

- Static stabilizer
  - contributes 20% to GH stability
- fibrous tissue
- deepens glenoid(50%), 9mm su
  AP
- 3purposes:
  - increases surface contact area
  - butress
  - attachment site for GH ligaments

Biomechanics of GH stability

- the normal shoulder precisely constrains the humeral head to the center of the glenoid cavity throughout most of the arc of movement.

Static restraints

- negative intra-articular pressure

(venting capsule increases inferior translation at 0 degrees of abduction)

- ligaments and capsule
- labrum (increases concavity)

- articular surfaces/osseous anatomy

(very little because square area of humeral head is 3X glenoid)

- joint fluid adhesiveness

Dynamic restraints

- Rotator cuff muscles
- deltoid and biceps
- concavity compression

- The humeral head will remained <u>centered</u> in the glenoid fossa if the glenoid and humeral joint surfaces are congruent and if the net humeral joint reaction force is directed within the effective glenoid arc.

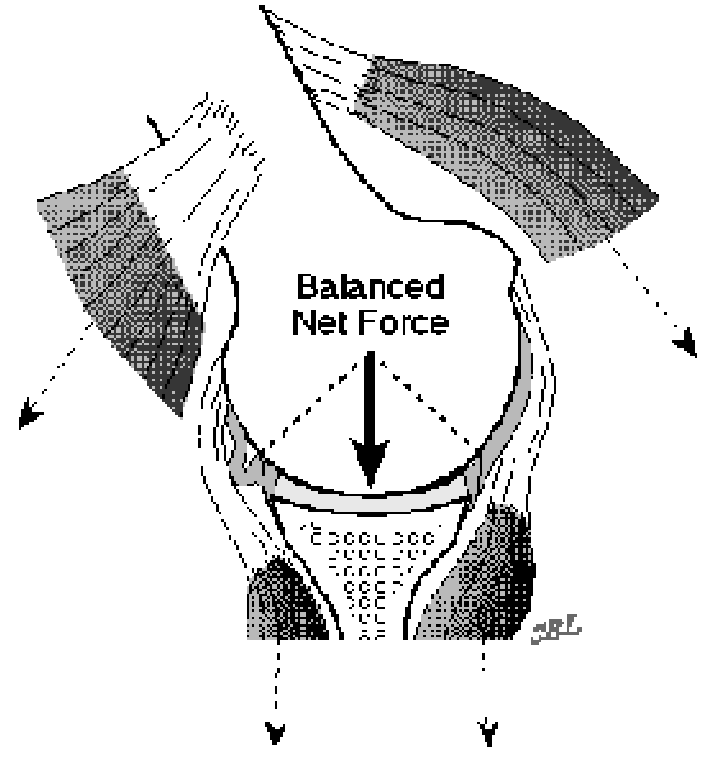


Figure 14-24

-The glenohumeral joint will not dislocate as long as the net <u>humeral joint reaction force</u> is directed within the <u>effective glenoid arc.</u>

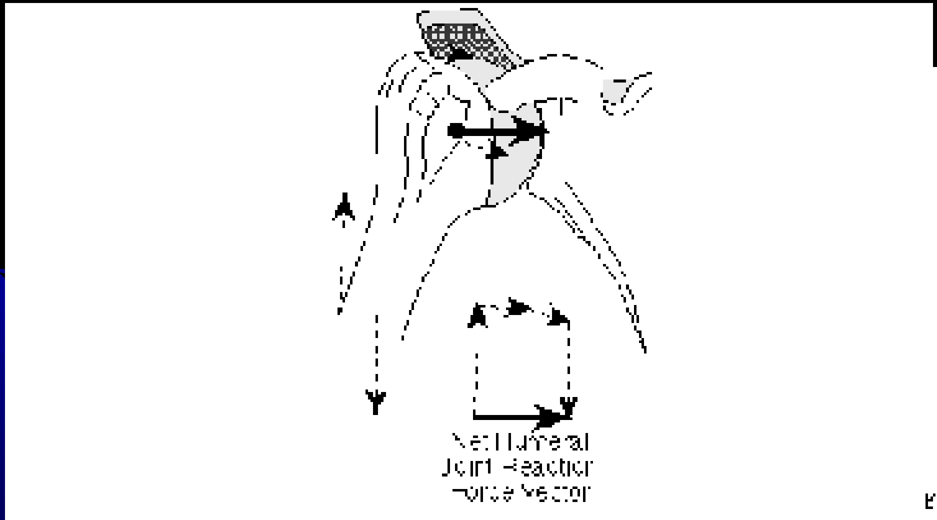


Figure 14-22

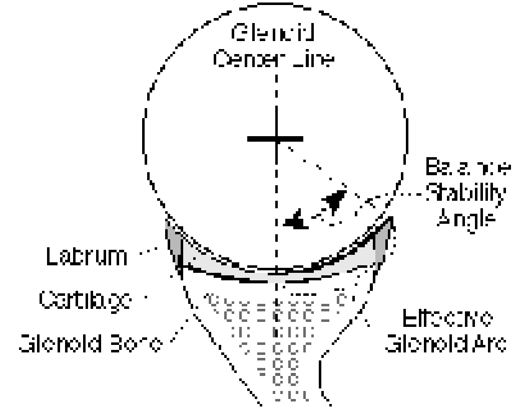
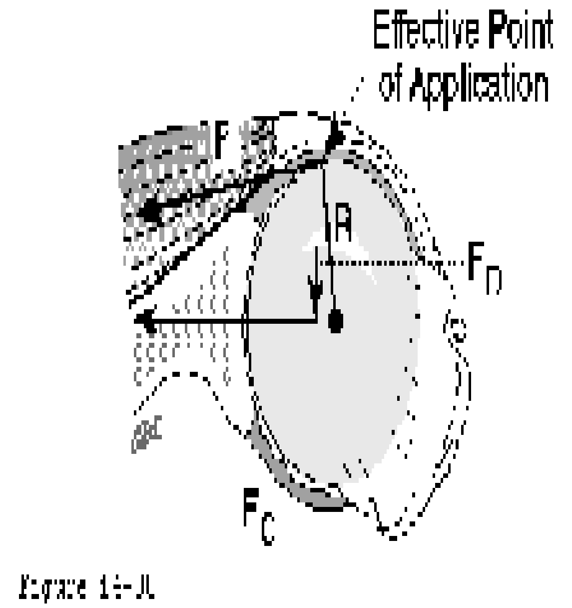


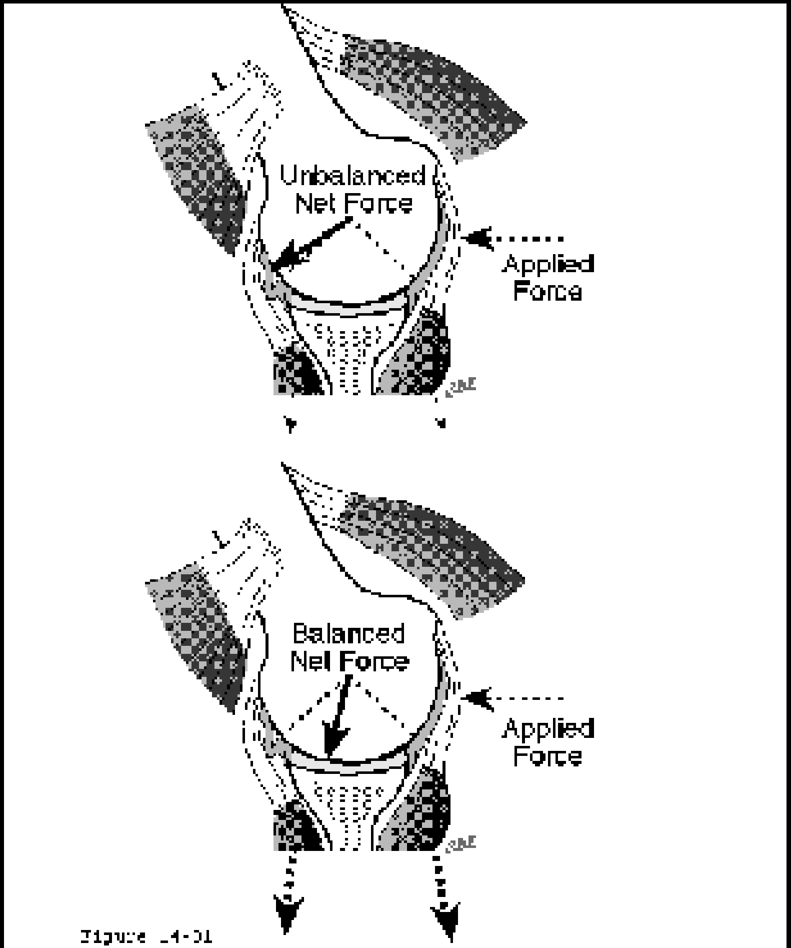
Figure 11 23

The maximal angle that the net humeral joint reaction force can make with the glenoid center line in a given direction is the <u>balance stability angle</u>

Increasing the force of contraction of a muscle whose force direction is close to the glenoid center line, the direction of the net humeral joint reaction force can be aligned more closely with the glenoid fossa.

The elements of the rotator cuff are well positioned to contribute to this muscle balance.





Stability ratio

- Maximal displacing force in a given direction(perpendicular to glenoid center line) that can be stabilized by compressive load.
  - Affected by
    - Glenoid/labrum depth
    - rim lesions
    - Glenoid version
    - dynamic stabilizer compromise
      - structural injury, paralysis, imbalance, atrophy etc..

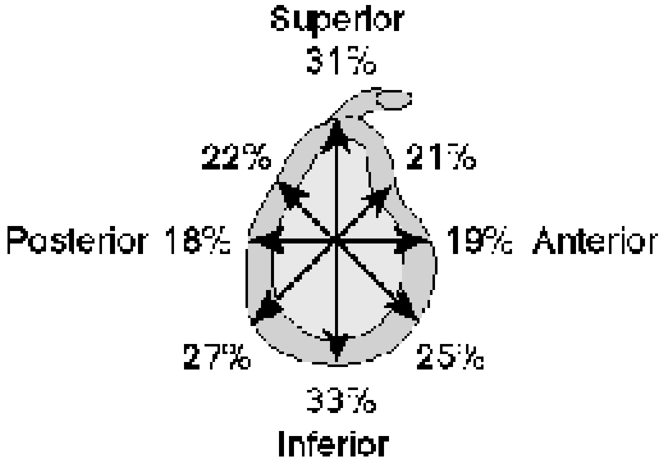
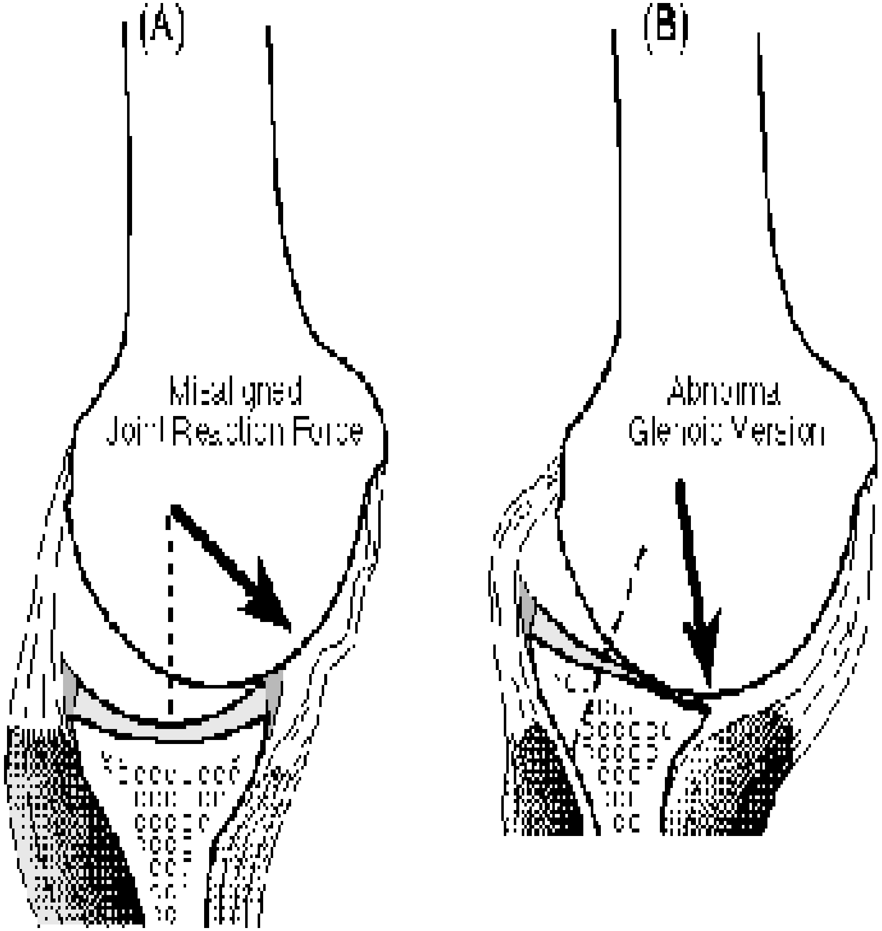


Figure 14-39



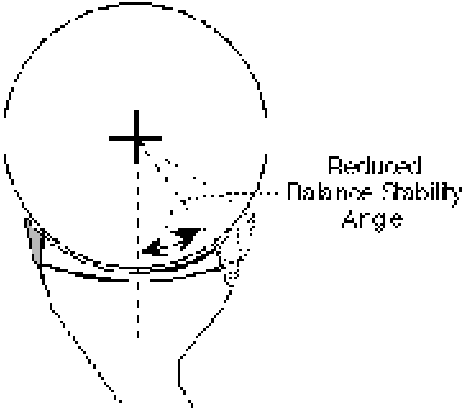


Figure 14-34

Glenoid version

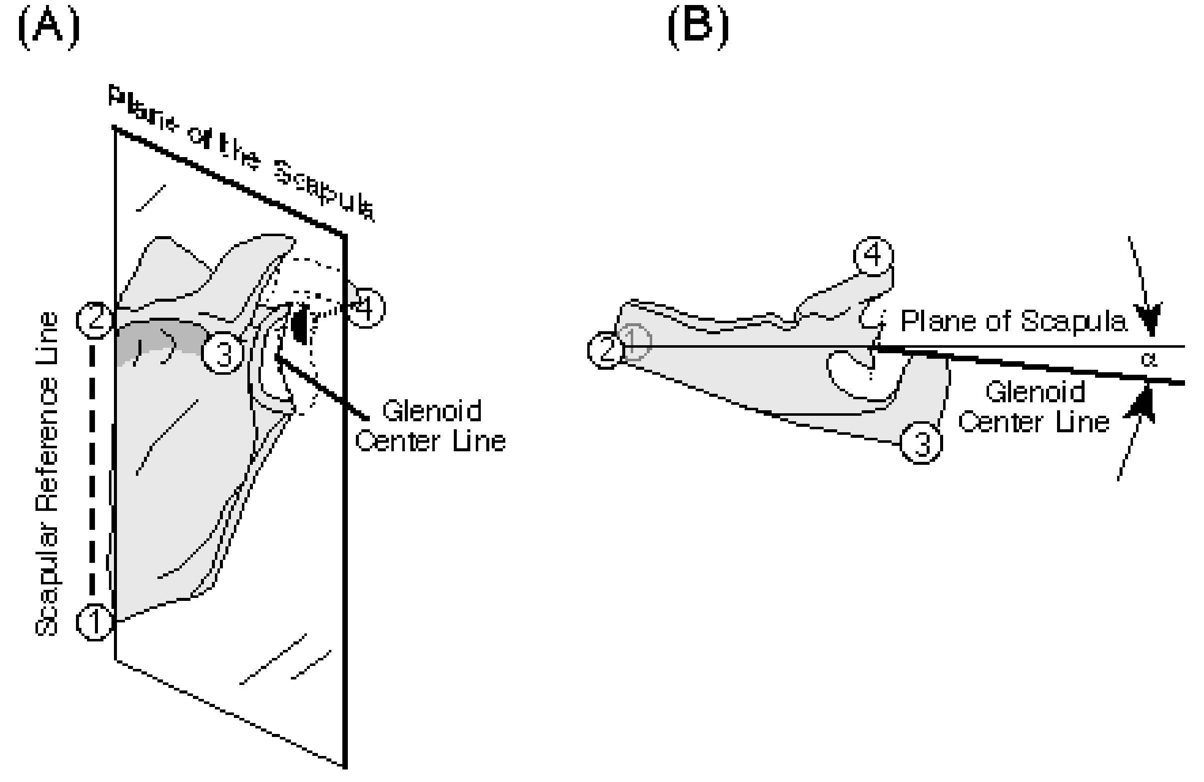


Figure 14-28

Scapular positioning

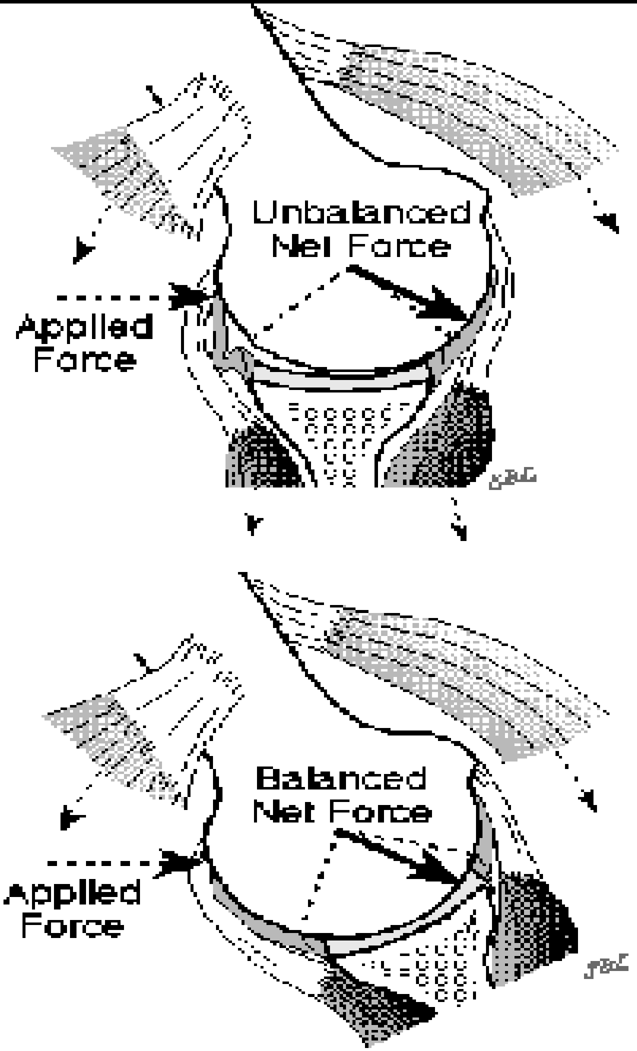
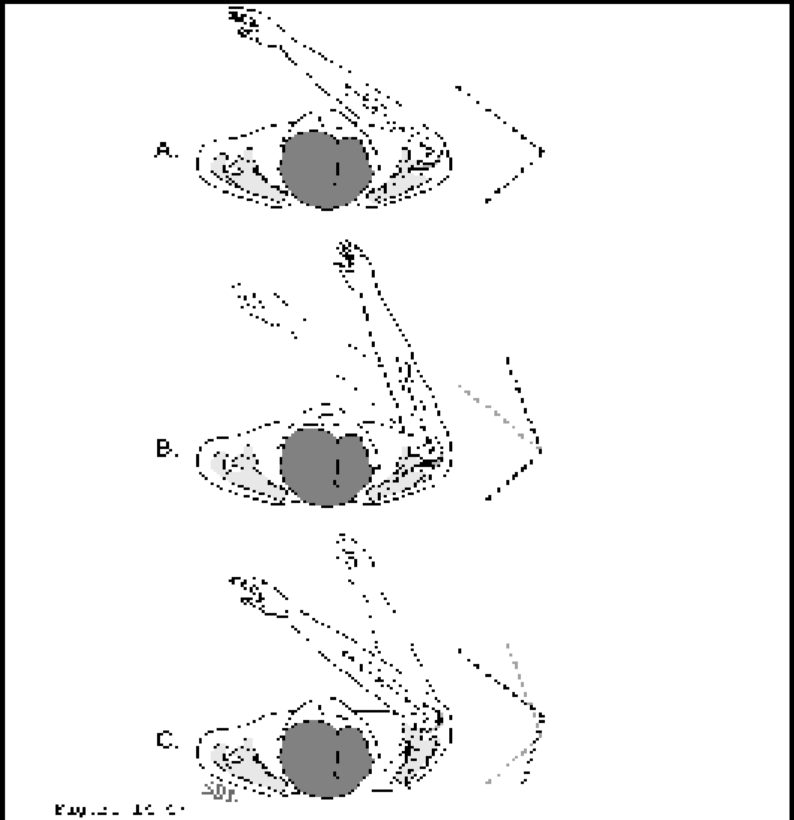


Figure 14-09

Ligamentous stabilization

- Check reins
  - ballanced force exceeds ballanced stability angle.



Countervailing force

-compresses humeral head into glenoid fosssa and resists displacement in direction of tight ligament

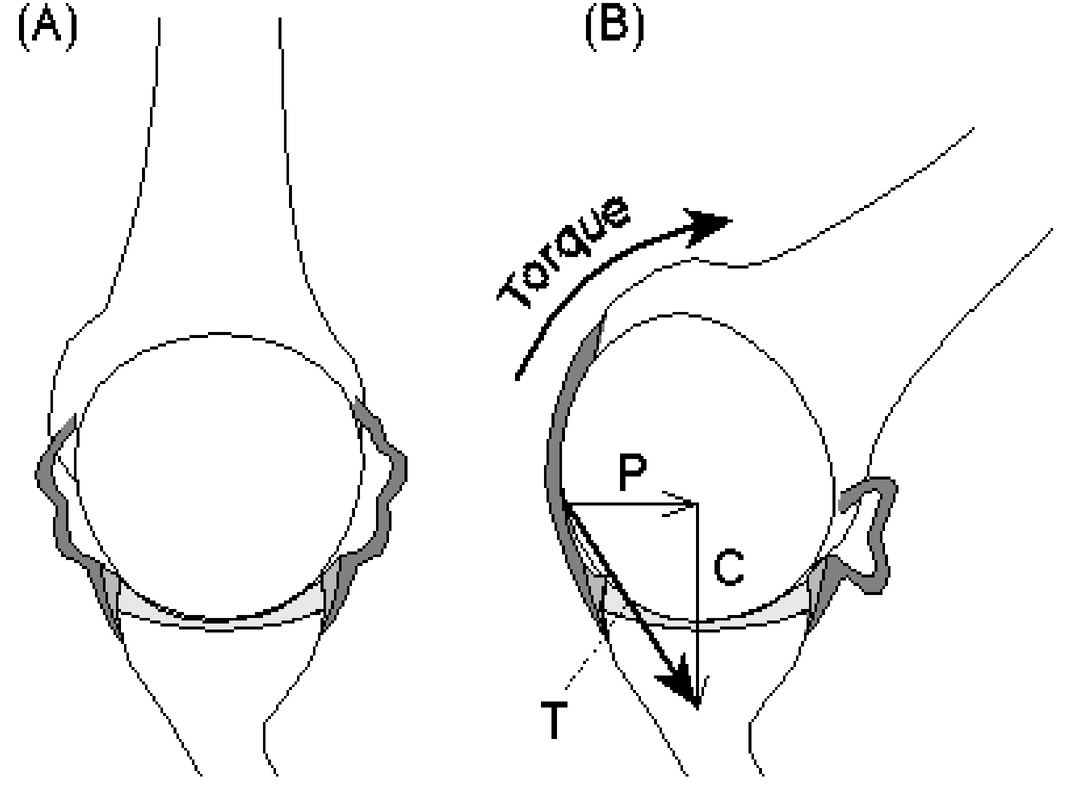


Figure 14-48

Types of instability

- Congenital
- Acute
- Cronic
- Recurrent
- Traumatic
- Atraumatic

Recurrent Instability

- Two groups:
  - TUBS
    - Traumatic, unidirectional, Bankart, surgery
  - AMBRII
    - Atraumatic(microtraumatic) multidirectional,bilateral, rehab,inferior capsular shift,rotator interval.

Who?

Atraumatic

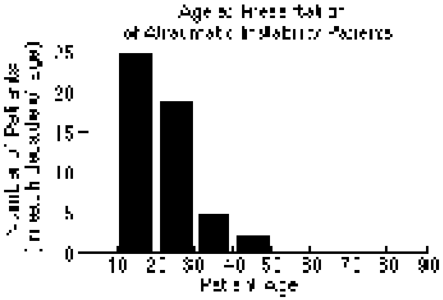


Figure 14-21D

Traumatic

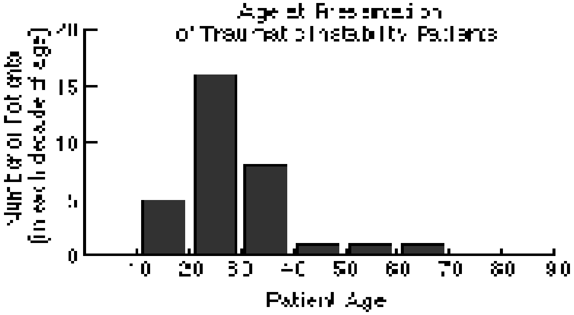
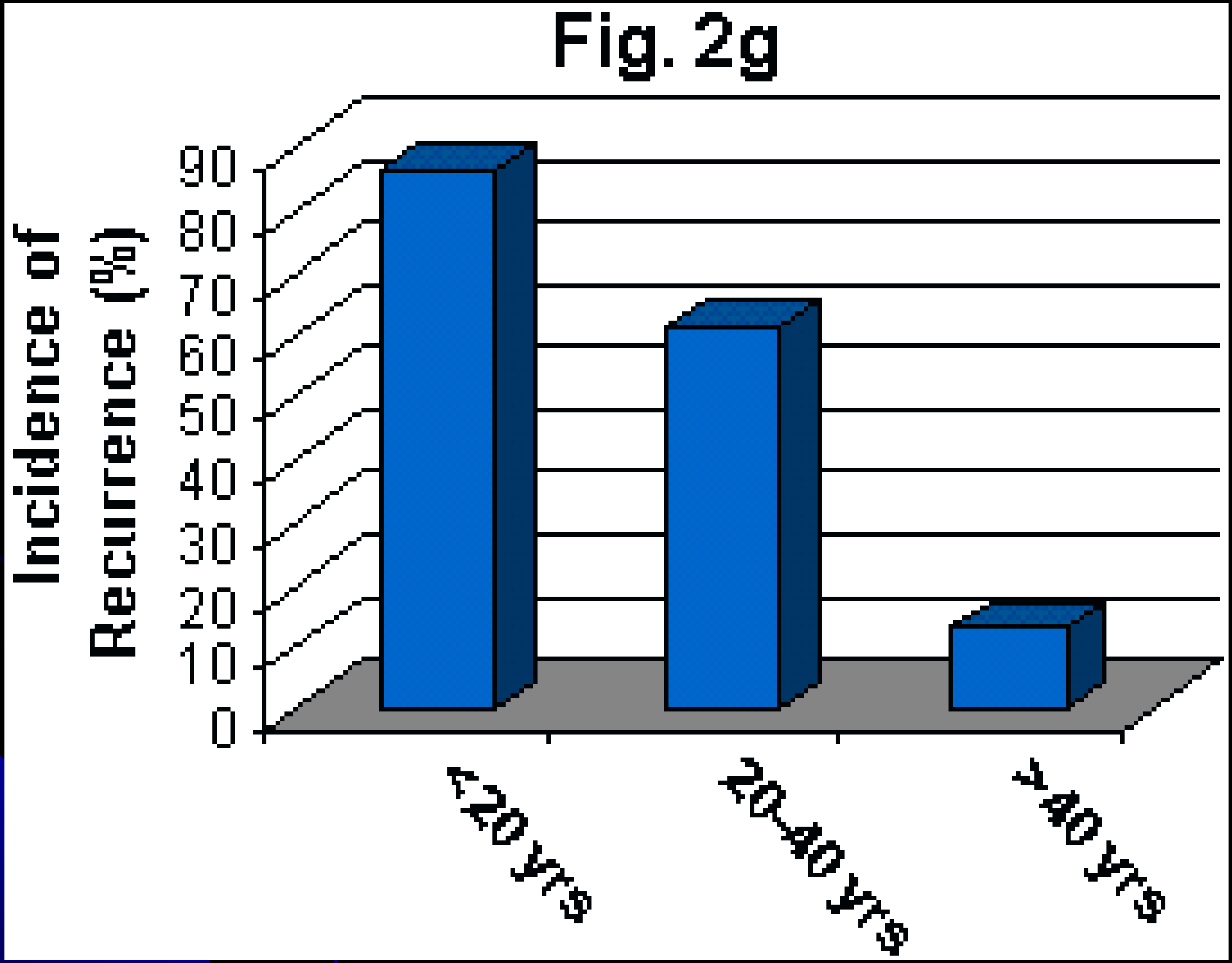


Figure 14-130

Combined Atraumatic and traumatic



Why?

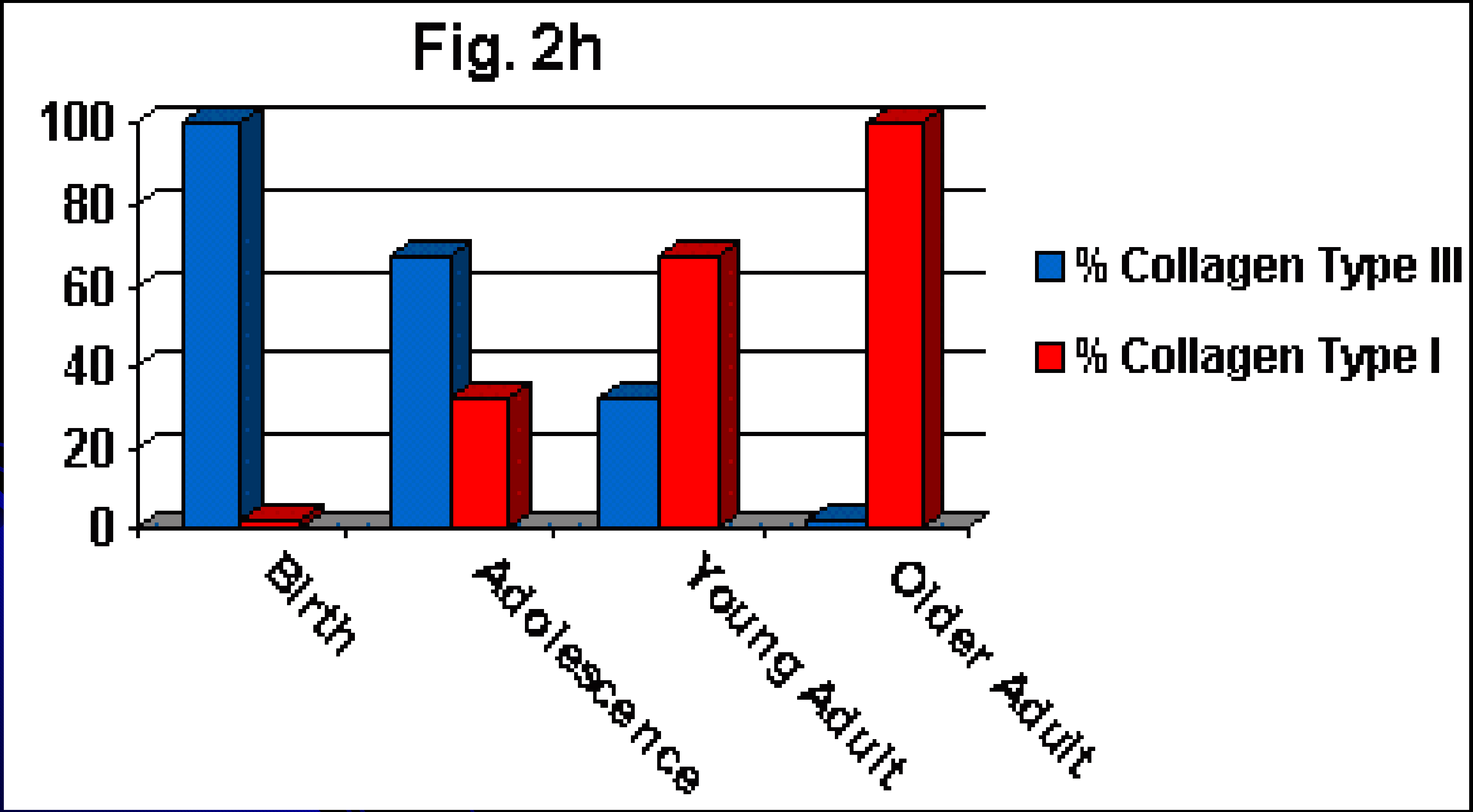


Fig. 2h
100
80
60
40
20
0
Birth
Adolescence
Young Adult
Older Adult
% Collagen Type III
% Collagen Type I

Directions of instability

- Anterior
  - 97% of recurrent dislocations
    - subcoracoid - abd, extension and external rotation
    - subglenoid
    - subclavicular
    - intrathoracic

- Posterior
  - 3% of recurrent
  - Seizures, shock, fall on flexed + adducted arm
    - subacromial
    - subglenoid
    - subspinous
- Inferior
- Superior
- Bilateral

Evaluation of recurrent atraumatic instability

- History
  - Trauma?
  - Sports
  - Throwing or overhead activitys
  - Voluntary subluxation
  - “Clunk” or knock
  - Fear
  - Hx of dislocations and energy associated

- Physical
  - Demonstrate dislocation/subluxation ?
  - Laxity tests
  - Stability tests

- Laxity tests
  - Drawer
  - Sulcus
  - Push - pull

- Stability tests
  - Fulcrum
  - Apprehension (crank)
  - Jerk

- Strength tests
- X-ray, arthrogram, MRI, arthroscope no help.

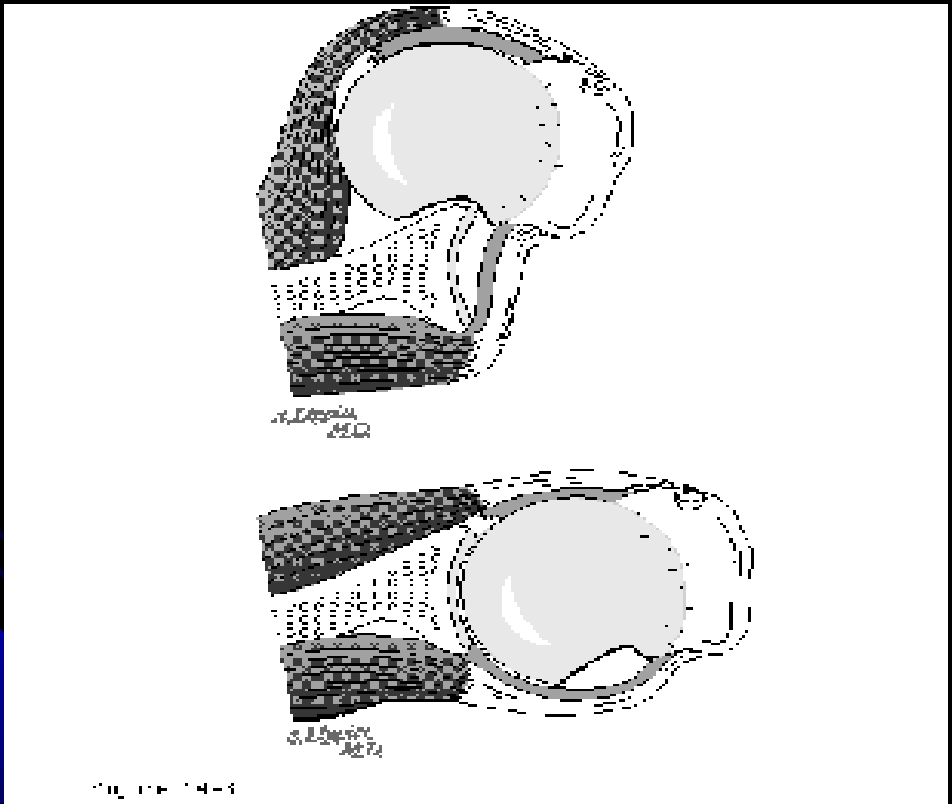
Evaluation of recurrent traumatic dislocations

- Injury to capsule, rot cuff, labrum, glenoid, humerus.
- Young (14-34)
- Male

- History
  - HX of 1st dislocation or injury
  - Subsequent dislocations/subluxations

- Physical
  - same tests
  - concentrate on area of capsule weakness
  - “fatigue tests”
  - Be prepared to reduce

- X-Rays
    - Identify Bankart, Hill-Sachs



HILL-SACHS

Stryker view

Apical Oblique view

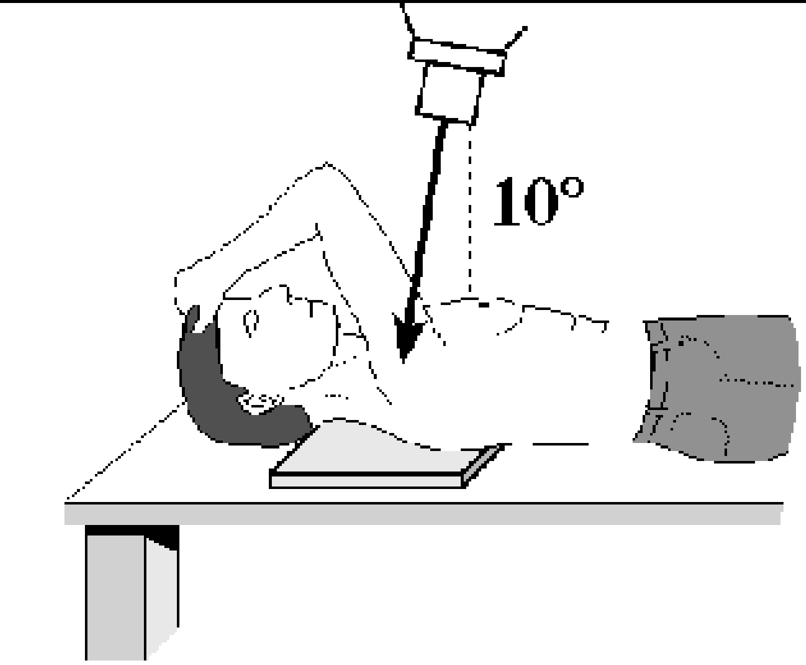


Figure 14-102

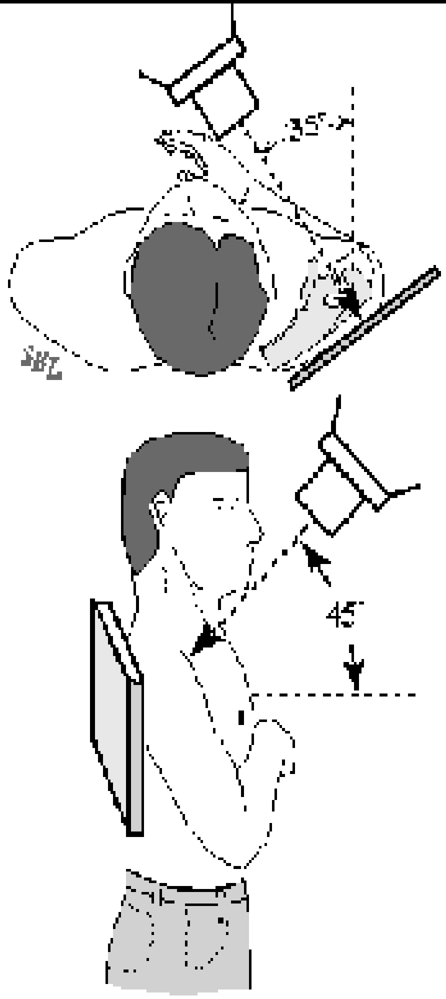
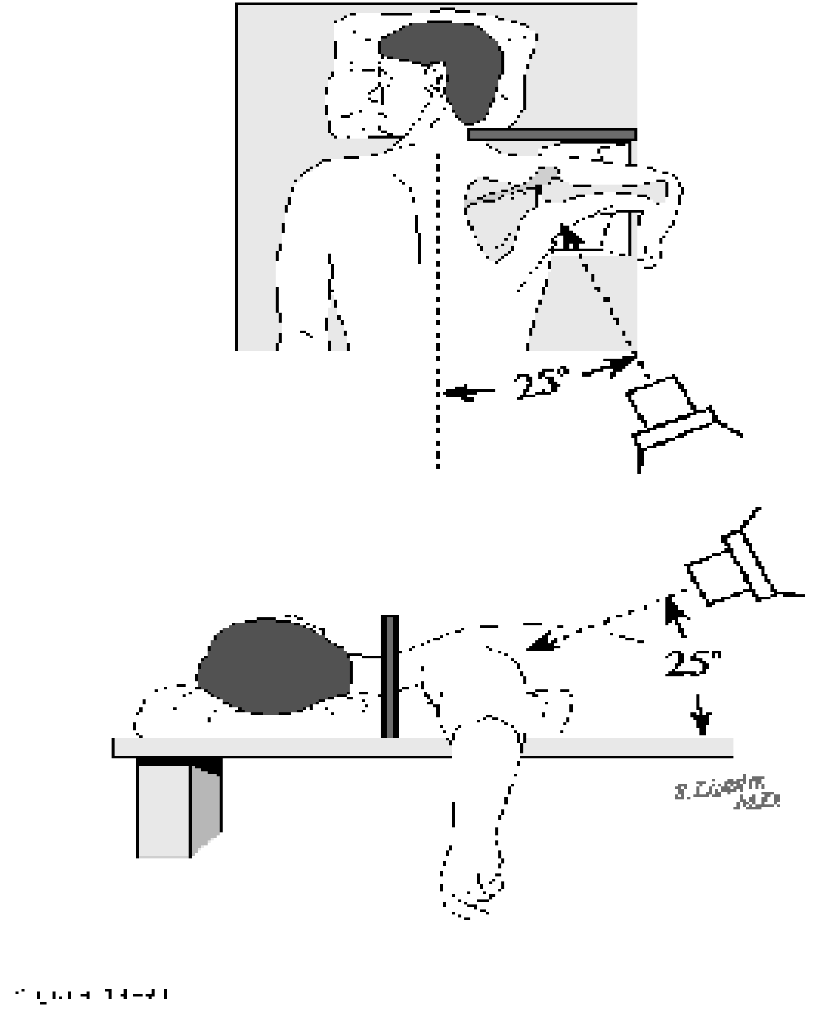


Figure 14-103

GLENOID

West Point Axillary view



- Arthrogram
- MRI
- Ultrasound
- Arthroscopy - not necessary

TREATMENT

- Recurrent Traumatic Ant. Dislocation
  - Surgical stabilization
    - Open or arthroscopic
  - Poor response to non operative tx

- Recurrent Traumatic Posterior instability
  - First line = non - operative (strengthening)
  - Failure of surgical stabilization = 12 - 50%

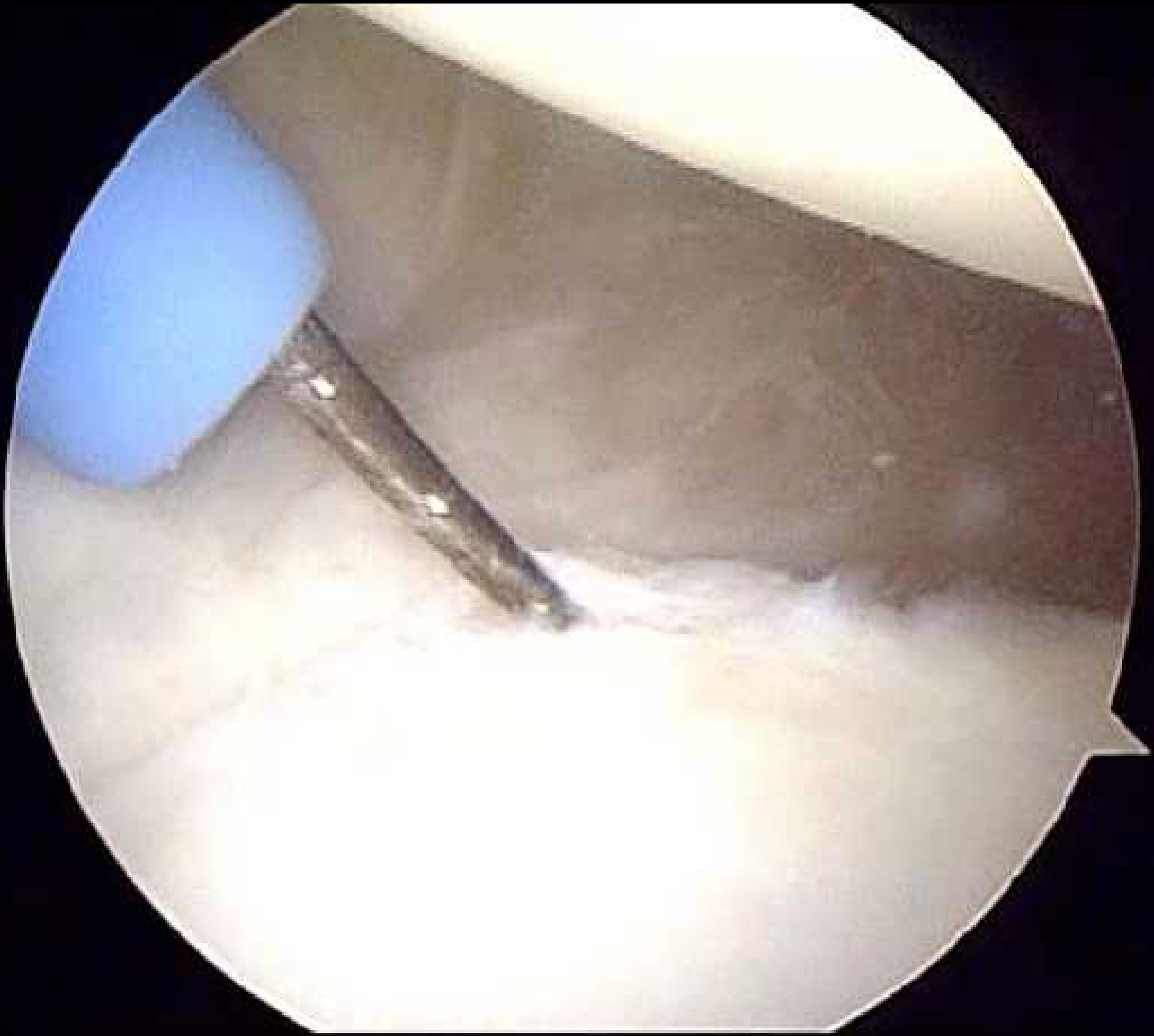
- Atraumatic Instability
  - 80% respond to physio
  - Surgical stabilization - capsulorraphy if non - operative fails.

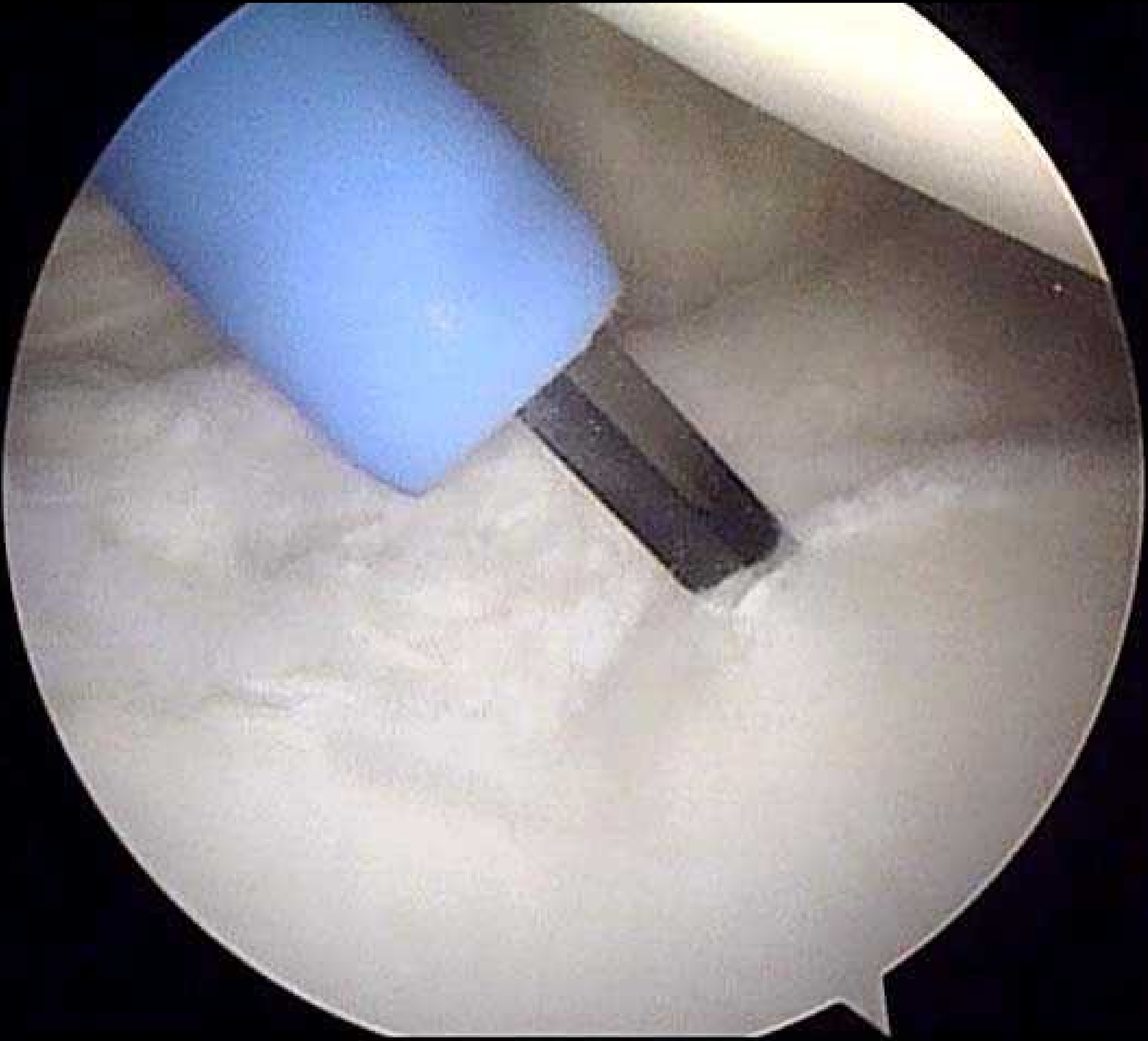
- Voluntary or Habitual
  - Retrain muscles
  - No surgery

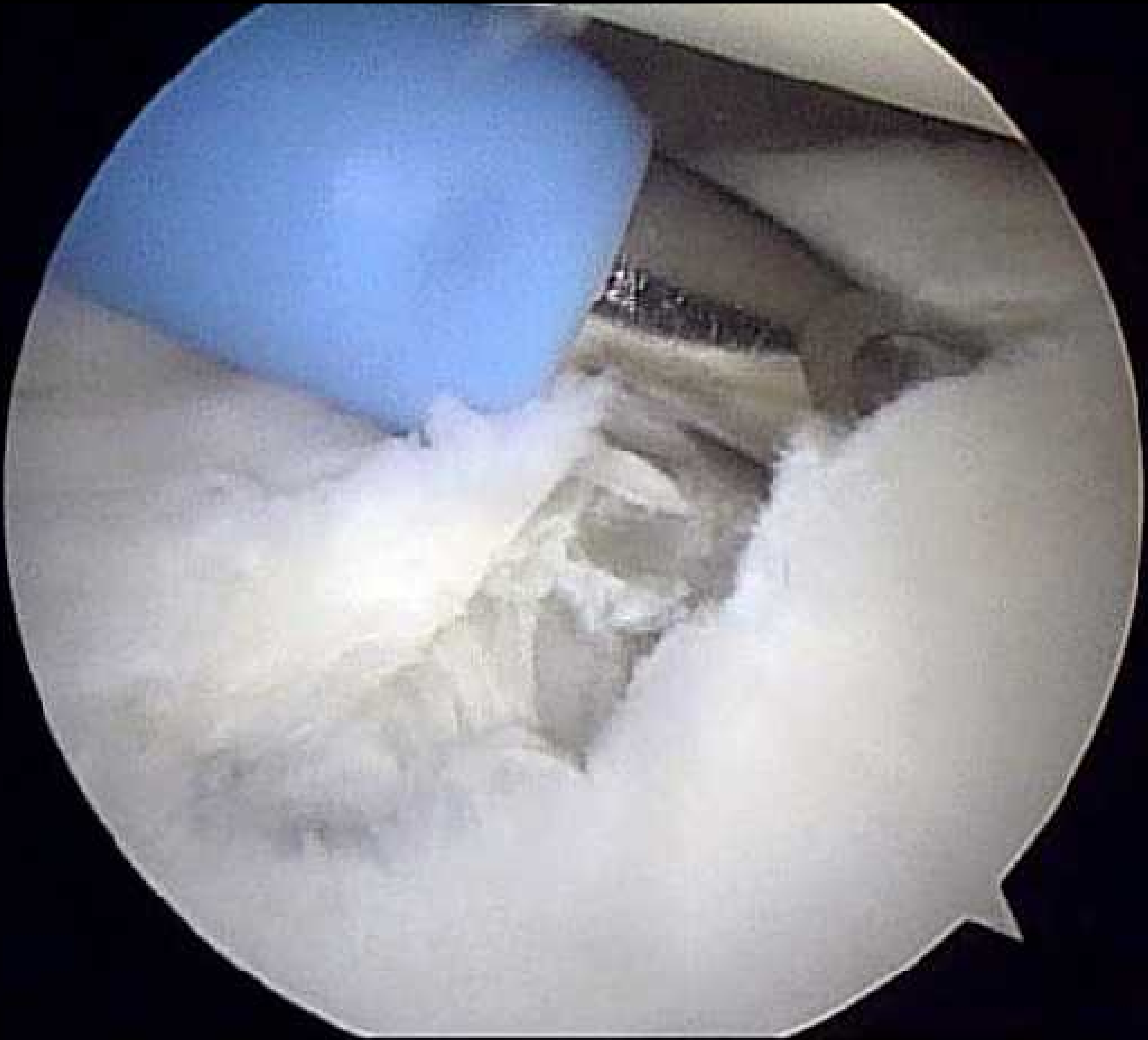
- Multidirectional Instability
  - Surgery only if non-operative fails
  - Surgery - capsulorraphy (approach depends on main direction of instability)
    - Latreral capsular shift (humoral side)- 91% success
    - Medial capsular shift (glenoid side) fo associated BanKart

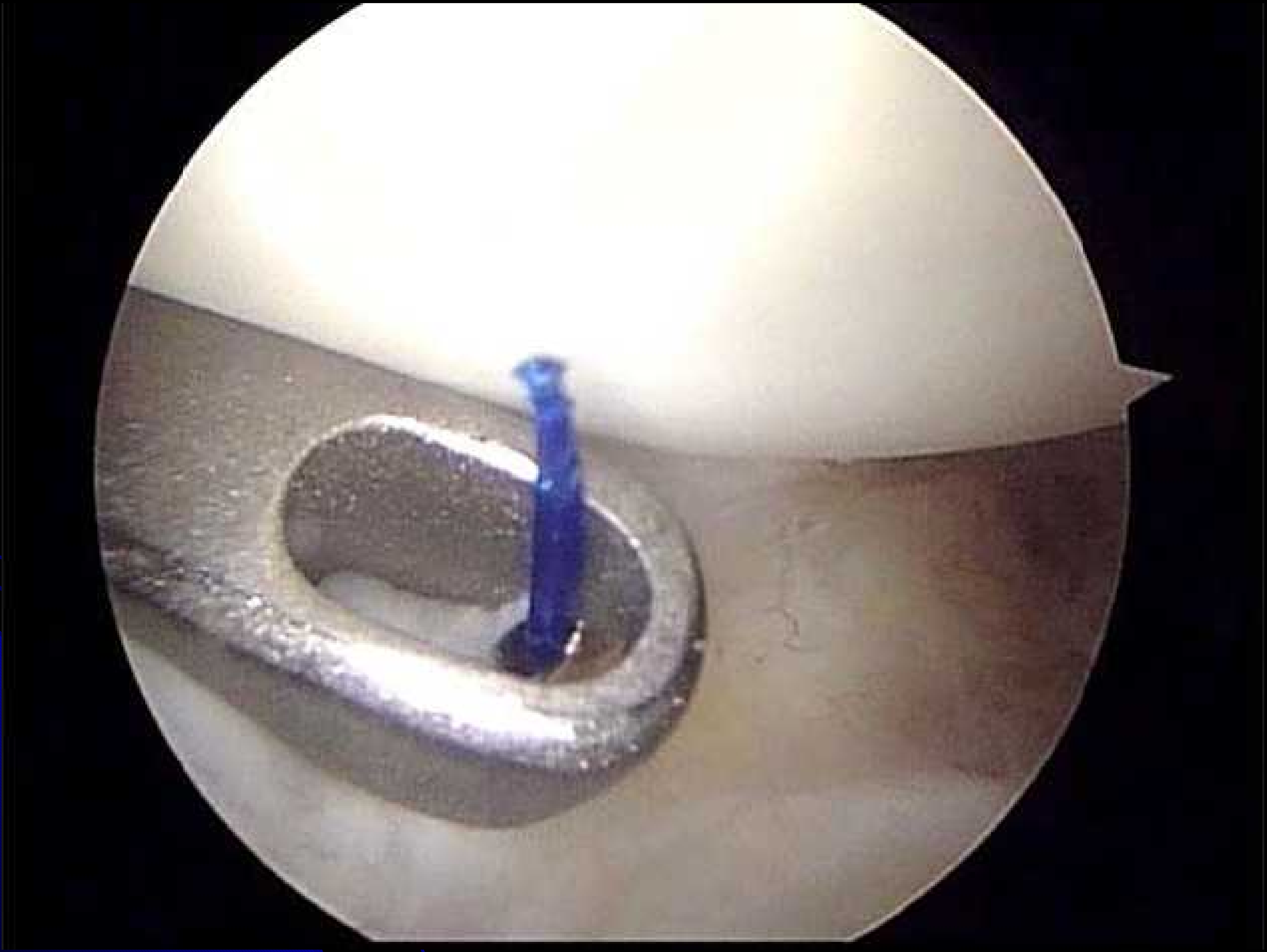
- Ant. Glenoid rim deficiency.
- Major glenoid bone loss.
- Impingement secondary to instability.
- Elderly

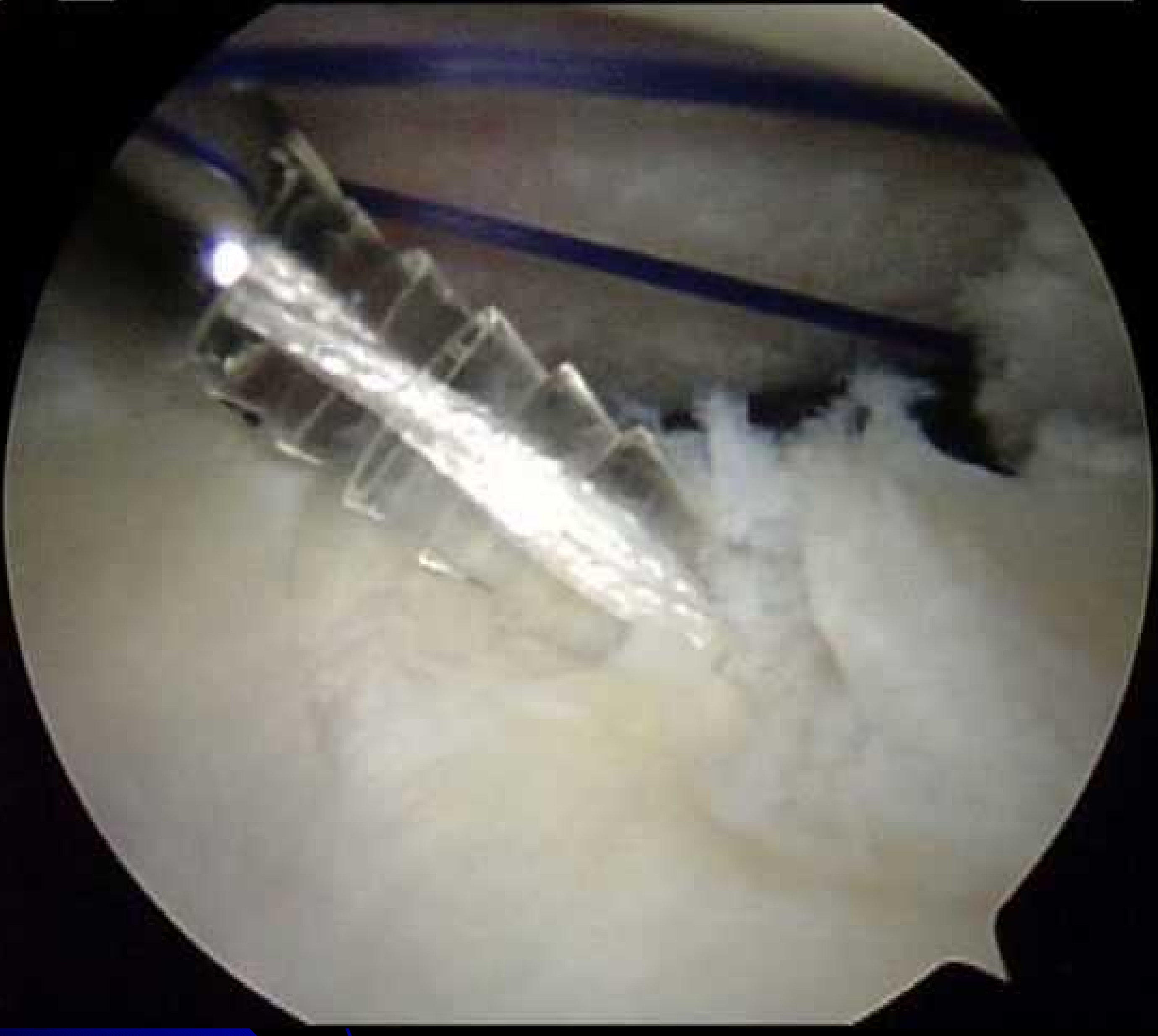
- Bristow.
- Bone butress procedure.
- Treat instability.
- Rot. Cuff repair.

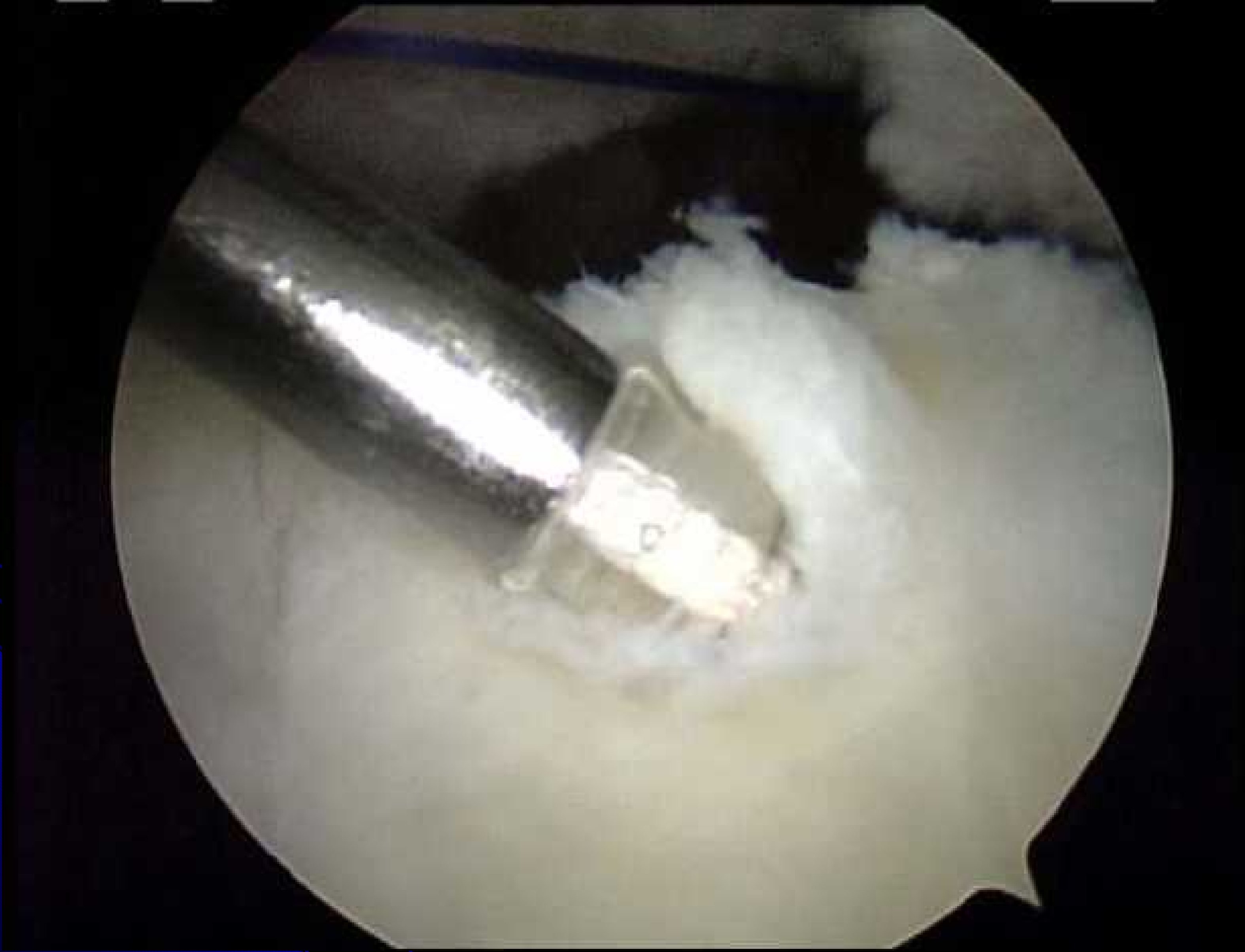


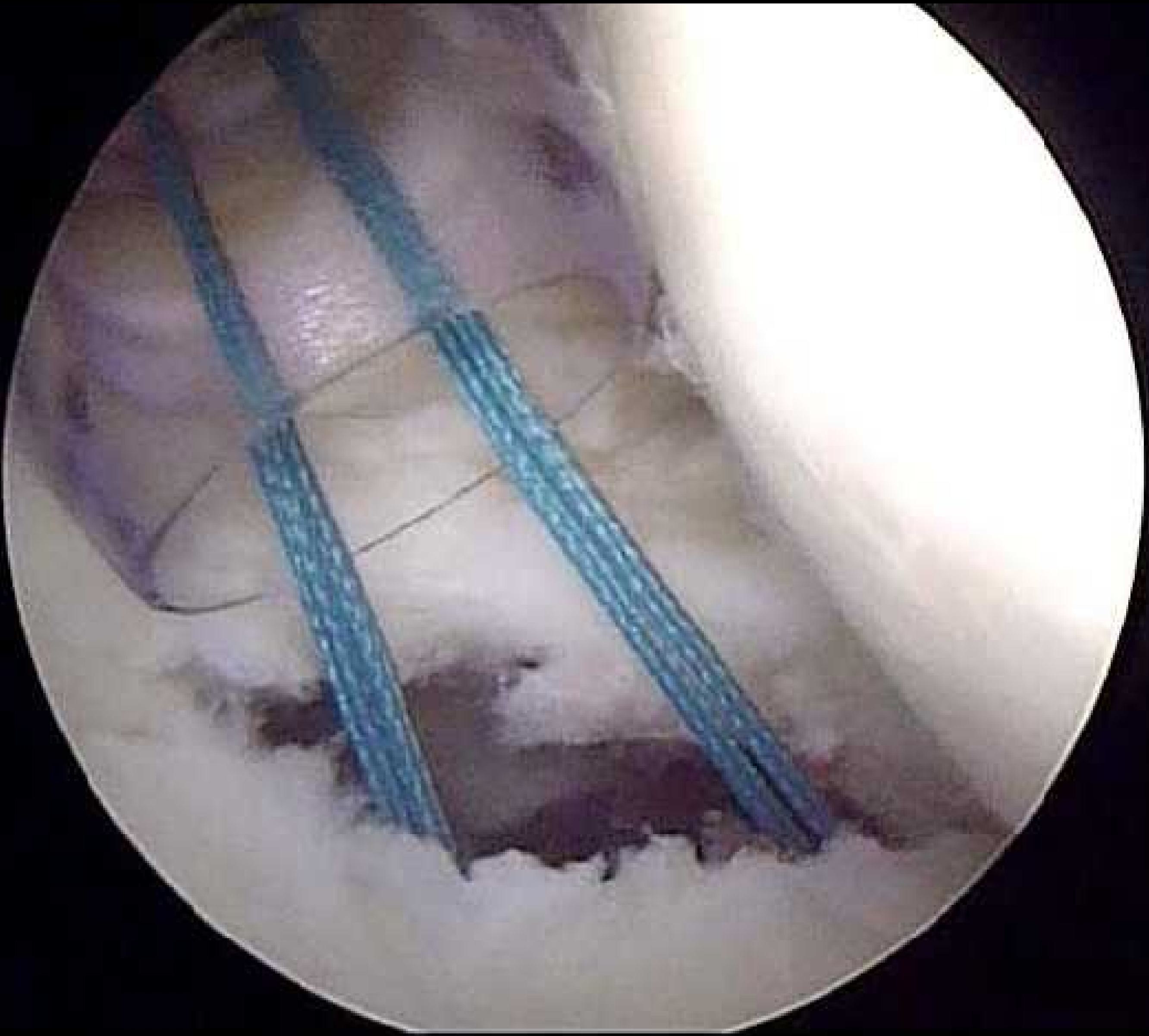


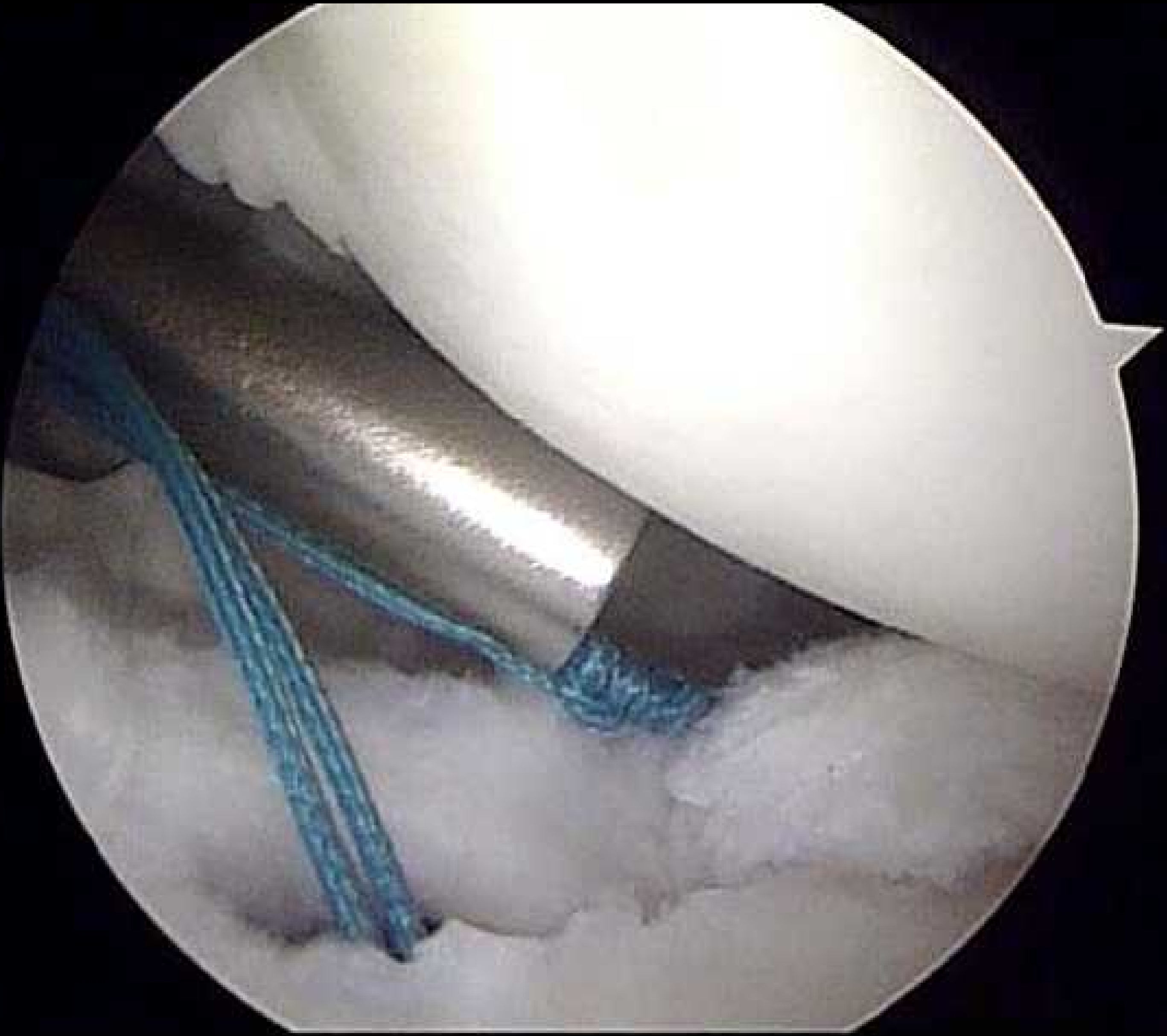


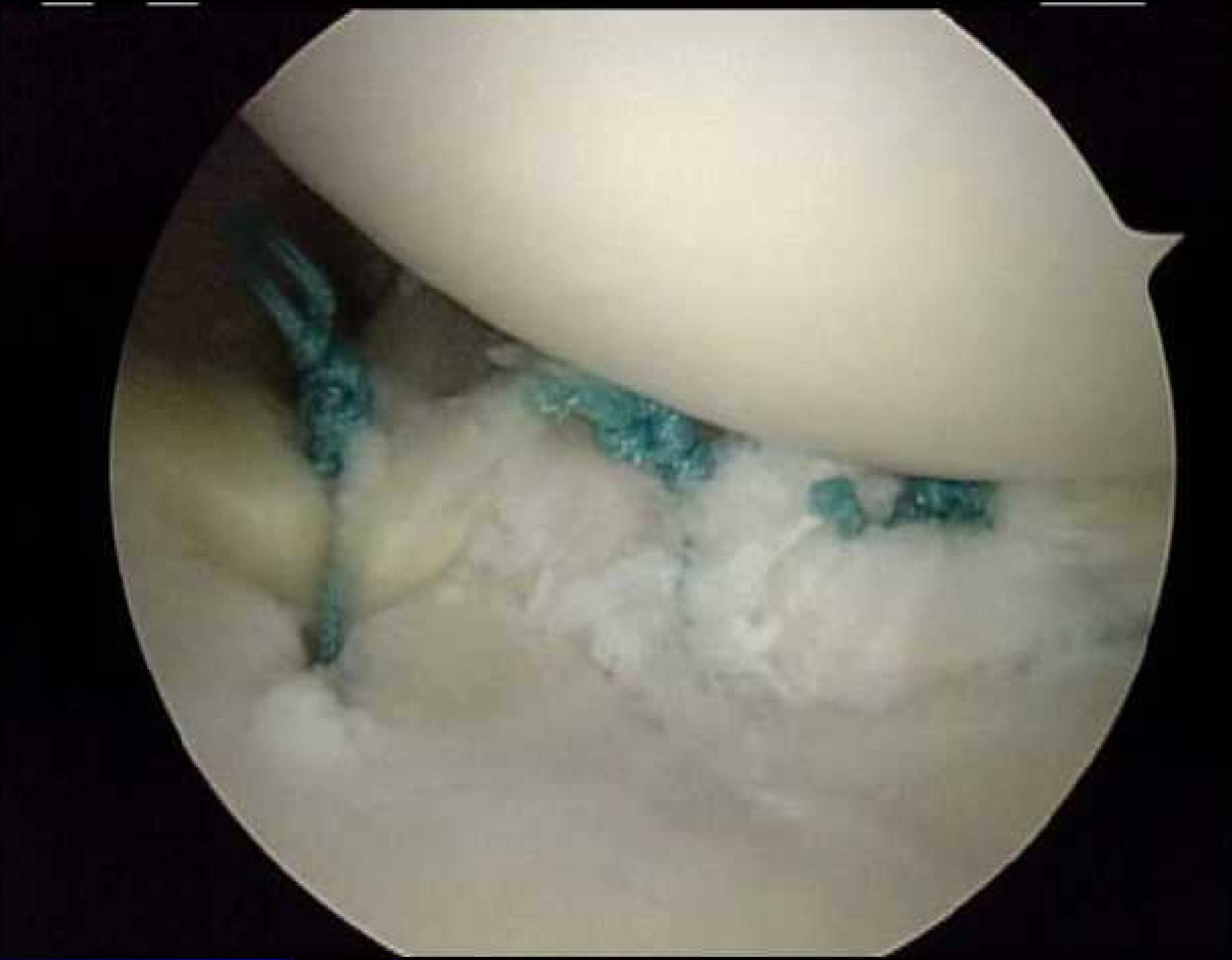












The Shoulder

- ✓ Greatest Range of Motion in the Body
- ✓ Motion in all 3 planes of movement
- ✓ Prone to injuries
- ✓ 8-20% of all sports injuries

What is Traumatic Shoulder Instability ?

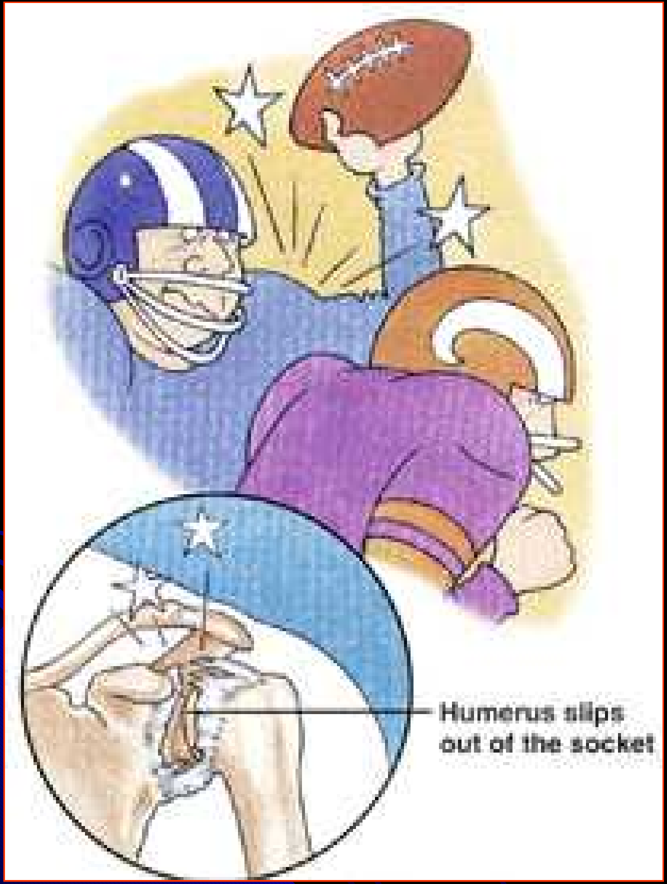
TRAUMA

INSTABILITY

TRAUMA

Mechanism of Injury

Direct impact



Forced AbD, ER,Ext

Instability

- ✓ Biomechanical Dysfunction
- ✓ Failure of static and dynamic stabilizers
- ✓ Ranges from mild subluxation to traumatic dislocation

Direction of the Instability

- Unidirectional
  - Anterior
  - Posterior
- Bidirectional
- Multidirectional

Detection of Instability

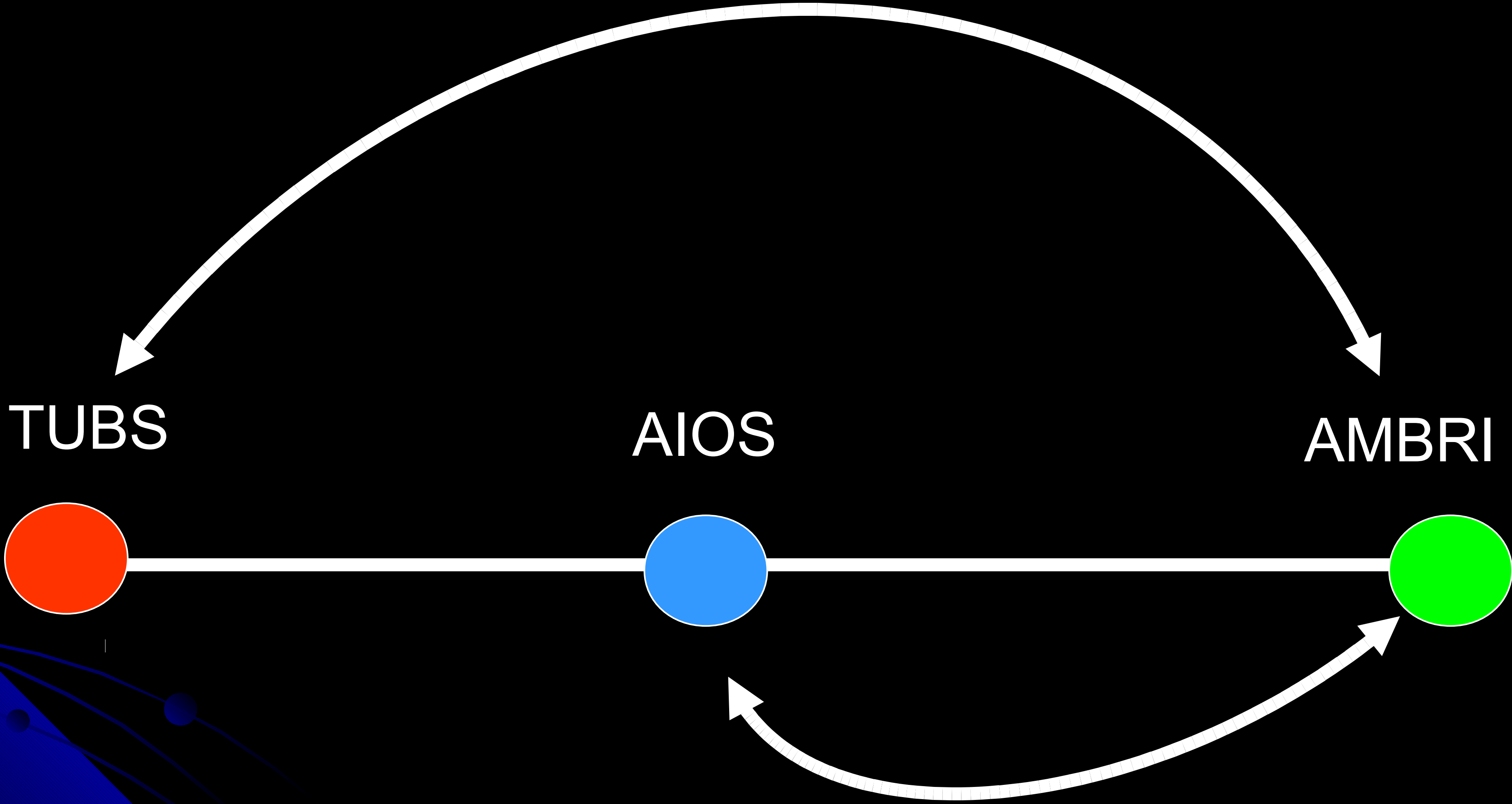
- ✓ History
- ✓ Clinical Examination
- ✓ EUA
- ✓ Imaging Studies
- ✓ Arthroscopy

Instability Profiles

T.U.B.S.
Traumatic
Unidirectional
Bankart lesion
Surgery

A.M.B.R.I.
Atraumatic
Multidirectional
Bilateral
Rehabilitation
Inferior capsular shift

A.I.O.S.
Acquired
Instability
Overstress
Surgery



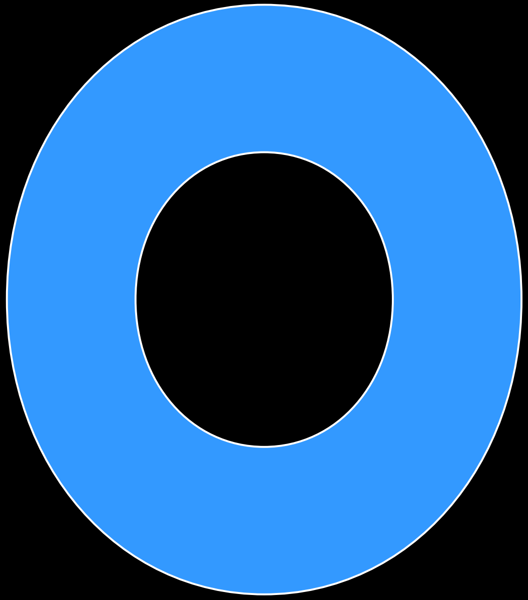
TUBS

AIOS

AMBRI

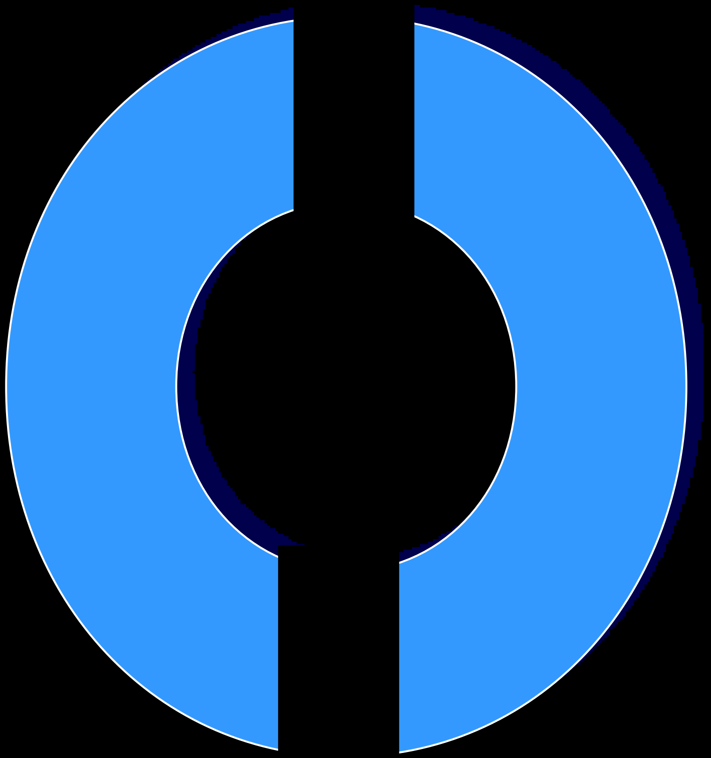
The Circle Concept

A single lesion (Bankart) will not produce complete dislocation until an additional area (RI, Post. Capsule) becomes damaged



2 breaks in the ring are necessary

for the shoulder to dislocate



Predictive Factors for Anterior Instability

- ✓ Age<20 yrs
- ✓ Ligamentous Laxity (RI, Post. Capsule)
- ✓ Activity Level is not a factor

The Spectrum of Instability Lesions

spectrum

Associated Lesions

BONY LESIONS

- Humeral Head
- Glenoid rim

LABRAL - LIGAMENTOUS INJURY

- Bankart lesion
- A.L.P.S.A.
- H.A.G.L.
- Capsular Tear

INCREASED CAPSULAR VOLUME

- Atraumatic elongation
- Traumatic stretch

BICEPS LESIONS

ROTATOR CUFF TEARS

- Partial thickness
- Full thickness

ROTATOR INTERVAL PATHOLOGY

- Widening
- Synovitis
- Rupture

Bankart Lesion

the essential lesion

- ✓ Avulsion of the IGHL from the glenoid rim from 2 o’clock to 6 o’clock
- ✓ Primary restraint to anterior translation at 90^{o} of abduction
- ✓ 85% in traumatic anterior dislocations
- ✓ Not enough to induce symptomatic instability

Bankart Lesion

VIDEO

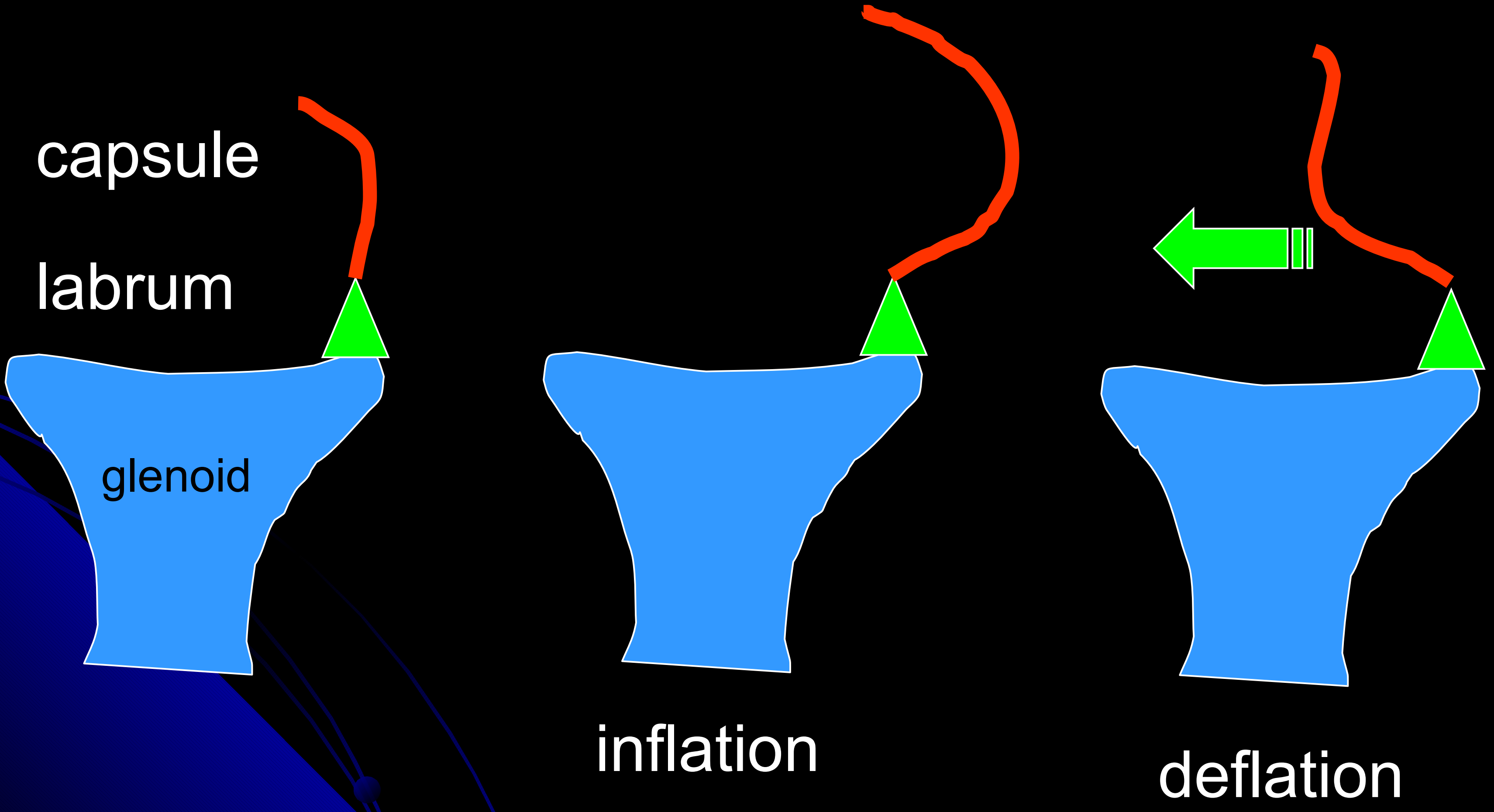
Bankart Lesion Equivalent

- ✓ Recurrent dislocations also can cause stretching of the glenohumeral capsule and ligaments

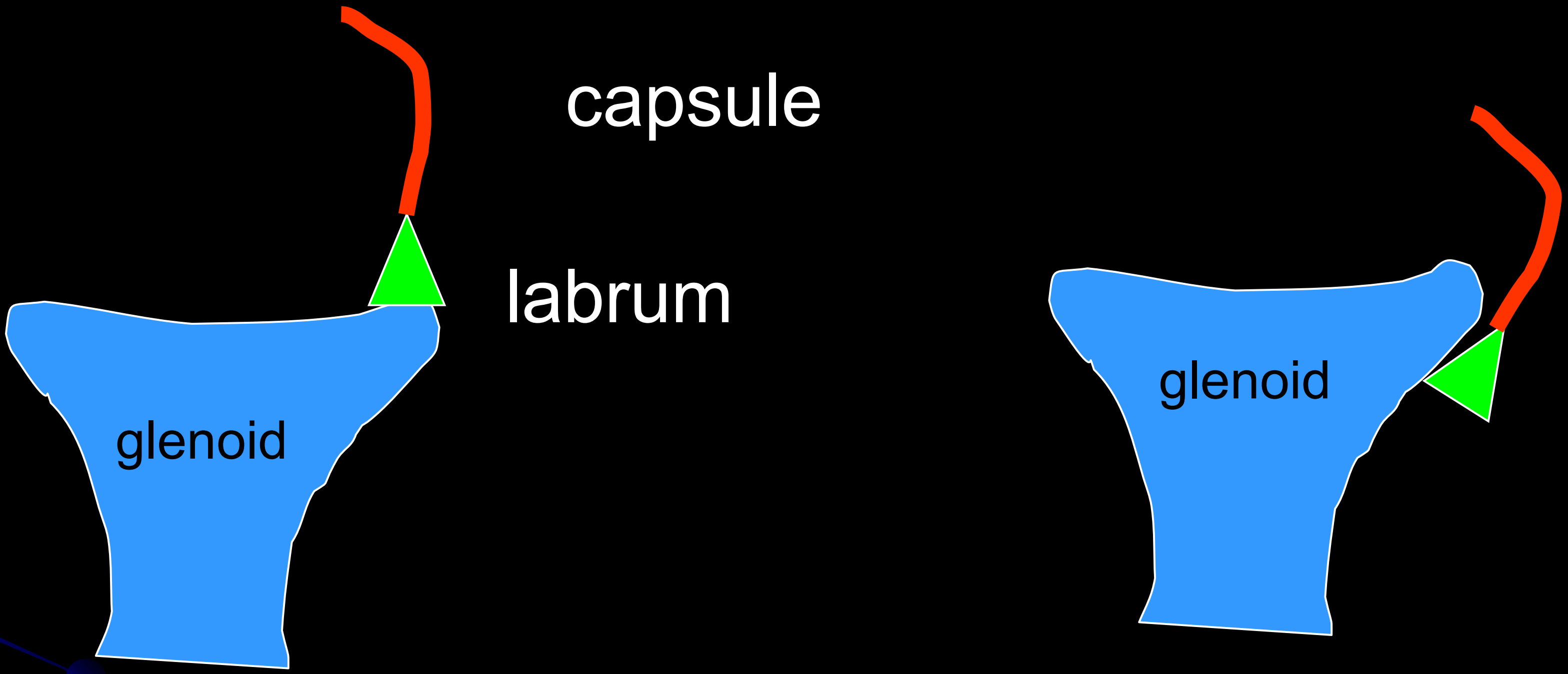
- ✓ This plastic deformation occurs from repetitive loading

Anterior Capsule Redundancy

the deflation phenomenon



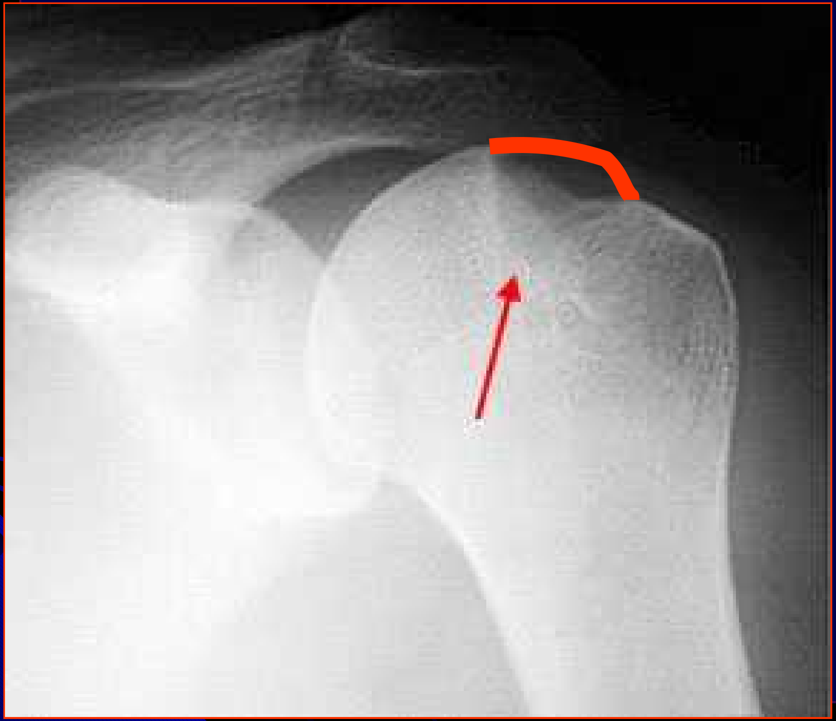
ALPSA lesion



capsule

labrum

Hill - Sachs Lesion



- ✓ Indentation fracture
- ✓ Present in 85% of recurrent dislocations

Hill-Sachs

Arthroscopic Shoulder Stabilization

Patient Selection

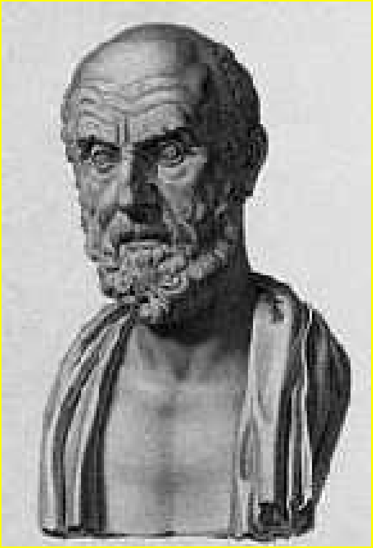
- ✓ Patients of all ages and all activity levels with recurrent anterior instability who are impaired functionally and in whom nonoperative treatment has failed
- ✓ Revision stabilization
- ✓ First-time, acute shoulder dislocations

Arthroscopic Shoulder Reconstruction

Goal of the Operation:

- ✓ Restoration of the Labrum to its anatomic attachment
- ✓ Reestablishment of the appropriate tension in the IGHL complex and capsule

Hippocrates, 5th Century B.C.



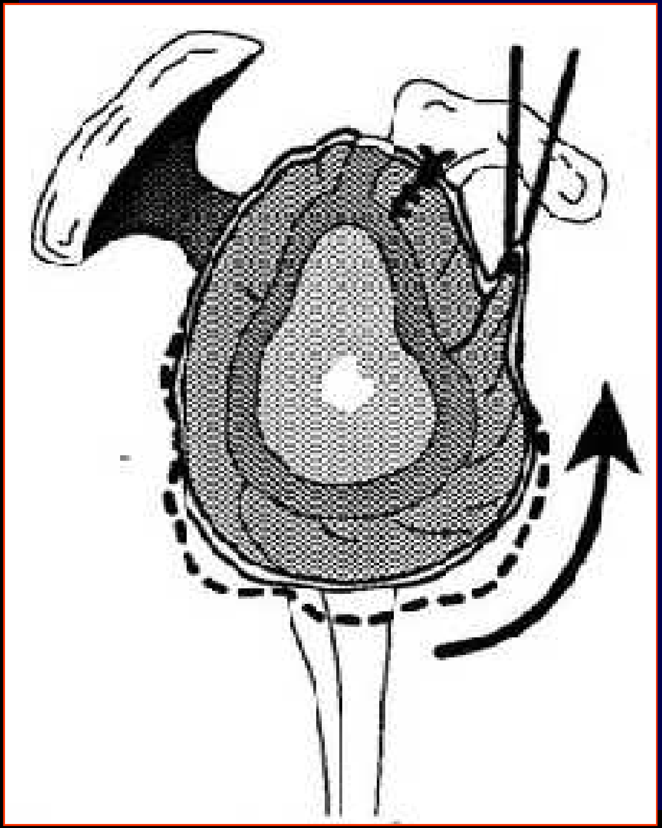
proposed iatrogenic decrease of shoulder ER causing a scar with a heated iron

Examination Under Anaesthesia

- ✓ In various degrees of abduction and ER
- ✓ Side-to-side comparisons
- ✓ Sulcus sign

Goal of arthroscopic shoulder reconstruction

Proximal Shift of the Capsule



Arthroscopic Reconstruction: Technique

1. Define Pathology
2. Debride damaged tissue
3. Release capsule to/past 6 o’clock
4. Free off subscapularis
5. Abrade glenoid
6. Repair capsulolabral complex
7. Associated Injuries (Posterior capsule, Rotator Interval, SLAP)

Lateral Decubitus Position

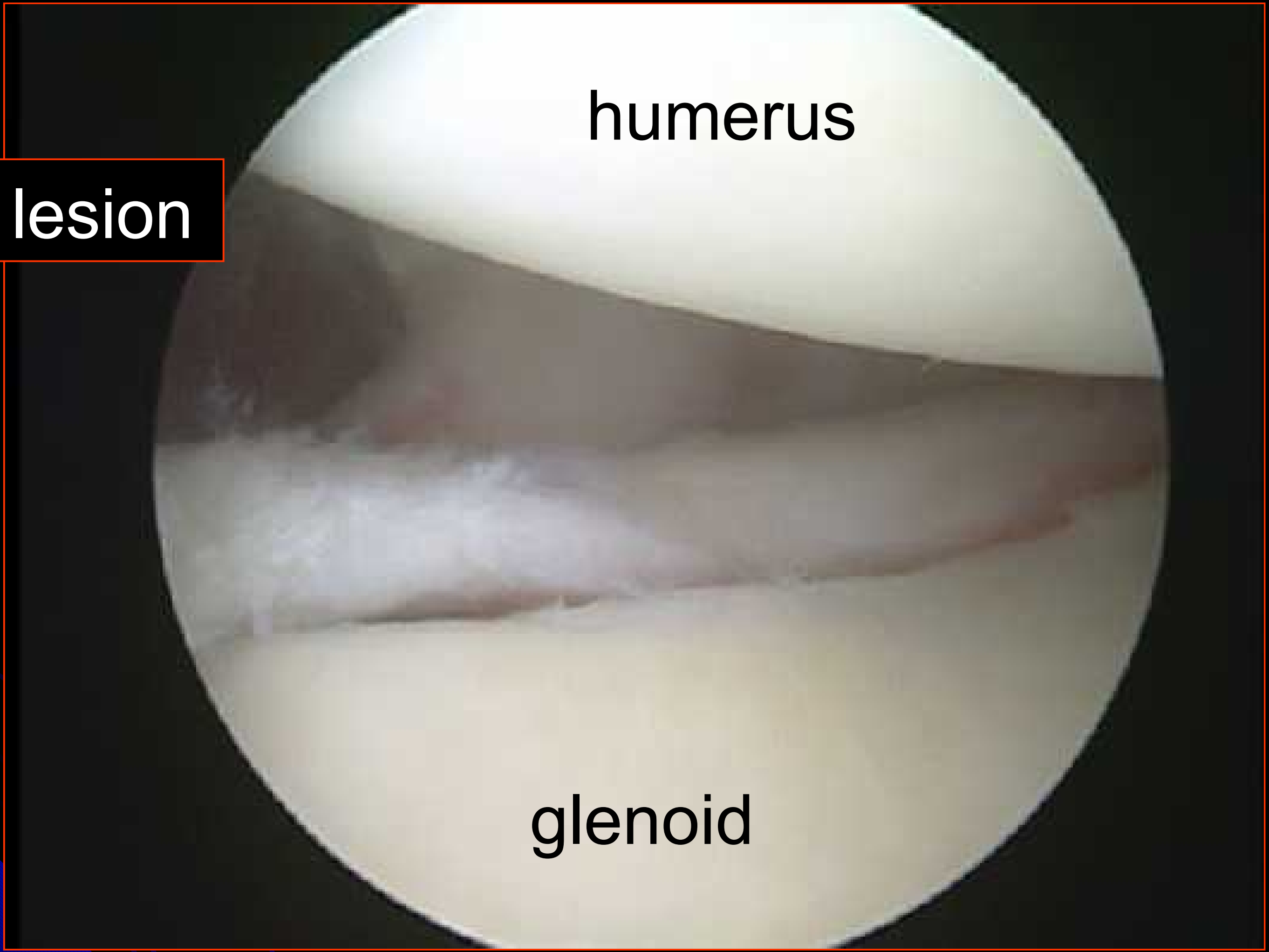
Abduction 70°

Traction 3-5 kg

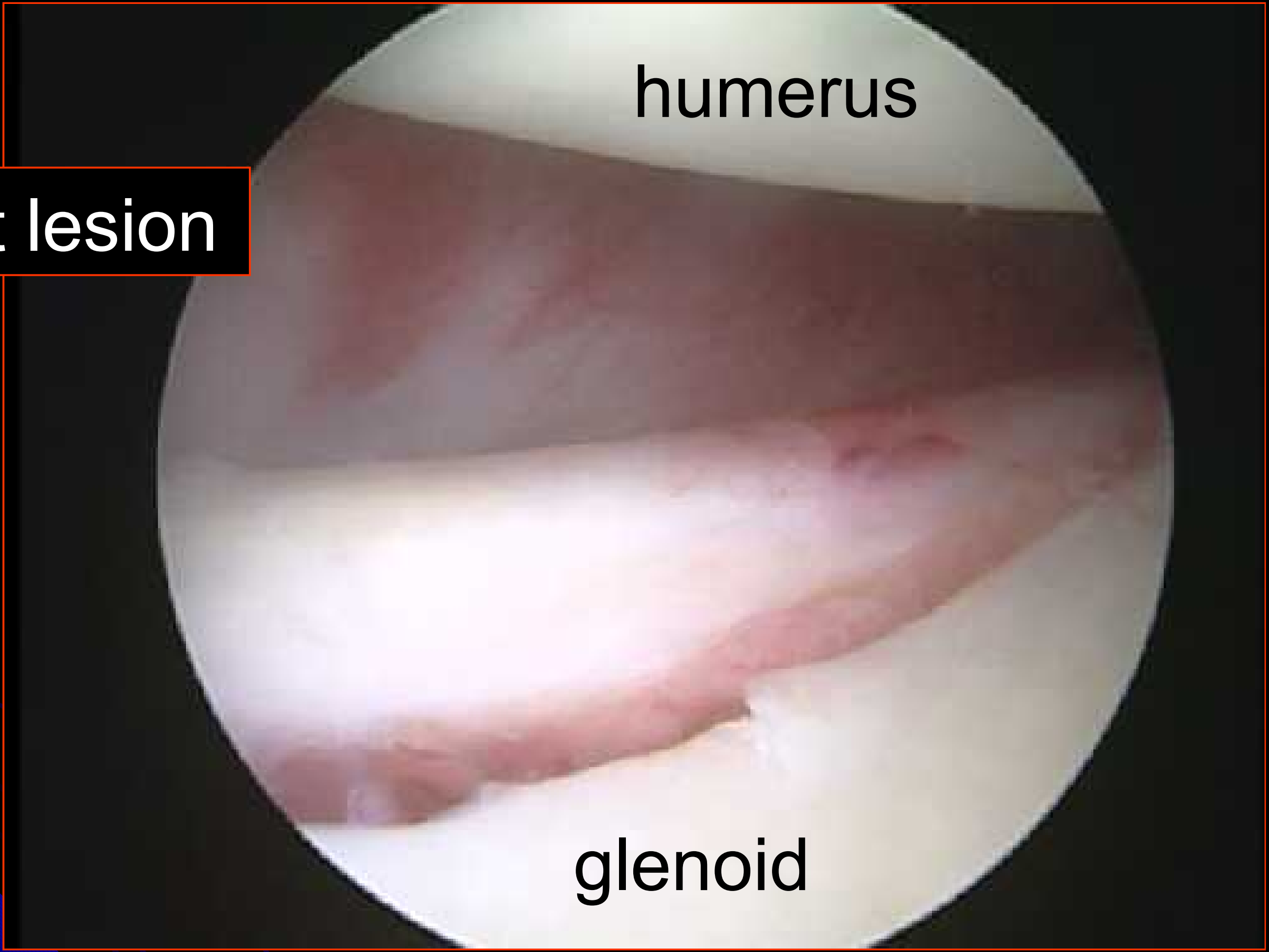
Portals: Left Shoulder

1. Identify and Define Pathology

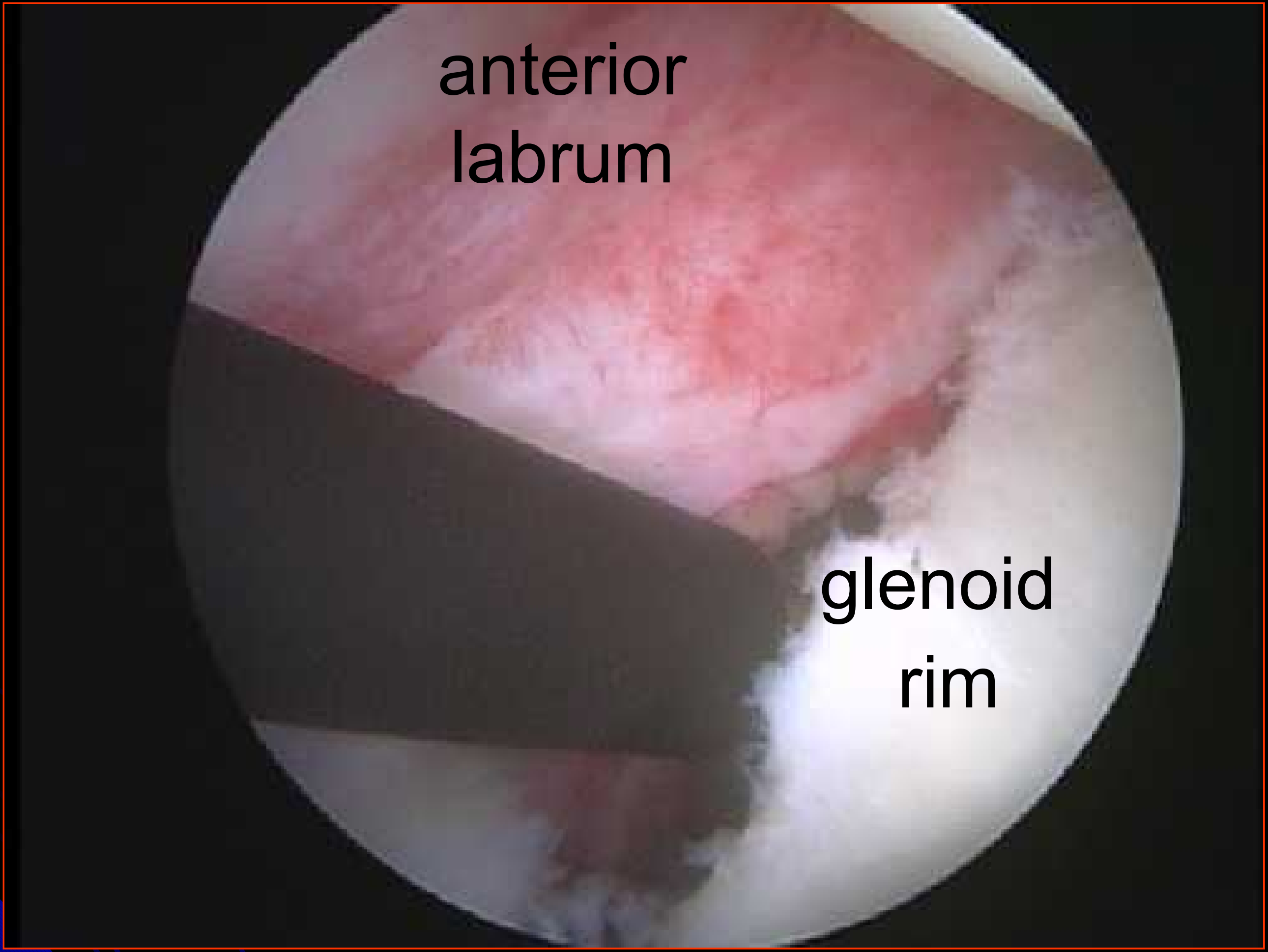
Bankart lesion



Bankart lesion

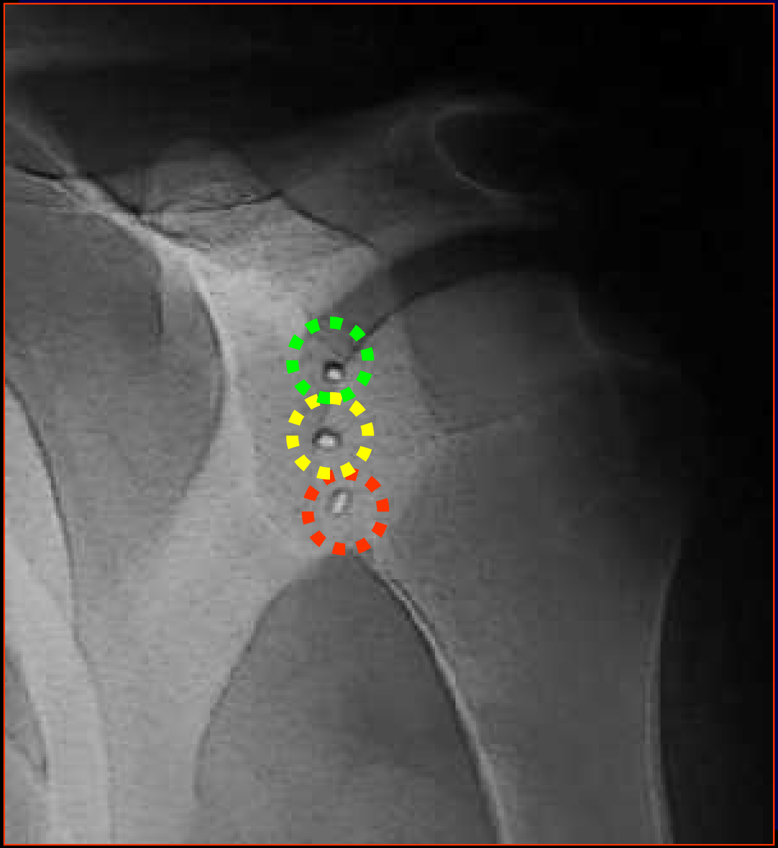


2. Mobilize Bankart Lesion and Abrade Glenoid Rim



3. Anchor Insertion

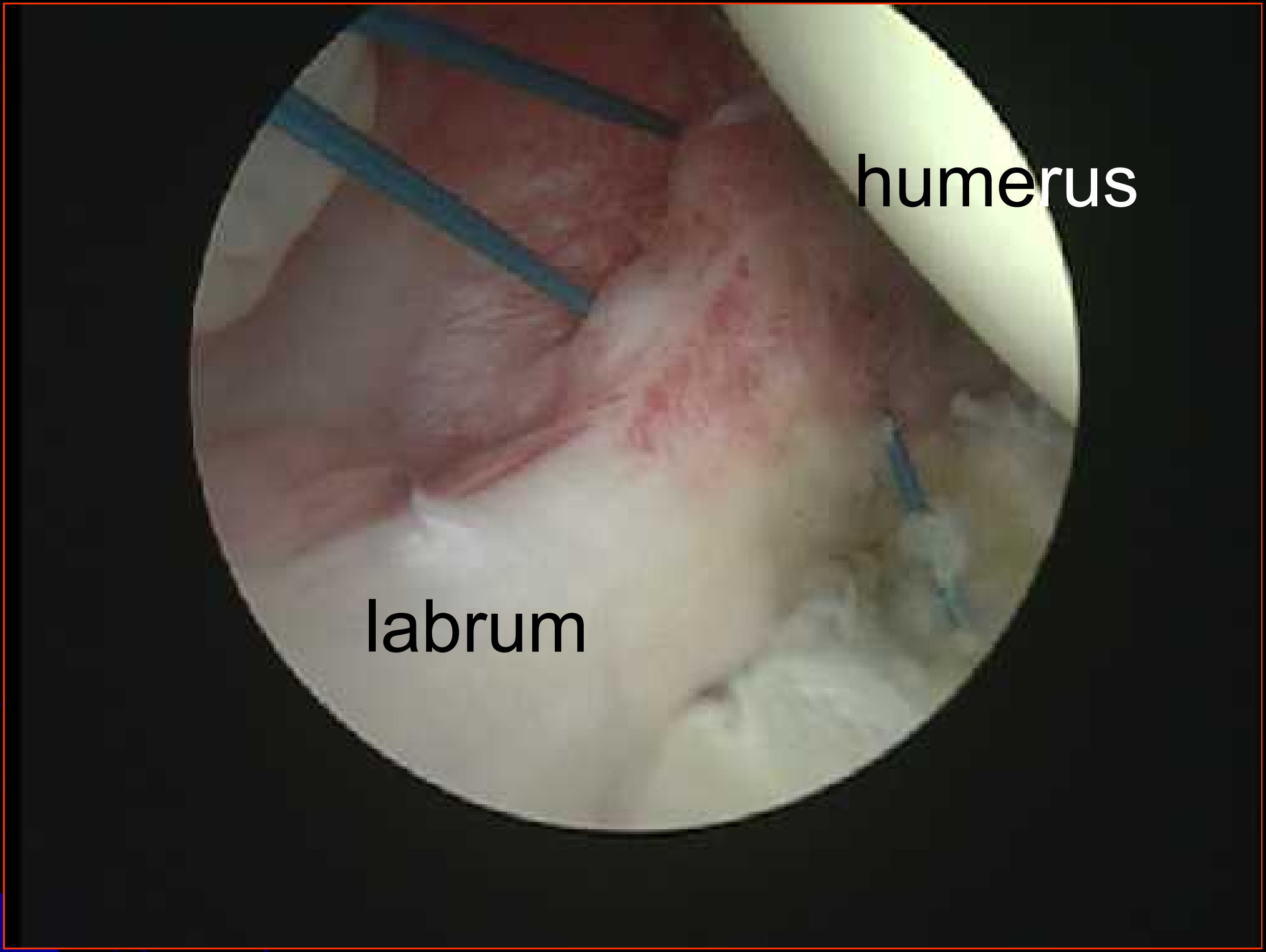
1st anchor	5 o’clock
2nd anchor	3 o’clock
3rd anchor	2 o’clock



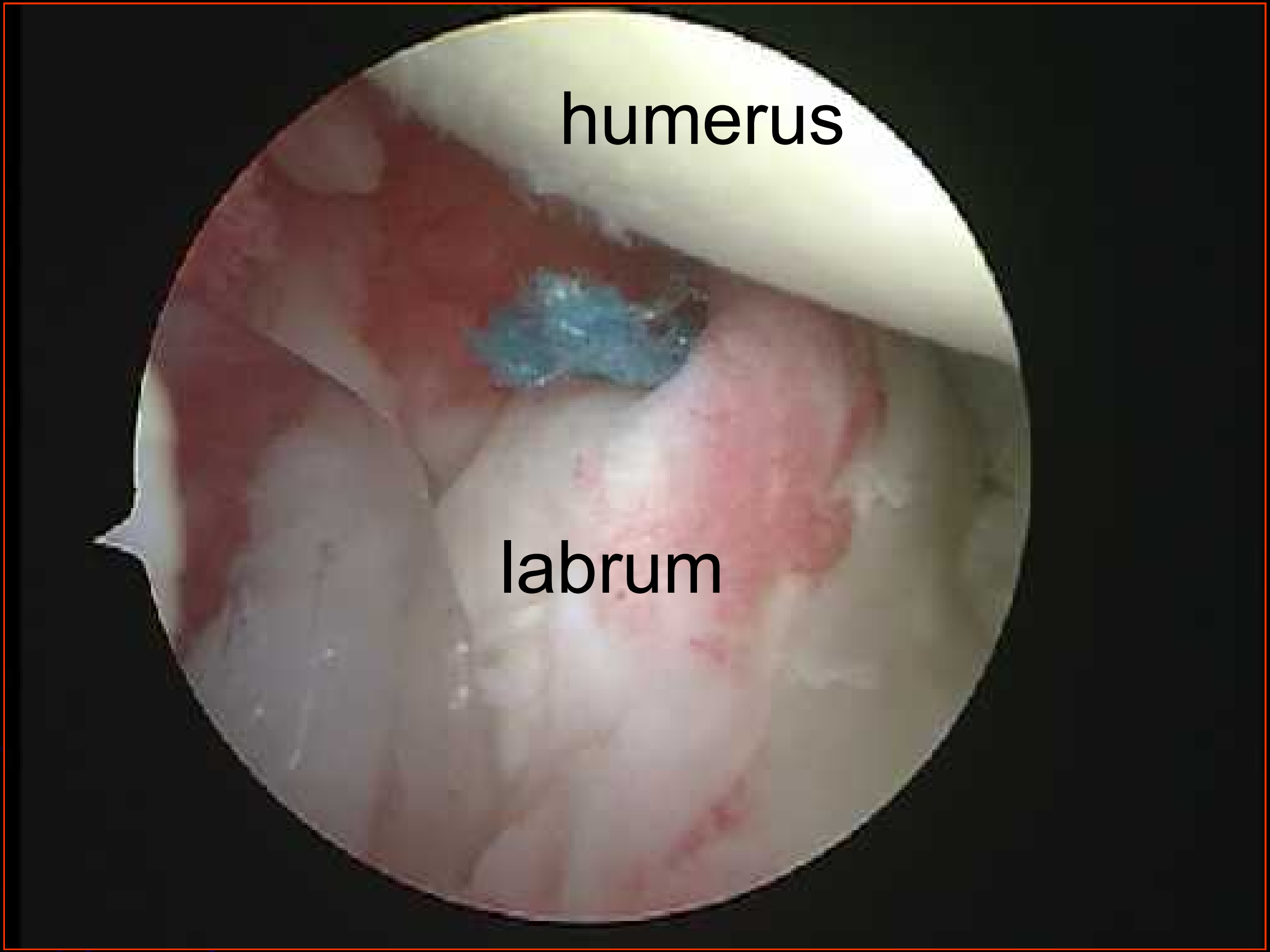
3-4 mm on the articular rim

from inferior to superior

4. Suture Passing



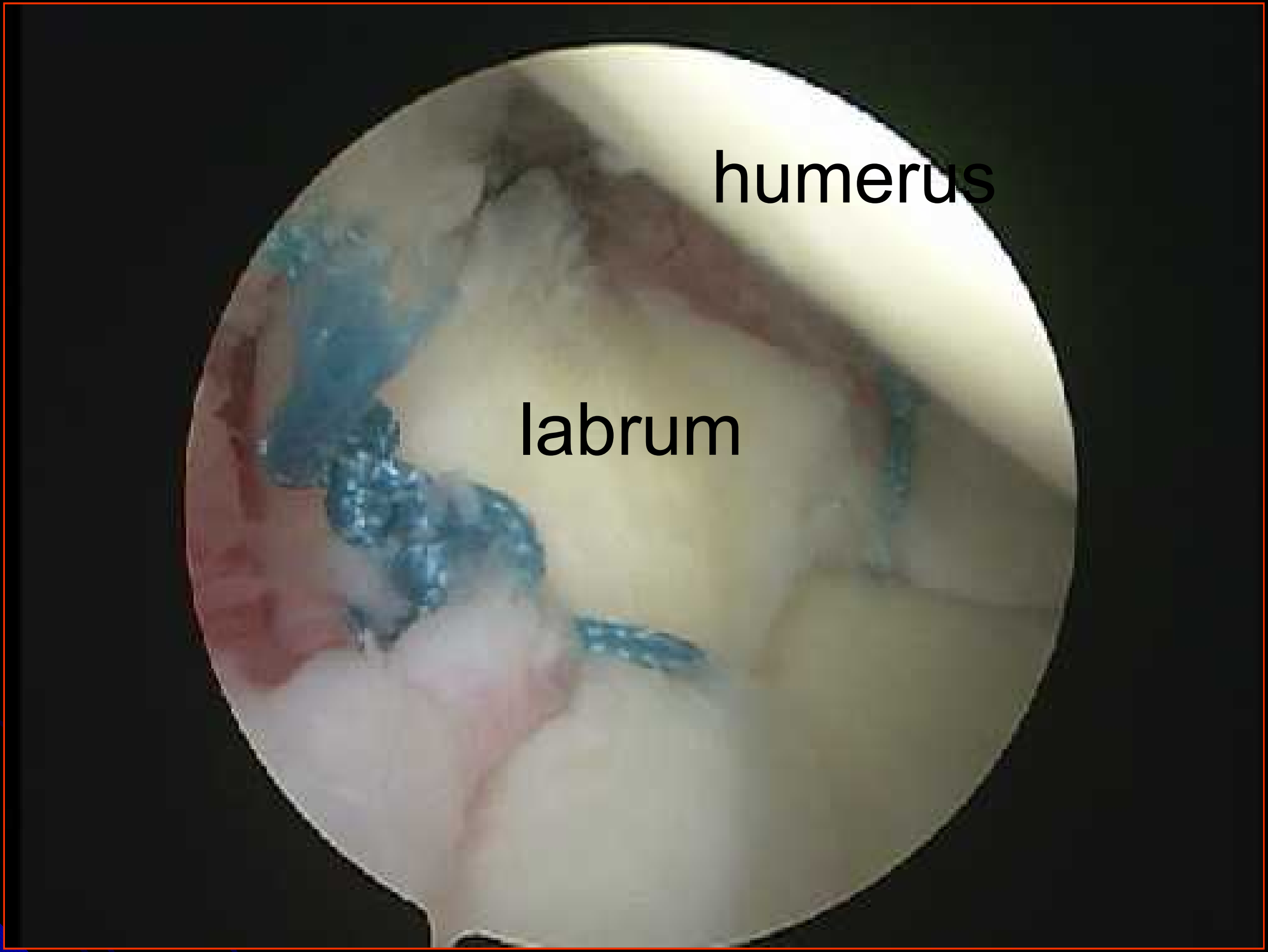
5. Knot Tying



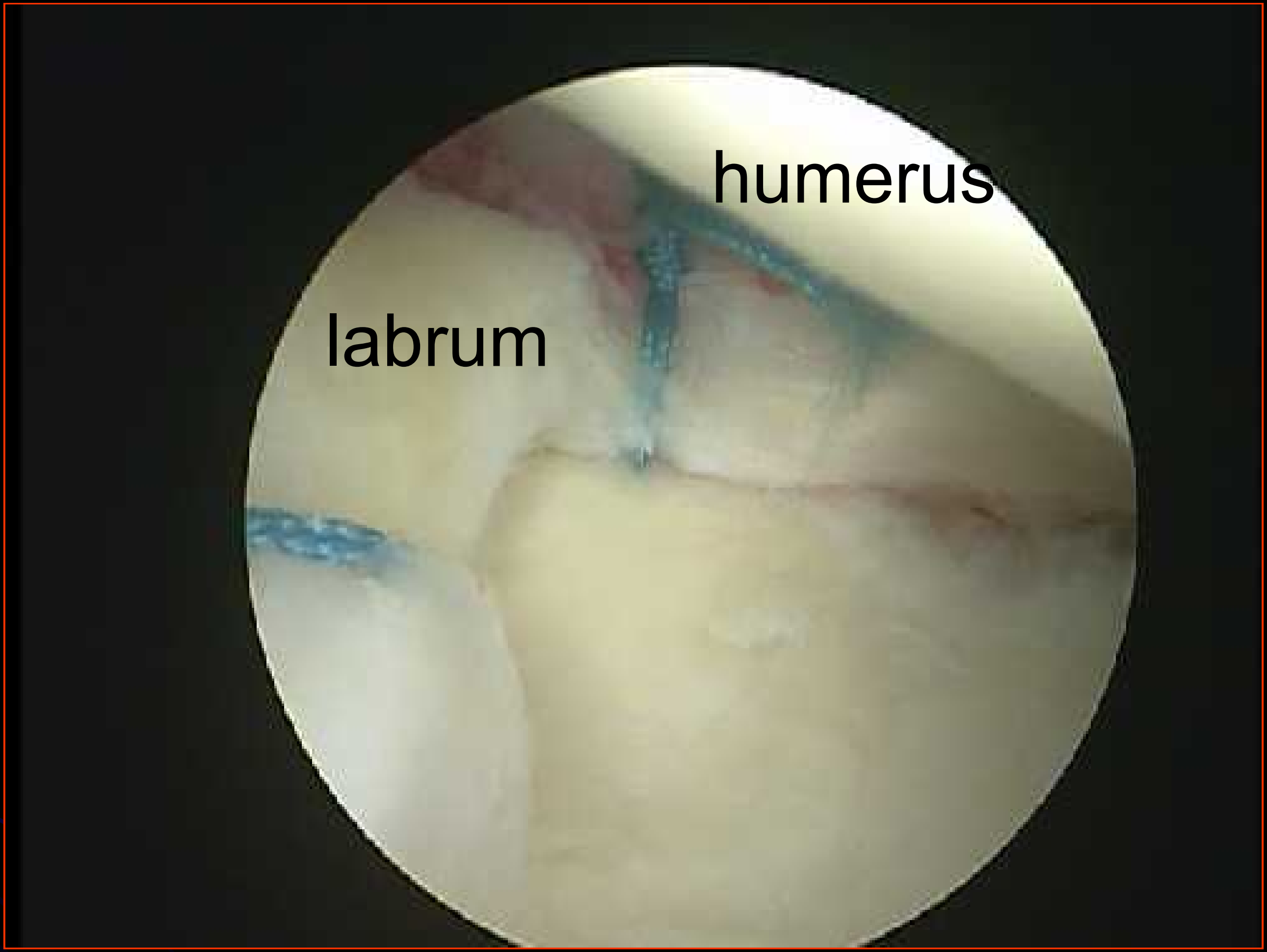
Completed repair

Capsular shift

6. Assessment of the Final Repair



completed repair



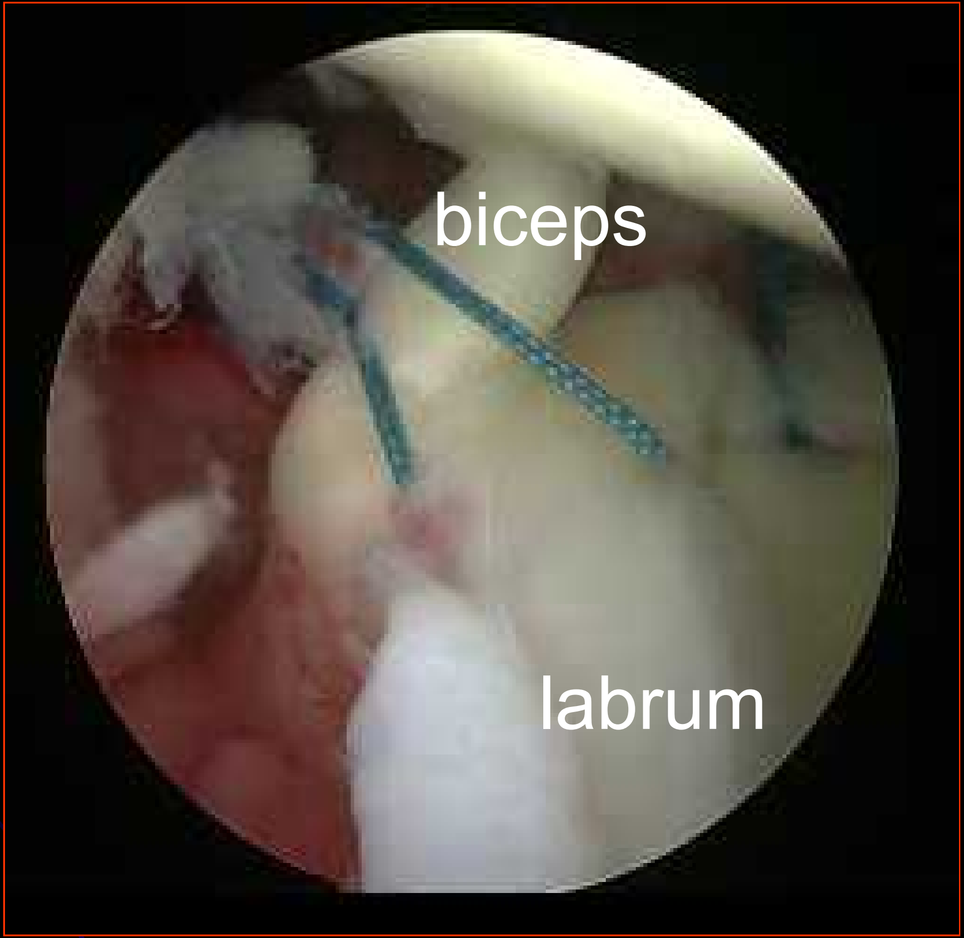
Completed repair

Recreation of labral bumper

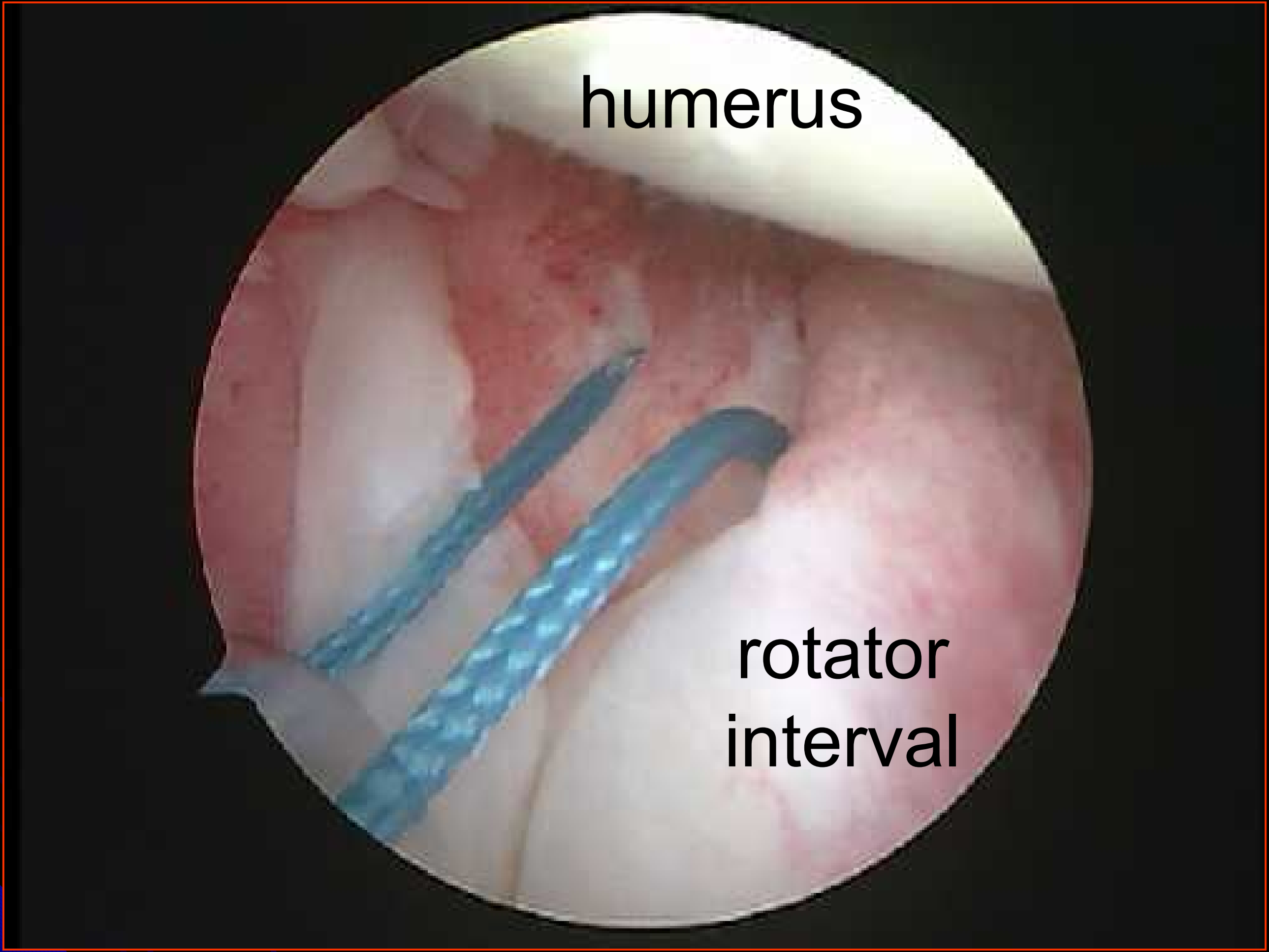
7. Associated Pathology

- ✓ RI laxity
- ✓ Posterior Capsule
- ✓ Ant. Capsular Stretch
- ✓ HAGL
- ✓ SLAP
- ✓ Hill-Sachs

SLAP repair



Rotator Interval Closure



in external rotation

Redundant posterior capsule

How to Reduce Capsule Redundancy

- ✓ the capsular “pinch-tuck” technique
- ✓ adjunctive thermal treatment
- ✓ rotator interval closure

Thermal Capsulorrhaphy

- ✓ an adjunct to tighten the capsule for persistent capsular laxity
- ✓ peer reviewed literature is limited

PHOTO SHRINKAGE

Posterior Instability Repair

Αγαμέμνονος

Postoperative Rehabilitation

well-supervised and individualized

- ✓ Sling for 4/52
- ✓ Isometrics and pendulum exercises immediately
- ✓ Active forward elevation may begin after 3/52
- ✓ External rotation to 30° to 40° at 4/52
- ✓ Progressive strengthening at 8/52
- ✓ Return to sport at 18 to 36 weeks

Postoperative Evaluation

- ✓ Rowe score
- ✓ UCLA score
- ✓ Apprehension
- ✓ ROM
- ✓ Return to activity
- ✓ Complications
- ✓ X-rays
- ✓ MRI

Arthroscopic Reconstruction

Success rate 50-100%

Randomized Controlled Studies

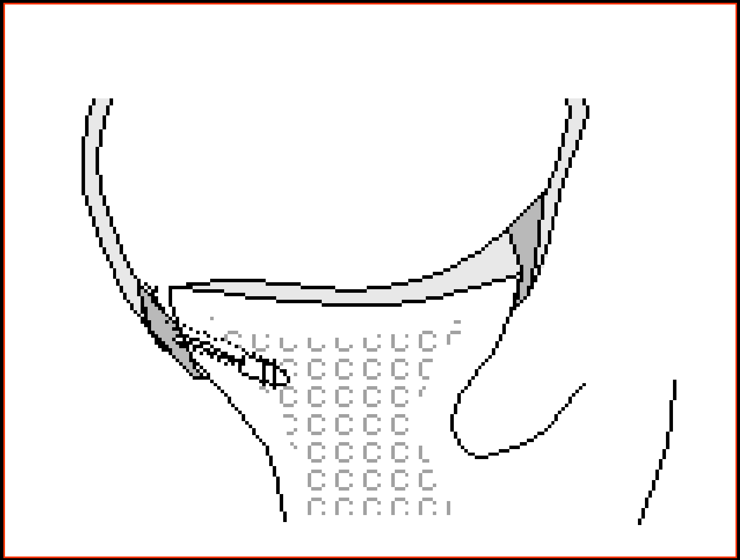
Kim (2002)	A>O
Karlsson (2001)	A>O
Jorgensen (1999)	A>O
Sperber (2001)	A=O
Steinbeck (1998)	transglenoid<O
Geiger (1997)	A<O

Arthroscopic or Open Shoulder Reconstruction ?

Not a black or white issue

High Initial Failure Rate of Arthroscopic Techniques

- ✓ Technical factors (medial repair)



- ✓ Failure to treat other lesions (RI, capsular laxity)

Arthroscopic vs Open Shoulder Reconstruction

- ✓ Less trauma
- ✓ Better cosmesis
- ✓ Addresses associated pathology
- ✓ Less postoperative pain
- ✓ On an outpatient basis
- ✓ Faster surgery
- ✓ Better ROM
- ✓ Return to sports
- ✓ Similar recurrence rate
- ✓ Patient Demand
- ✓ Insurance Policy (Less cost)
- ✓ Equipment dependent

Arthroscopic vs Open Shoulder Reconstruction

- ✓ familiar to most orthopaedic surgeons
- ✓ requires little special equipment
- ✓ reasonably reproducible recurrence rate
- ✓ addresses large glenoid bone defects

Neither technique is "easy"

Both techniques are equivalent in terms of “success”

The operation should be tailored to the patient and not the patient to the operation.

Arthroscopic Techniques are suitable

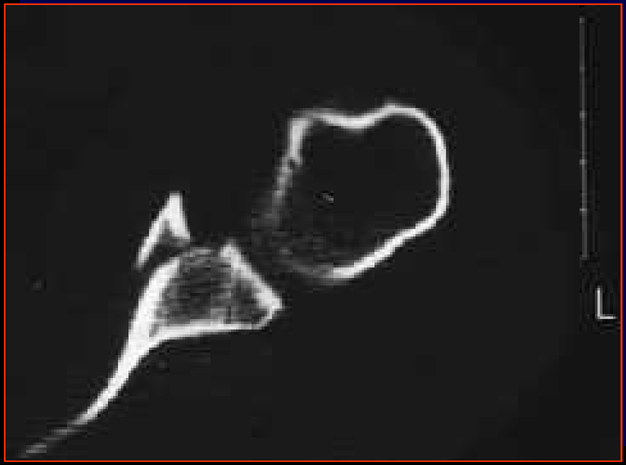
for almost every instability problem

Arthroscopic stabilization is the technique of choice when confronted with the patient exhibiting unilateral anterior shoulder instability

The Ideal Patient

- ✓ Unidirectional, traumatic instability
- ✓ Bankart lesion
- ✓ First dislocation
- ✓ Robust labroligamentous tissue
- ✓ Low activity level
- ✓ Experienced surgeon

Limitations of the Arthroscopic Techniques



✓ Glenoid Bone Loss > 30%

✓ Engaging Hill-Sachs

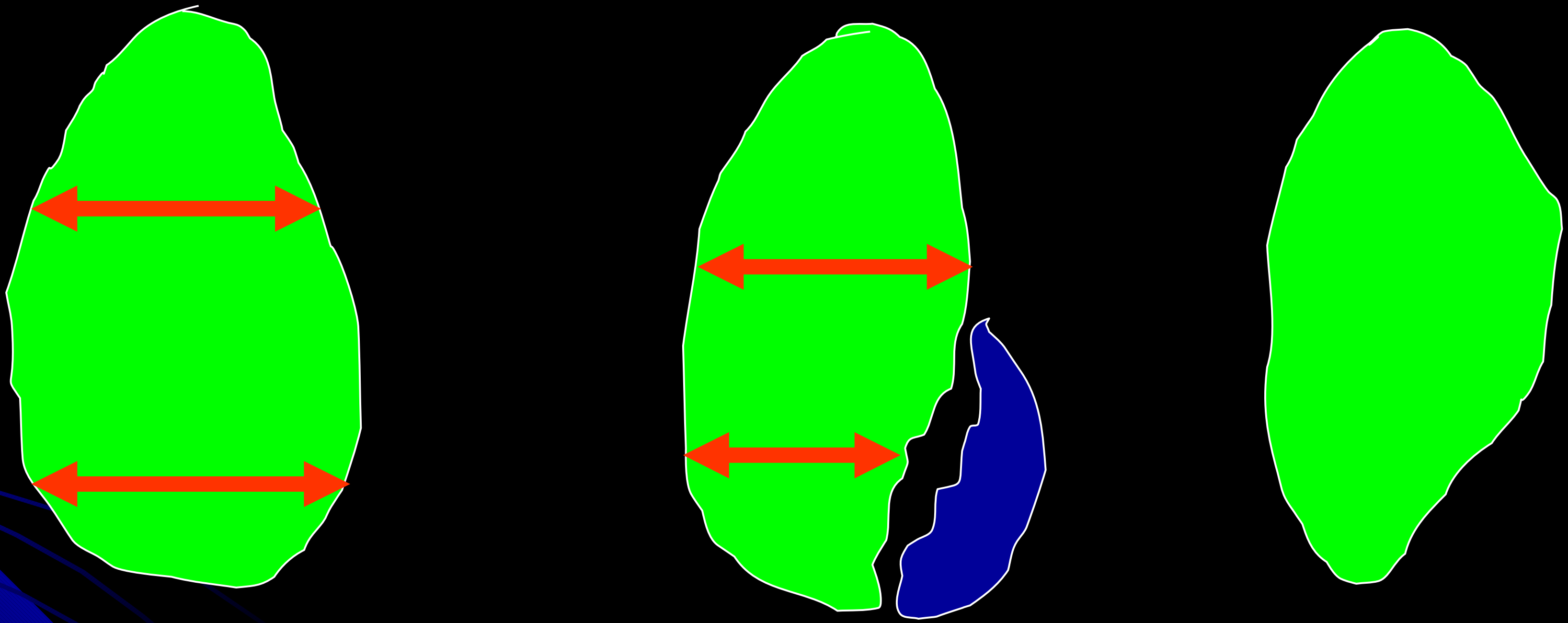
✓ HAGL lesions

HAGL Lesion

Normal Glenoid

Bony Bankart

Compression Bankart

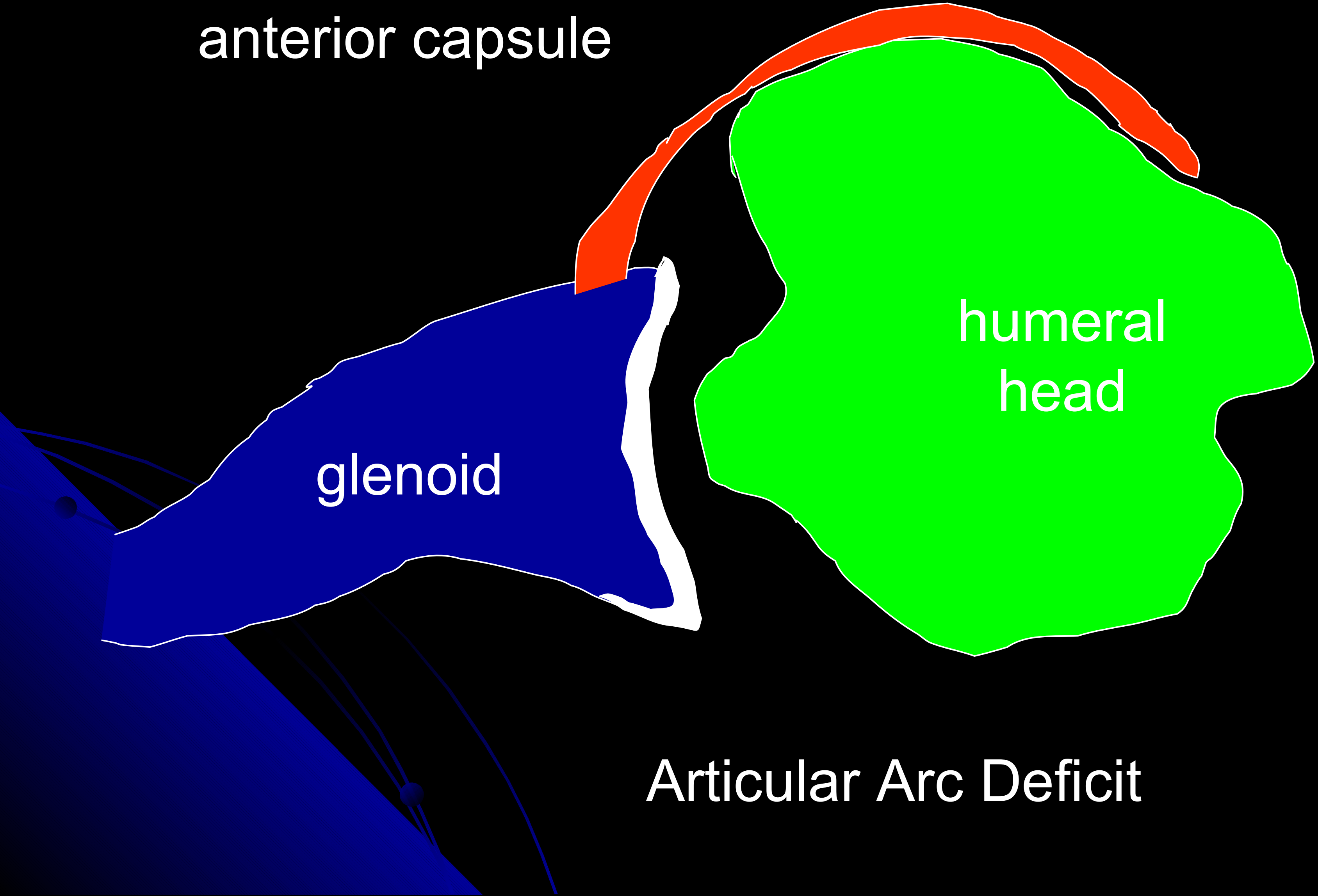


pear

inverted pear

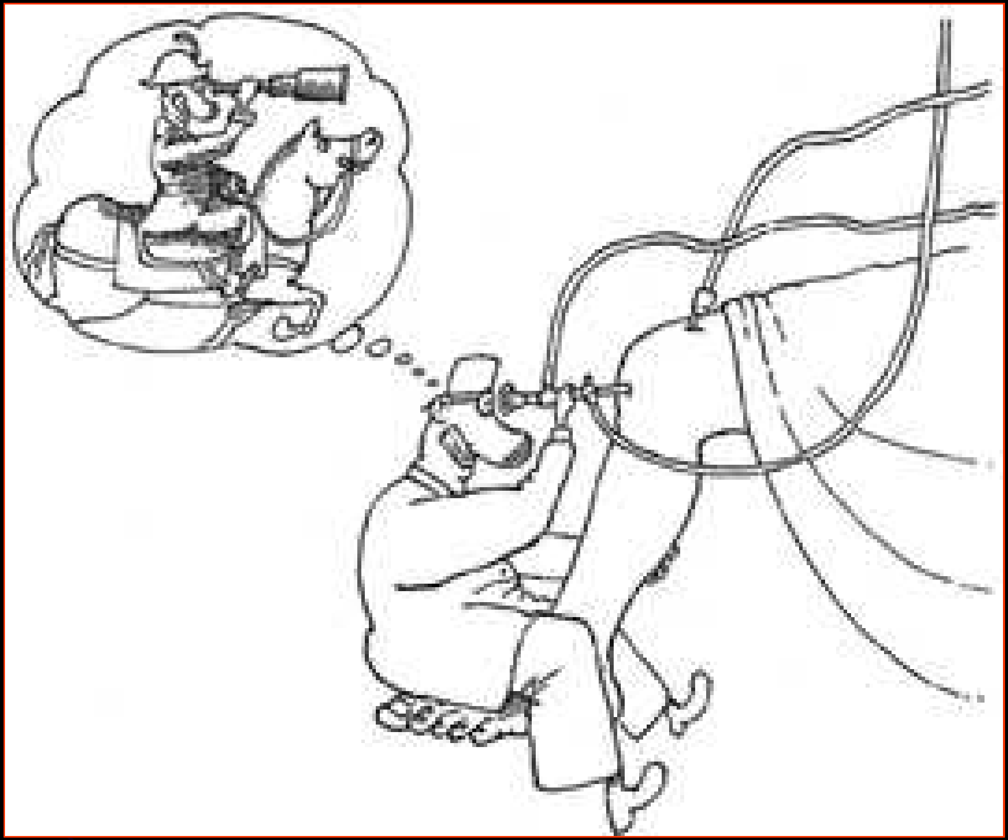
loss of anterior rim

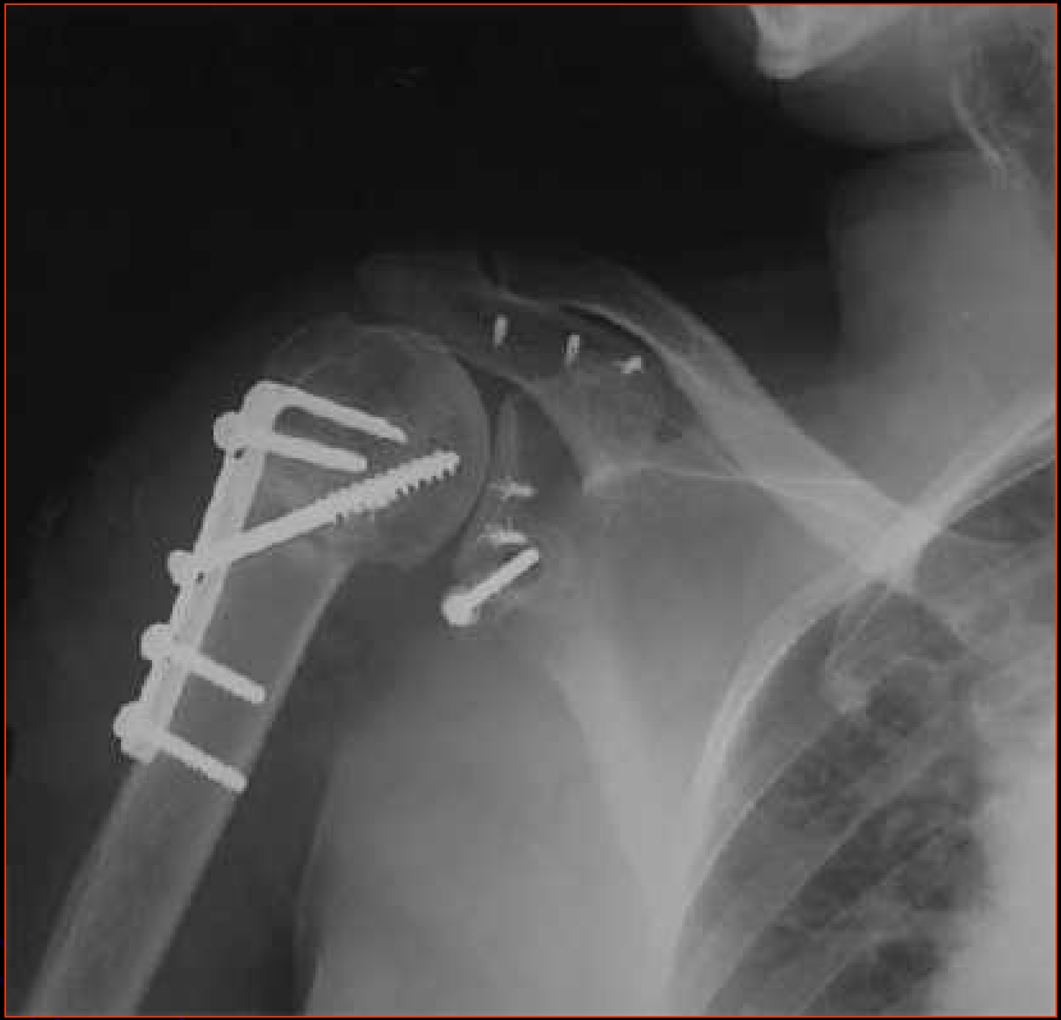
Engaging Hill-Sachs Lesion



Articular Arc Deficit

Arthroscopic Surgery is not a Panacea

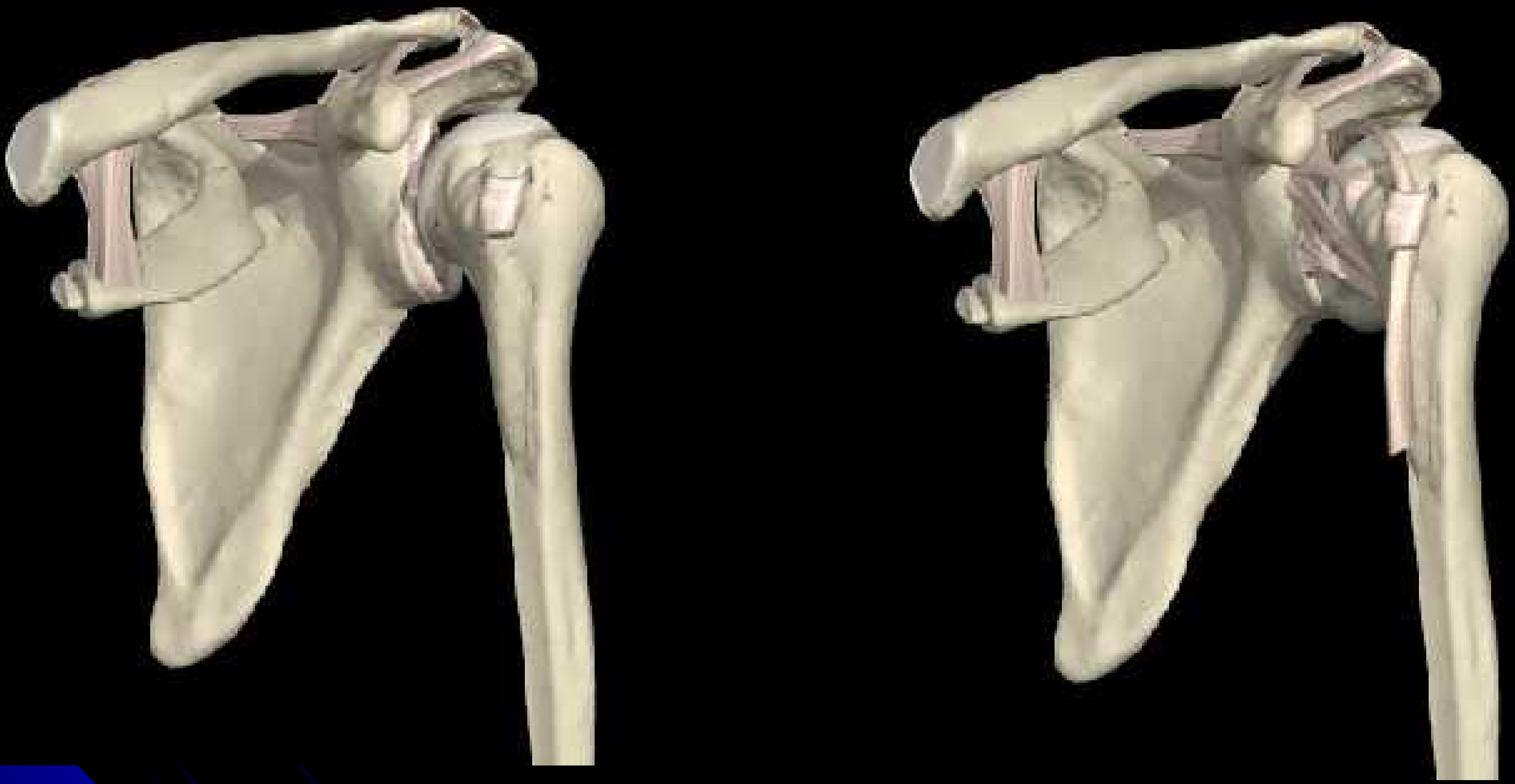


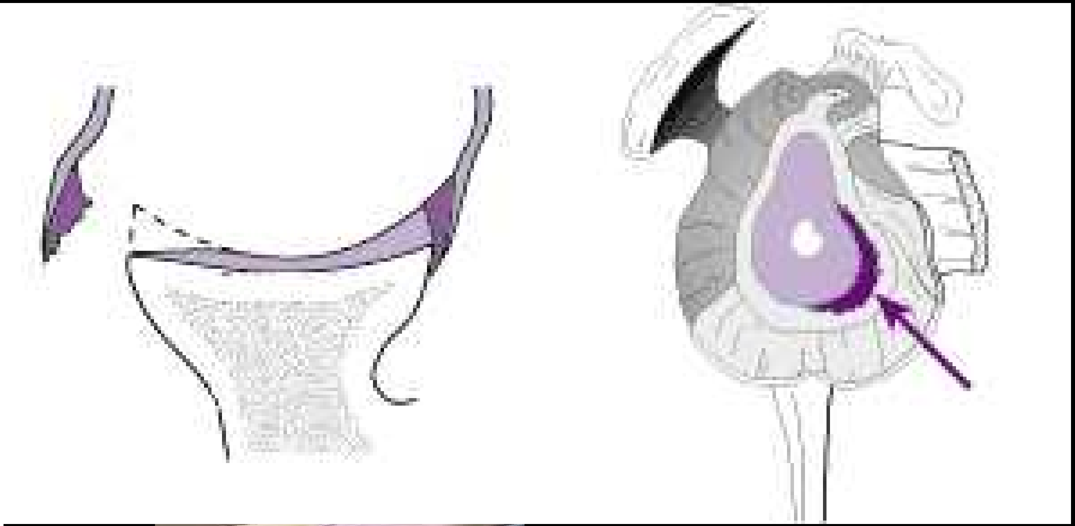


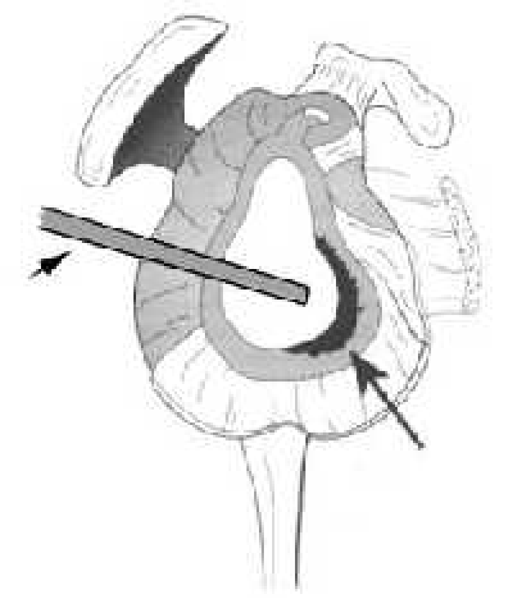
Dr. F. Matsen

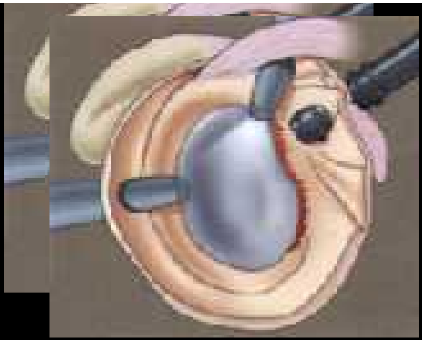
JOGGLER

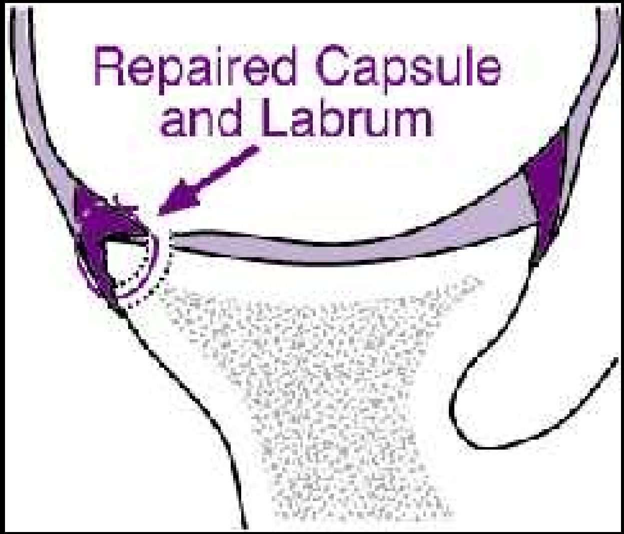
MAGICIAN

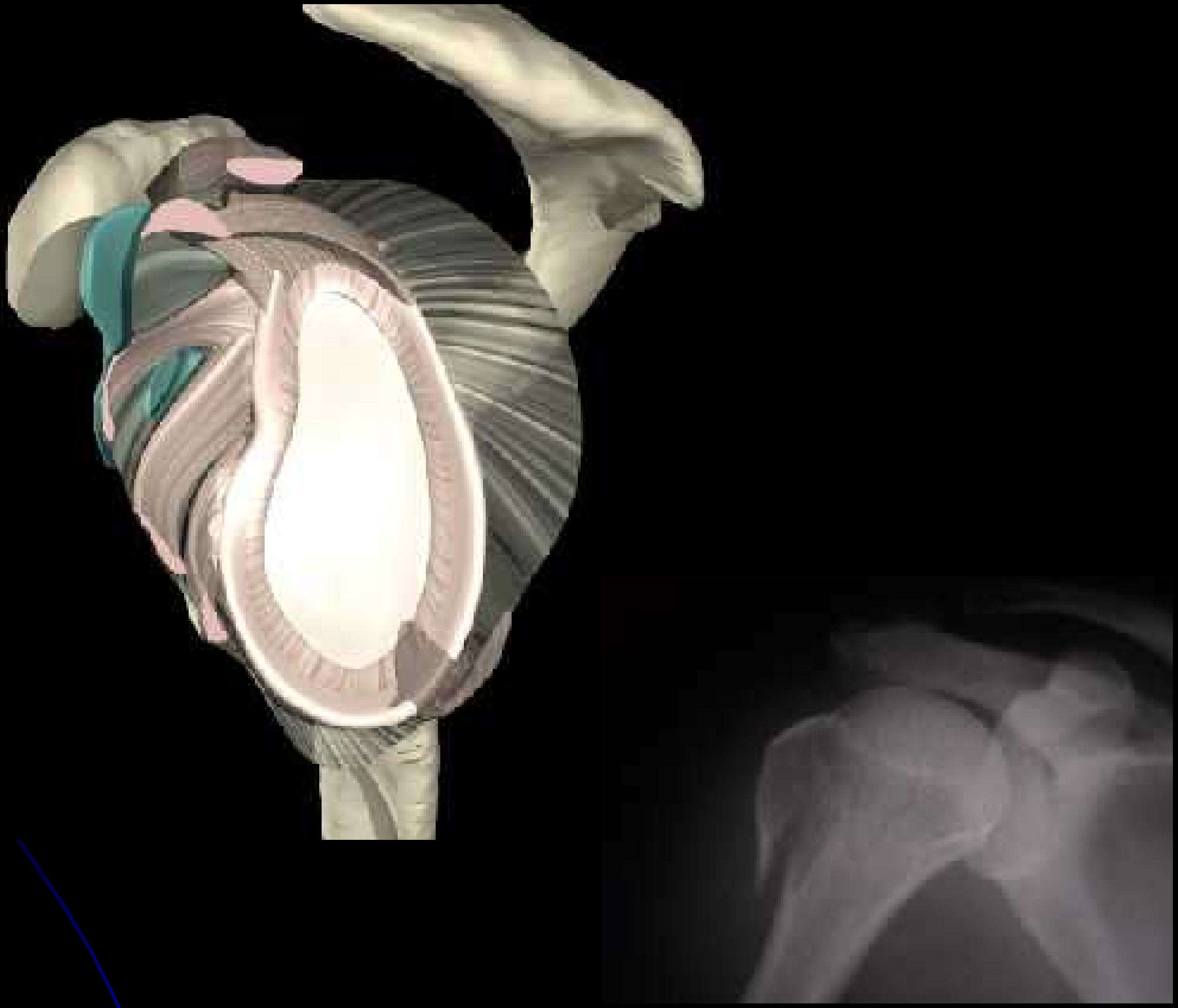


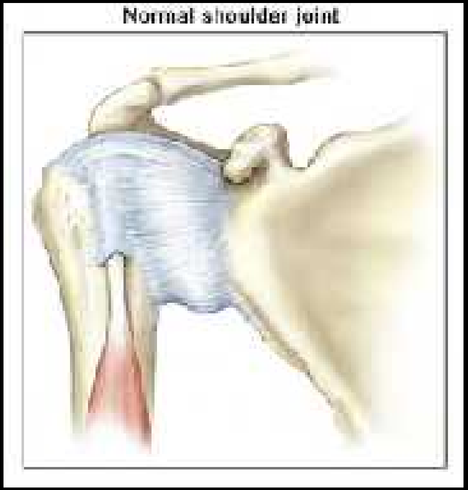






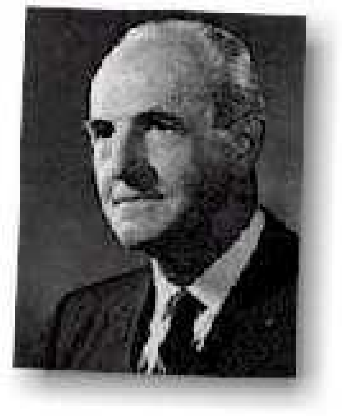

Repaired Capsule and Labrum




Normal shoulder joint

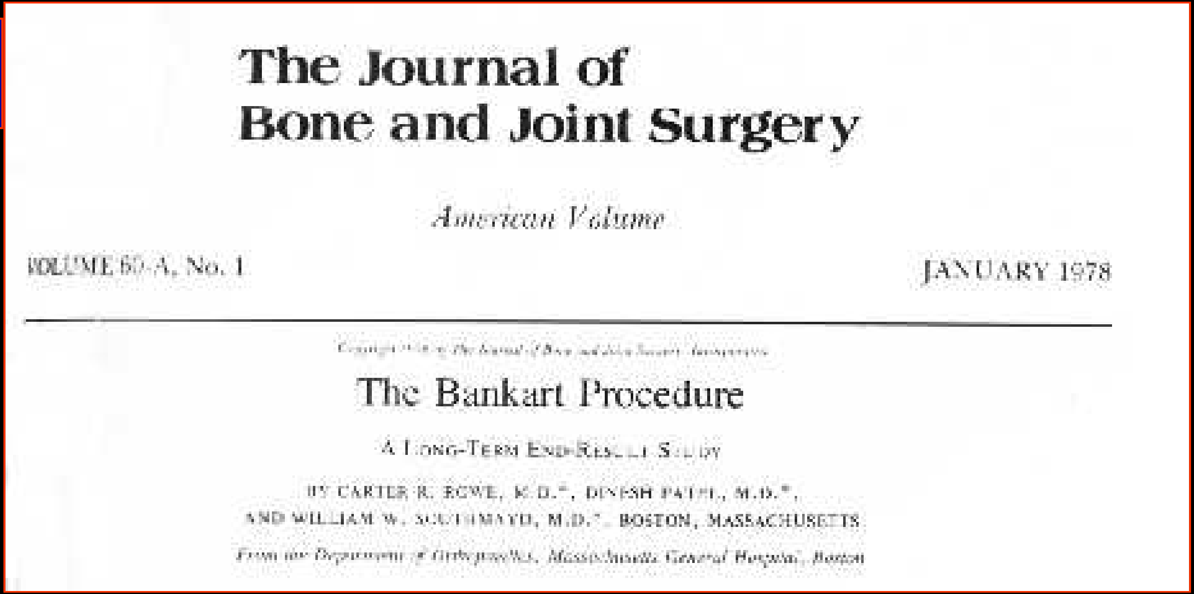
Open shoulder repair is more effective than arthroscopic repair !

Is Open shoulder repair is more effective than arthroscopic repair ?



Carter Rowe M.D.
(1907-2001)

Rowe, JBJS 1978



The Journal of
Bone and Joint Surgery

American Volume

VOLUME 60-A, No. 1

JANUARY 1978

The Bankart Procedure

A LONG-TERM END-RESULT STUDY

BY CARTER R. ROWE, M.D.*, DINESH PATEL, M.D.*,
AND WILLIAM W. SOUTHMAYD, M.D.*, BOSTON, MASSACHUSETTS

From the Department of Orthopaedics, Massachusetts General Hospital, Boston

96.5% success rate (Gold Standard)

< 2/3 f-up

69% normal rotation

33% return to sports

Would not be published in the JBJS today

Standing at a crossroads

What does "better" mean?

- ✓ Recurrence rate
- ✓ Function
- ✓ Range of motion
- ✓ Expenses

The Ideal Procedure

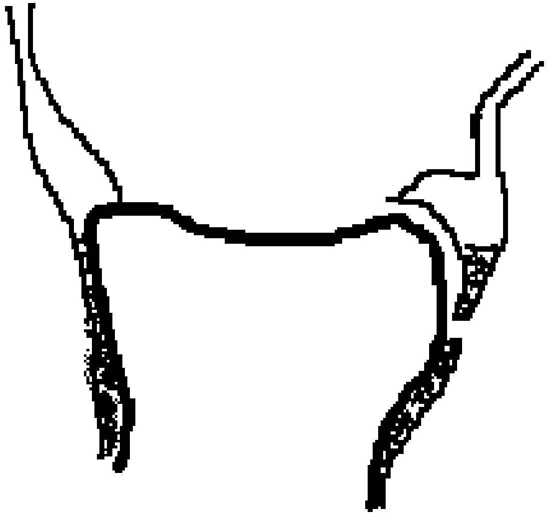
- ✓ no recurrences
- ✓ normal motion
- ✓ no pain
- ✓ return to preinjury performance levels

Neither technique is "easy"

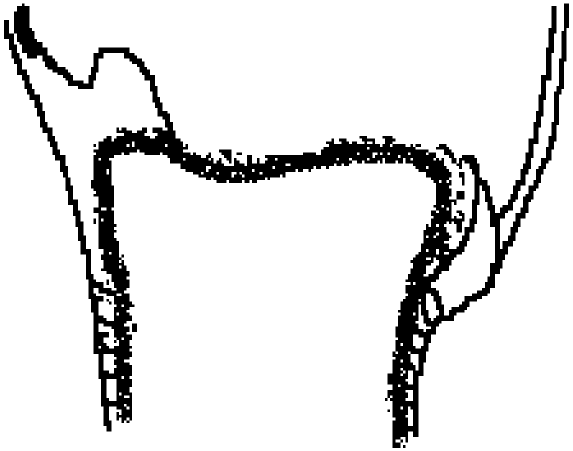
Both techniques are equivalent in terms of “success”

The operation should be tailored to the patient and not the patient to the operation.

BANKART lesion



ALPSA lesion



Anatomic structures and their sequential identification:

- Biceps tendon
- Humeral head
- Glenoid
- Glenoid labrum
- Superior, middle and inferior glenohumeral ligament
- Axillary pouch
- Posterior inferior glenohumeral ligament
- Posterior labrum
- Subscapularis tendon and recess
- Rotator cuff

Biceps Tendon

- This serves as the reference structure for maintaining orientation during the arthroscopic procedure
- Attaches at the supraglenoid tubercle at the posterior superior aspect of the glenoid rim
- Sends fibers to the superior anterior and superior posterior labrum
- Extends anterolaterally across the joint to exit in the bicipital groove between the subscapularis and the supraspinatus tendons (the rotator cuff interval)

Humeral Head

- Smooth, articular surface "bare area" represents a non-articular surface of the posterior portion of the humeral head
- This is a normal non-articulating portion of the humeral head

Glenoid

- Pear or bean shaped articular surface
- Approximately one-fourth the size of the humeral head

Glenoid Labrum

- Function:
  - Provides inherent stability to the glenohumeral joint by restricting anterior and posterior excursion of the humerus
  - Ovoid, wedged-shape structure approx. 3-4 mm in height bordering the rim of the glenoid
  - Consists of cartilage, fibrocartilage and fibrous tissue
  - Contiguous with the hyaline cartilage of the glenoid cavity; anteriorly inherently related to the inferior glenohumeral ligament complex; superiorly related to the superior glenohumeral ligament and biceps tendon
- Anatomic variations - Detrisiac and Johnson
  - Five types

Anterior Glenohumeral Ligaments - Superior, Middle and Inferior

- Considerable variations in size, shape and bony attachment

Superior Glenohumeral Ligament

- Smallest of the three
- Functions with the coracohumeral ligament to stabilize the shoulder in an adducted position
- Prevents downward dislocation of the shoulder
- Two capsular attachments
  - Near the base of the coracoid process
  - Superior anterior aspect of the glenoid labrum
- Courses anterolaterally across the joint
- Originates at the anterior anatomic neck of the humerus at the medial ridge of the intertrabecular groove

Middle Glenohumeral Ligament

- Stabilizes the glenohumeral joint with the shoulder abducted 45°
- Prevents anterior subluxation and dislocation
- Originates from the anterior humeral neck, just medial to the lesser tuberosity
- Courses anteromedially across the shoulder to insert on the middle and superior glenoid and glenoid neck
- Varies considerably in width and thickness; normally identified just posterior to the subscapularis tendon
- Crosses the subscapularis tendon at approx. 60° angle

Inferior Glenohumeral Ligament

- Stabilizes the shoulder when the arm is abducted at approx. 90°
- Most important structure in prevention of anterior and inferior dislocations
- Turkel - two portions
  - superior band and axillary pouch
- The superior band originates from the lower anatomic neck of the humerus, just distal to the lesser tuberosity
- Axillary pouch arises from the inferior one third of the humeral head
- Inserts in a broad, oblique fashion to almost the entire glenoid margin
- Higher degree of variability exists in the superior band

Subscapularis Tendon and Recess

- The interarticular portion of the tendon is only a small portion of the total tendon length
- Covered obliquely by the middle glenohumeral ligament
- Tendon fibers run perpendicular to the long axis of the glenoid

Subscapularis Recess

- Located over the anterior aspect of the shoulder beneath the subscapularis tendon in the region of the middle glenohumeral ligament
- In a plane between the scapula and subscapularis muscle
- May be identified superiorly and/or inferiorly to the subscapularis tendon and middle glenohumeral ligament

Rotator Cuff

- Composed of the subscapularis, supraspinatus, infraspinatus and teres minor muscle
- The tendinous portion of the infraspinatus and supraspinatus and teres minor blend at the proximal level of the glenoid and continue laterally to insert into the greater tuberosity.
- Close attention is paid to the relationship of the rotator cuff tendons to the biceps tendon; the supraspinatus tendon is just posterior to the biceps tendon as it enters the intertrabecular groove
- No distinct division is noted between the three tendinous contributions to the rotator cuff

Arthroscopy of the Shoulder Joint: Set-Up, Instrumentation and Portals

Positioning:

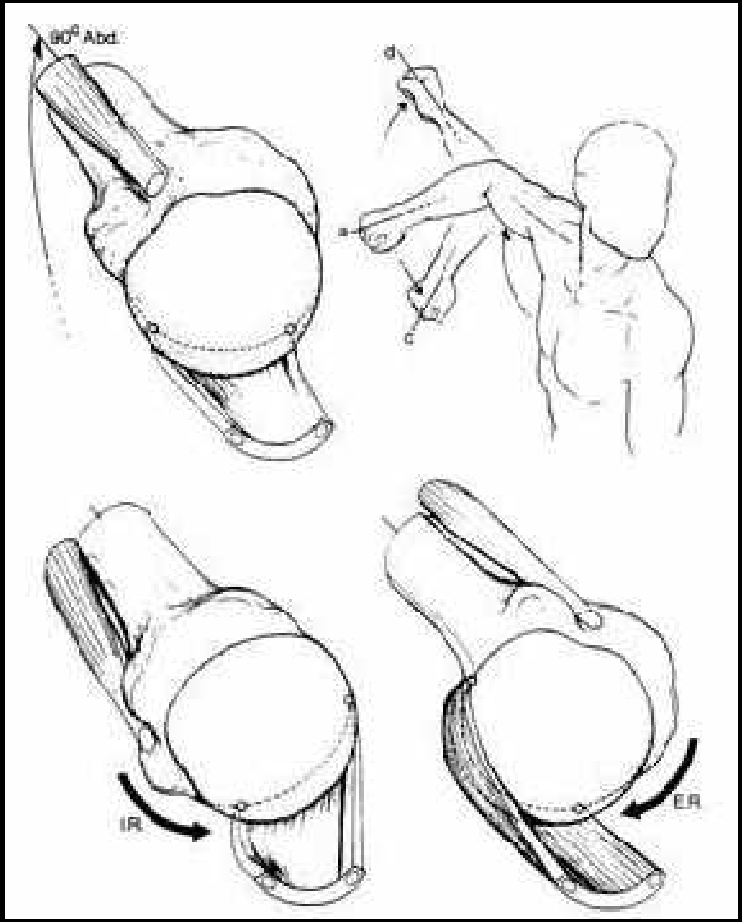
- Lateral decubitus

Positioning Aids:

- Vacupac bean bag
- Axillary roll
- Head and neck support
- 3" adhesive tape to stabilize the pelvis to the OR table
- Foam for fibular head, ankles and between the legs

Mechanism of Injury

- Most common mechanism of injury is a fall onto an outstretched arm
- Extremity is typically in an externally rotated and abducted position
  - Places the anterior structures at greatest risk for failure (especially the inferior glenohumeral ligament)
- Other mechanisms:
  - elevation combined with external rotation
  - direct blow



Anatomy

- humeral head is retroverted 30°
- typical neck-shaft angle is 130°
- glenoid fossa average radius of curvature is 24 mm, only 2 mm less than humeral head
- less than one-third of the humeral head articulates with glenoid during any given position of rotation
- glenohumeral articulation is minimally constrained by bony anatomy alone
- glenoid labrum is a fibrocartilaginous structure
  - functionally deepens the glenoid fossa
  - serves as an anatomic restraint to humeral head translation
  - provides an anchor point for the glenohumeral ligaments
- stability is conferred by a series of dynamic and static soft tissue restraints

Shoulder Stabilisers - Static

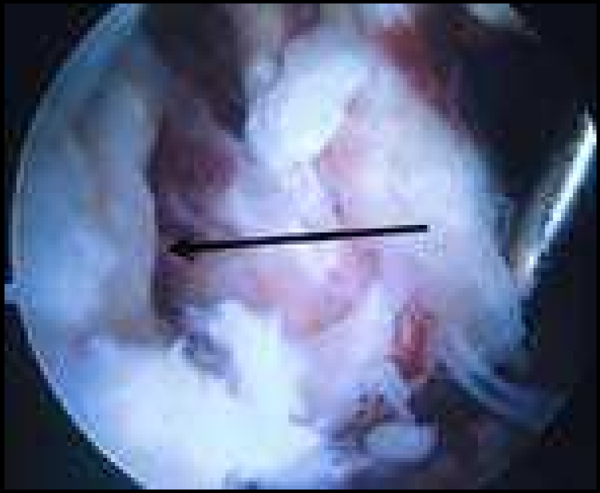
- Intracapsular pressure
- Suction effect: glenoid labrum acting on humeral head like a "plunger"
- Adhesion-cohesion: between 2 wet smooth surfaces
- Glenoid version
- Humeral retroversion: normal 21-30º, some studies have shown a significant reduction in patients with recurrent anterior dislocation
- Labrum: "chock block" to humeral head movement, increases depth of the glenoid by 50%
- Ligaments – main static restraints
  - Coracohumeral ligament
  - Superior glenohumeral ligament (SGHL)
  - Middle glenohumeral ligament (MGHL)
  - Inferior glenohumeral ligament complex (IGHLC) – "hammock"
  - Posterosuperior capsule

Primary static stabilizer limiting anterior movement of the shoulder in 90 degrees of abduction is the IGHL complex

Shoulder Stabilisers - Dynamic

- Rotator cuff
  - Subscapularis muscle provides stability at lower degrees of abduction but contributes little when shoulder is in 90^{o} abduction
  - Rotator cuff compresses humeral head into glenolabral socket, contributing stability, esp. in middle ROM when ligaments are lax
- Proprioception
  - Lephart et al 1994 studied proprioception in three groups of patients: Normal, Unstable, Reconstructed shoulders
  - Proprioception was significantly reduced in unstable shoulders but returned to near normal in reconstructed shoulders
- Long head of biceps: biceps is much more active in patients with recurrent dislocation

Pathophysiology



- pathologic lesions leading to the unstable shoulder can be divided into two main groups:
  - anterior labrum
  - glenohumeral capsule

Anterior Labrum

- Bankart lesion
  - classically described as the detachment of the anteroinferior labrum with its attached inferior glenohumeral ligament complex
- Initially felt that this detachment was the “essential lesion”
- Speer et al.
  - Created Bankhart lesion from 12 o’clock to 6 o’clock and found minimal translation (<4 mm)
  - Capsular injury also required to dislocate shoulder

Glenohumeral Capsule

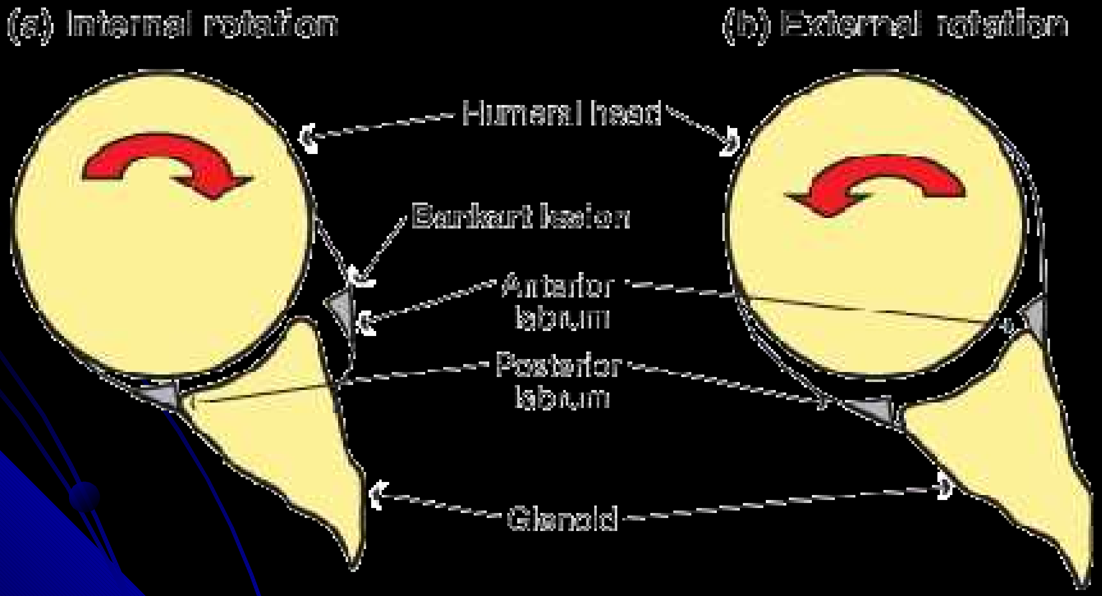
- Turkel 1981
  - Selective cutting study showed importance of GH ligaments
- Bigliani et al. 1992
  - Cadaveric bone-ligament-bone specimens of the IGHL were created and tested to failure
  - found that ligament failed
    - off the glenoid in 40% of the specimens (Bankart)
    - intrasubstance in 35%
    - off the humeral side in 25%
  - Most importantly showed that the capsule underwent plastic deformation prior to failure in all specimens

Pathoanatomy

Capsule	•Bankart lesion •Capsular stretching •Congenital laxity •Wide rotator interval
Glenoid	•Bony Bankart (4%) •Glenoid fracture •Glenoid dysplasia
Labrum	•Bankart tear •Posterior labral tear (10%) •SLAP tear
Humerus	•Tear of the lig. insertion (HAGL) •Greater tuberosity fracture •Hill-Sachs lesion (77%)
Rotator cuff (13%)	•Supraspinatus tear •Subscapularis avulsion

Is Sling Appropriate?

- Non-operative management = Sling immobilzation with the arm internally rotated →No evidence
- Itoi et al. J Bone Joint Surg Am 2001; 83-A(5): 661-667
  - magnetic resonance imaging in patients
- Hatrick C, O'Leary S, Miller B, et al. ORS 2002.
  - load sensors in cadavers



Itoi et. al. J Shoulder Elbow Surg. 2003 Sep-Oct;12(5):413-5.

- Prospective, nonrandomized trial
- 40 patients initial shoulder dislocations
  - Immobilization in internal rotation (IR group, n = 20)
  - Immobilization in external rotation (ER group, n = 20)
- Recurrence rate @ 15.5 months
  - 30% in the IR group
  - 0% in the ER group
- Difference in recurrence rate was even greater < 30 years
  - 45% in the IR group
  - 0% in the ER group

Nonanatomic Repairs

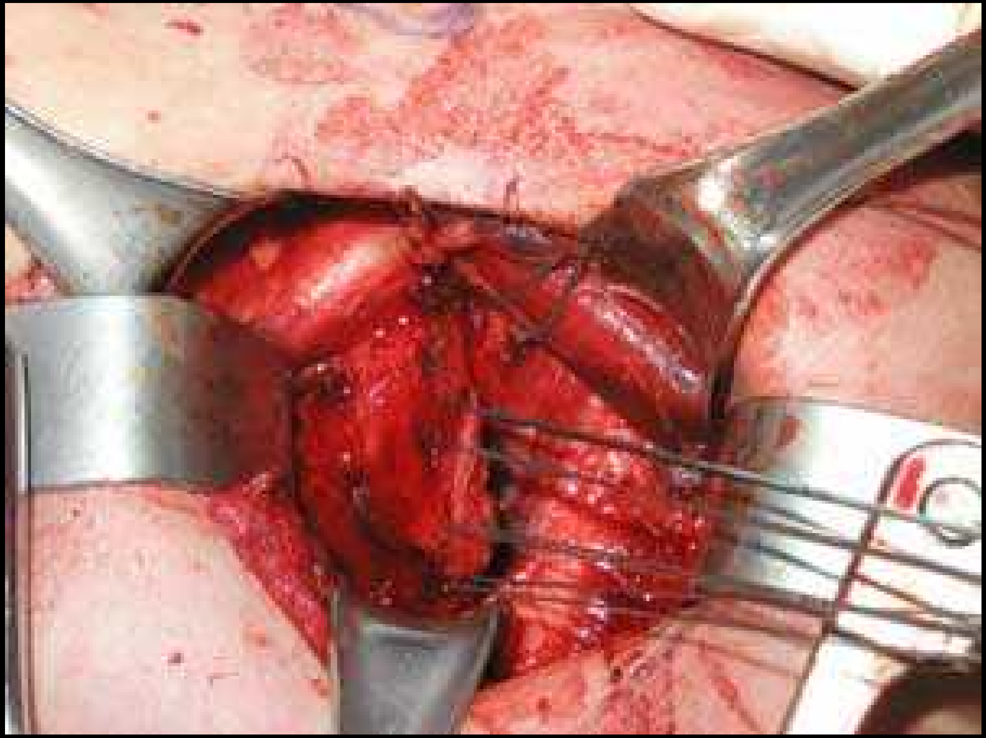
- Bristow
  - Transfer coracoid process to anteroinferior glenoid
  - Sling effect and bone block
- Putti-Platt
  - “Pants-over-vest” repair capsule
- Magnusen-Stack
  - subscapularis tendon is detached from its insertion on the lesser tuberosity, transferred laterally to the greater tuberosity
- Infrequent indications for using these procedures except in revision surgery

Anatomic Repairs

- Restoring normal anatomy is guiding principle in surgery to correct anterior shoulder instability
  - If the labrum has been detached, it is reattached to the anterior glenoid rim
  - If the capsule has been stripped off the glenoid neck, the capsule is reattached to the bony glenoid rim
  - If greater than one-third of the glenoid fossa is involved, a bone block procedure such as a Bristow or iliac crest bone graft may be considered
- Guidelines
  - Anatomic dissection at time of surgery
  - Identification and repair of lesions responsible for instability
  - Returning tissues to their anatomic locations
  - Early postoperative range of motion

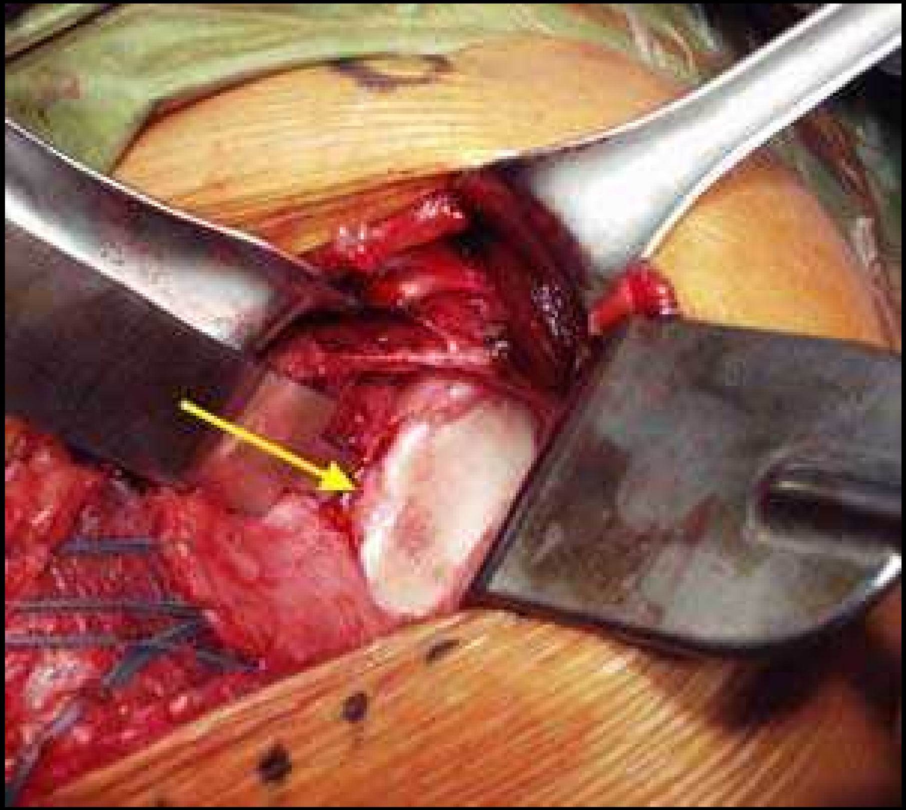
Open anteroinferior capsular shift and Bankart procedure.

- Modified beach chair position with the head elevated ~30°
- Deltopectoral incision was used
- Subscapularis was dissected off the underlying capsule



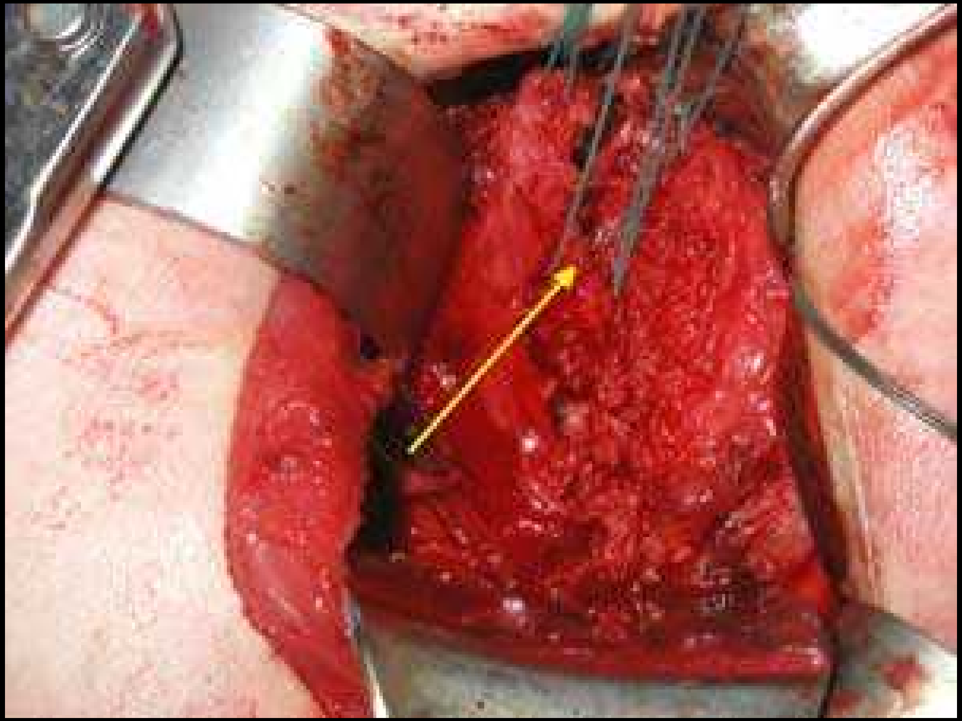
Bankart lesion

- Capsule dissected off the humerus
- Fukuda retractor placed to expose the glenohumeral joint
- Large Bankart lesion was identified from the 6-9 o'clock position
- Bioabsorbable suture anchors were used but had to be redirected carefully to avoid the previously placed metal suture anchors in the anteroinferior glenoid



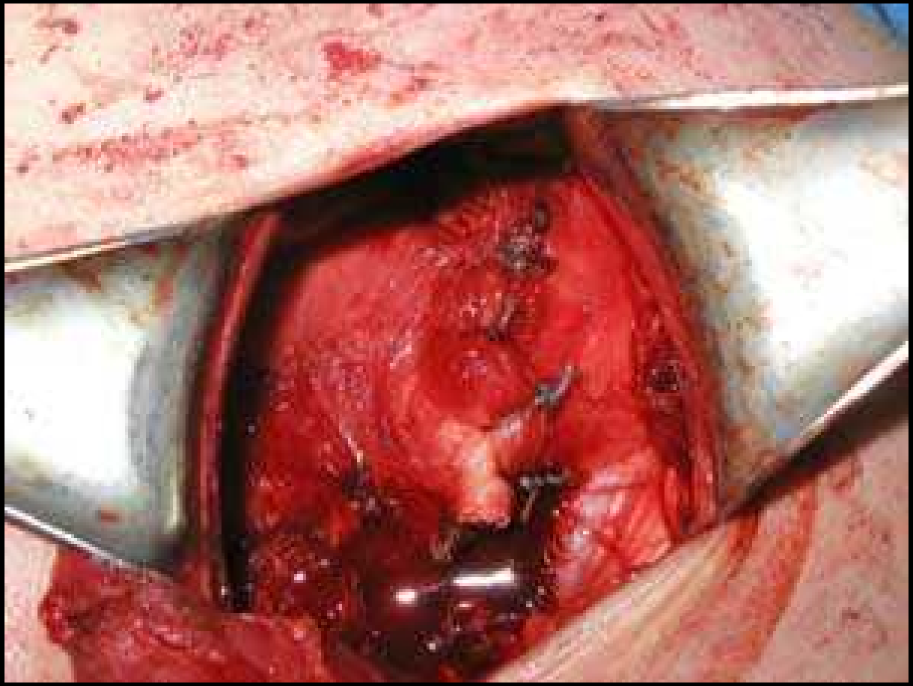
Capsular Shift

- Superolateral capsular shift (formal "T" capsulorrhaphy was not necessary) of the entire capsule
- Arm placed in 30° abduction and 30° external rotation for capsular repair

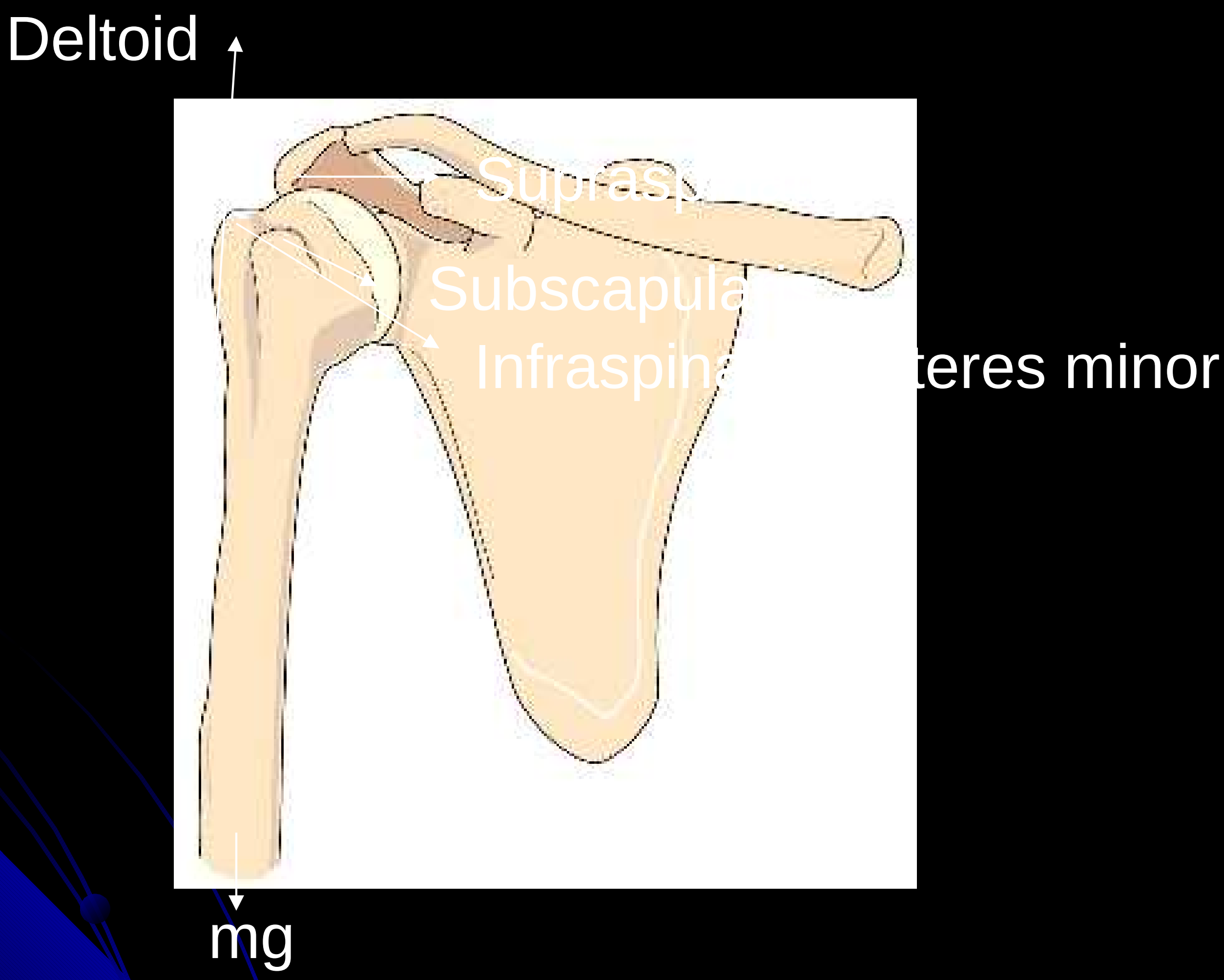


Subscapularis Repair

- Subscapularis was then anatomically repaired with #2 nonabsorbable sutures

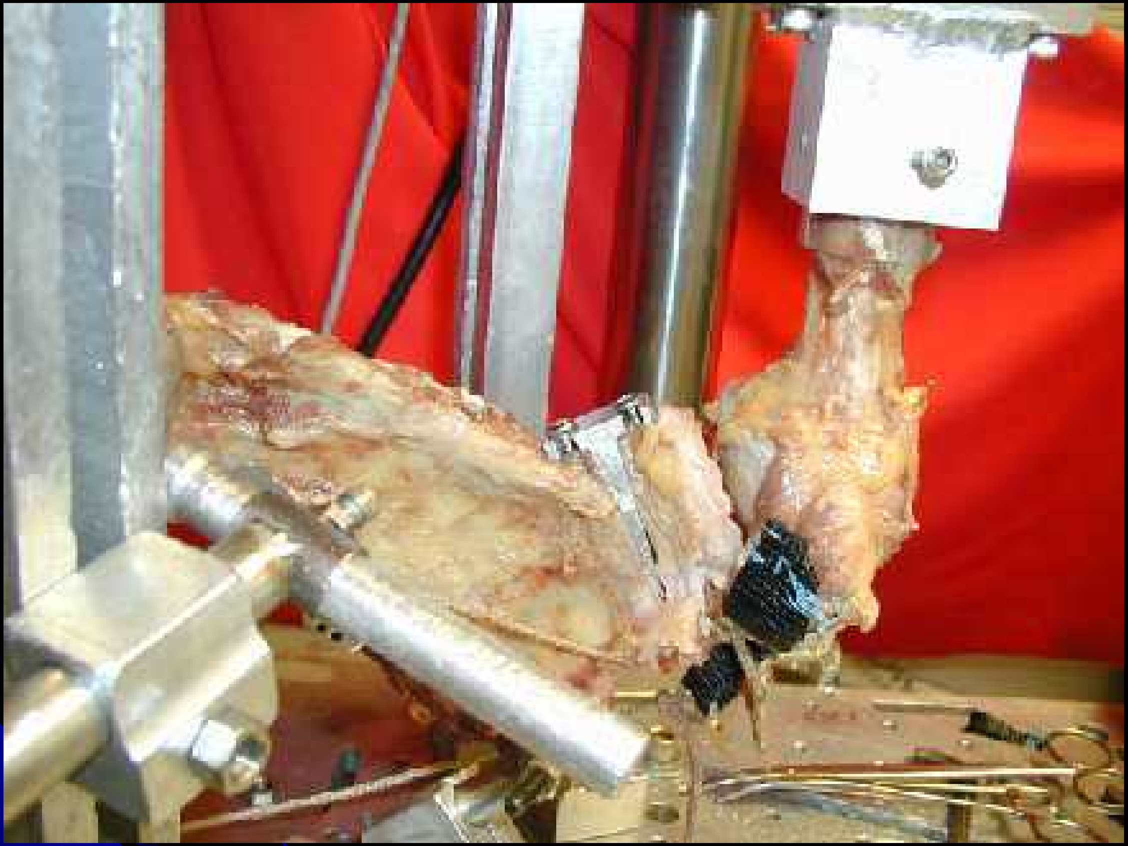


THEORY

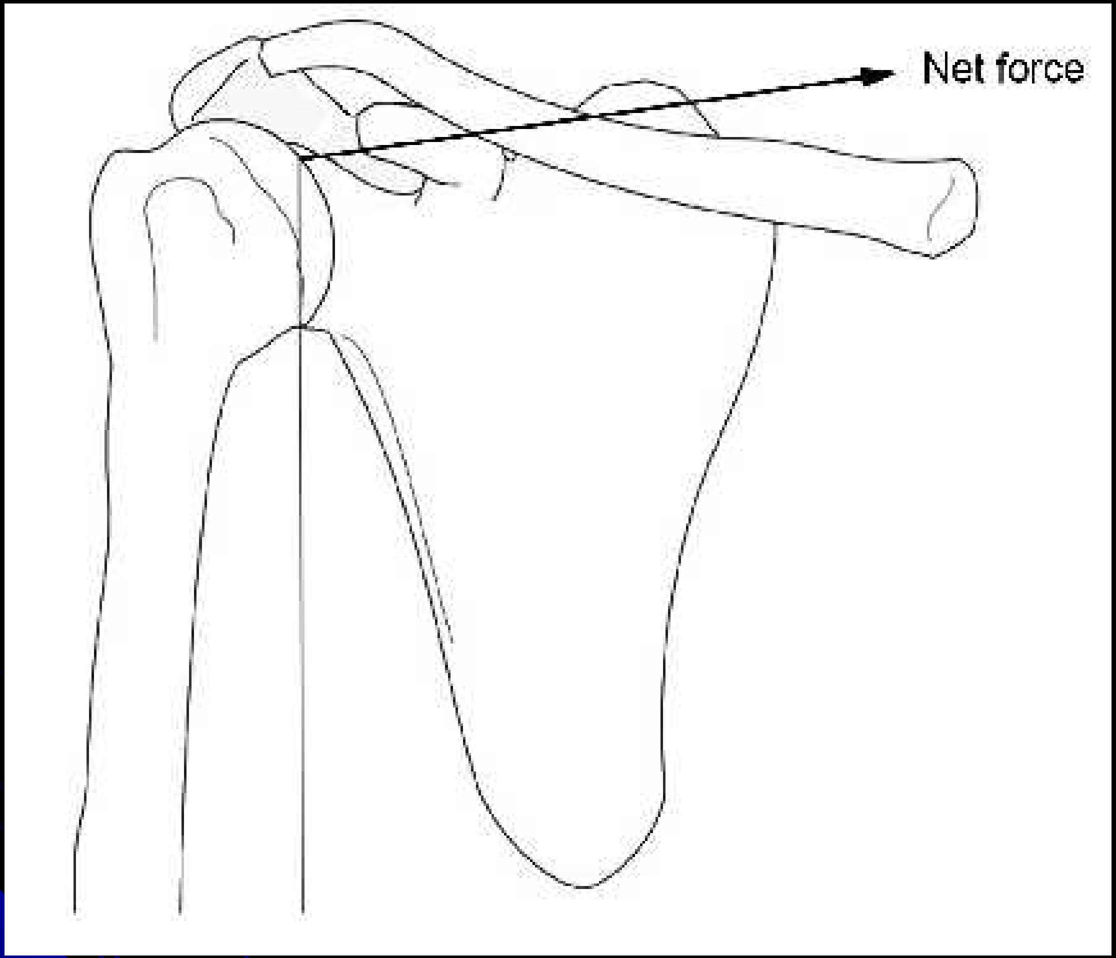


TEST SETUP

TEST SETUP



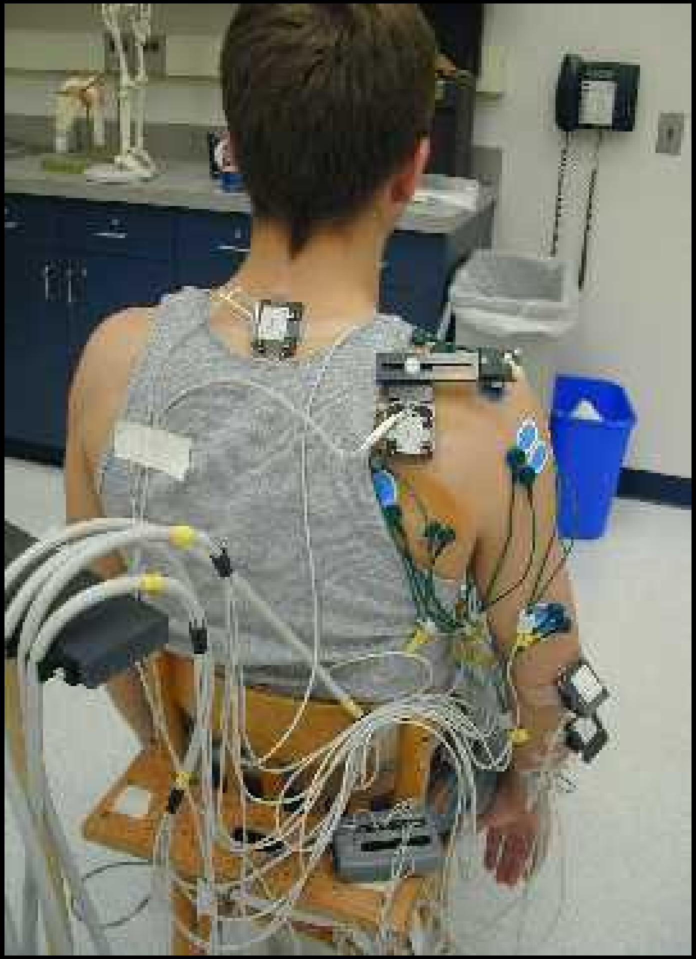
PROBLEM: AVERAGE FORCE



Poppen, N.K. and Walker, P.S. (1978) CORR 135:165-170

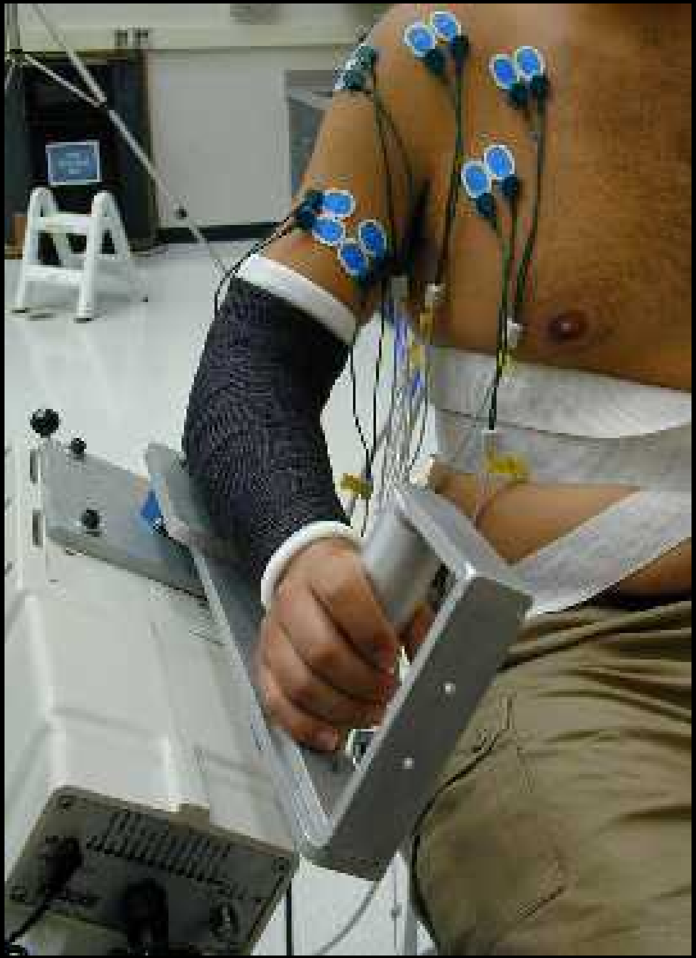
DATA COLLECTION

- Surface EMG: deltoid (middle, anterior, posterior); biceps; infraspinatus, latissiumus dorsi; triceps; pectoralis major
- Wire EMG: supraspinatus, subscapularis, teres major
- Motion: Certus (Northern Digital)

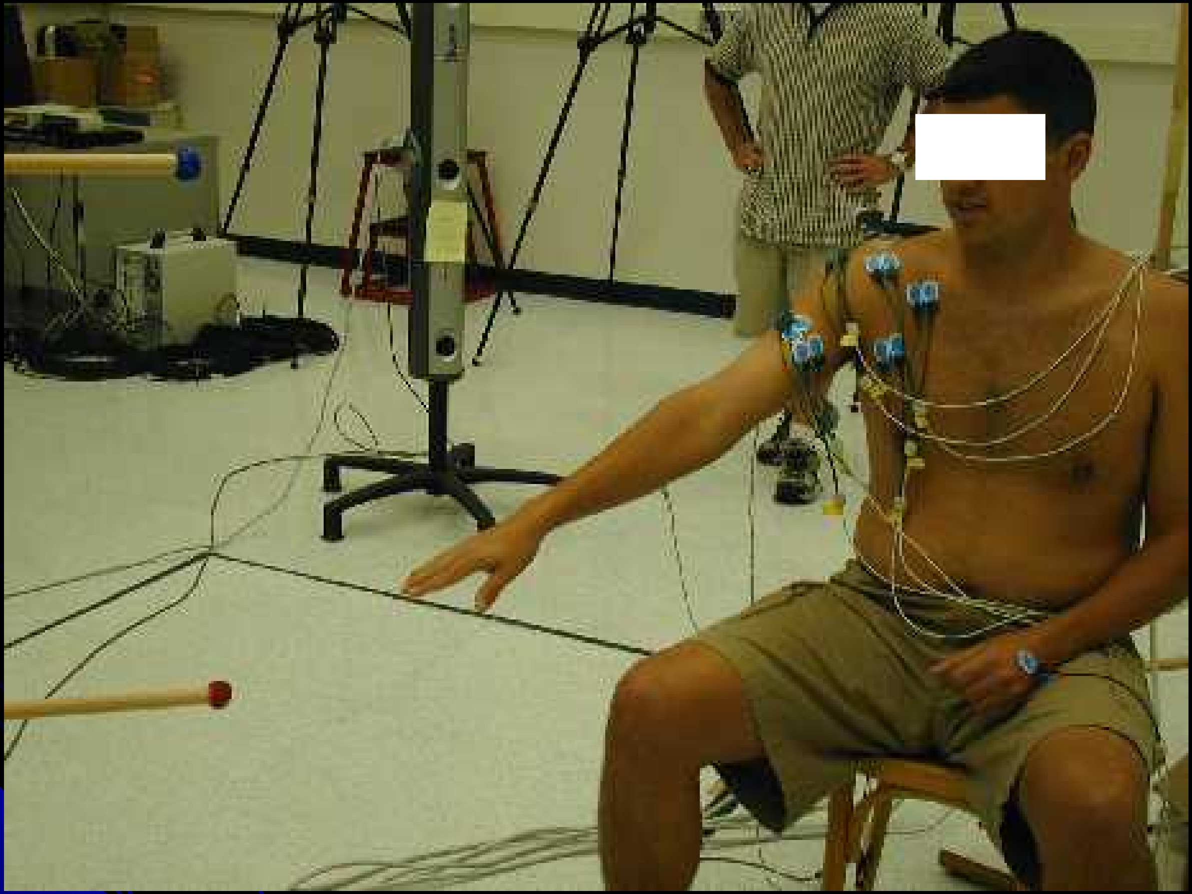


FORCE-EMG CALIBRATION

- Isometric ramps
  - Flexion/extension
  - Abduction/Adduction
  - Internal/external rotation
- Compute glenohumeral moments
- Filter and model delay
- Principal components regression



DYNAMIC ARM ELEVATION

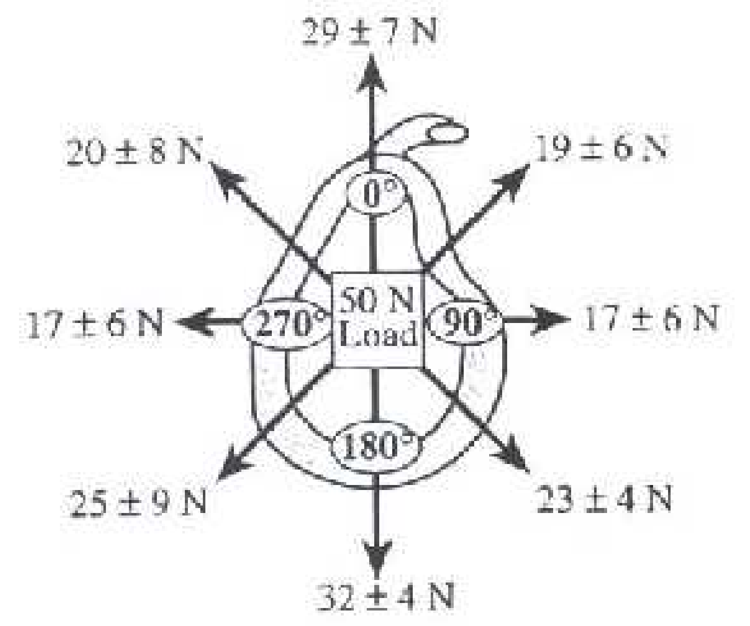


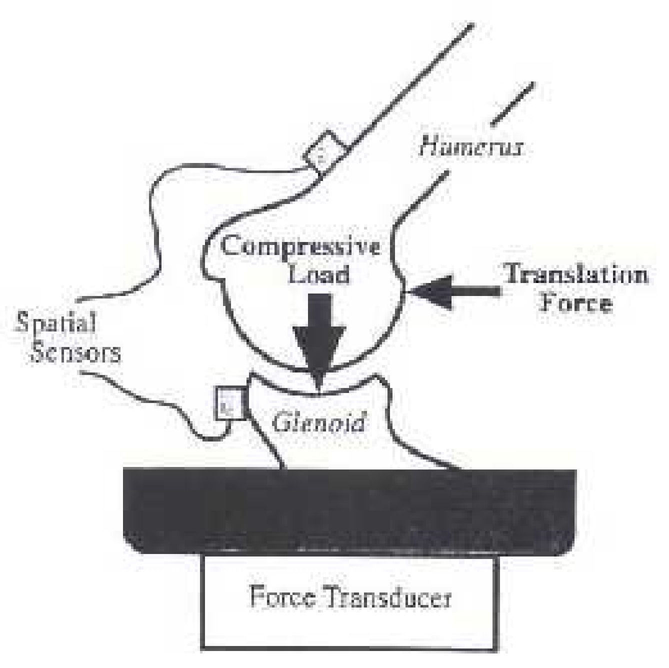
EMG-DRIVEN MODEL

- Muscle force depends on
  - EMG
  - Gains from PCR
  - length-tension
  - Force-velocity
- Electromechanical delay
- Musculoskeletal geometry
  - Muscle length
  - Muscle shortening velocity
  - SIMM implementation

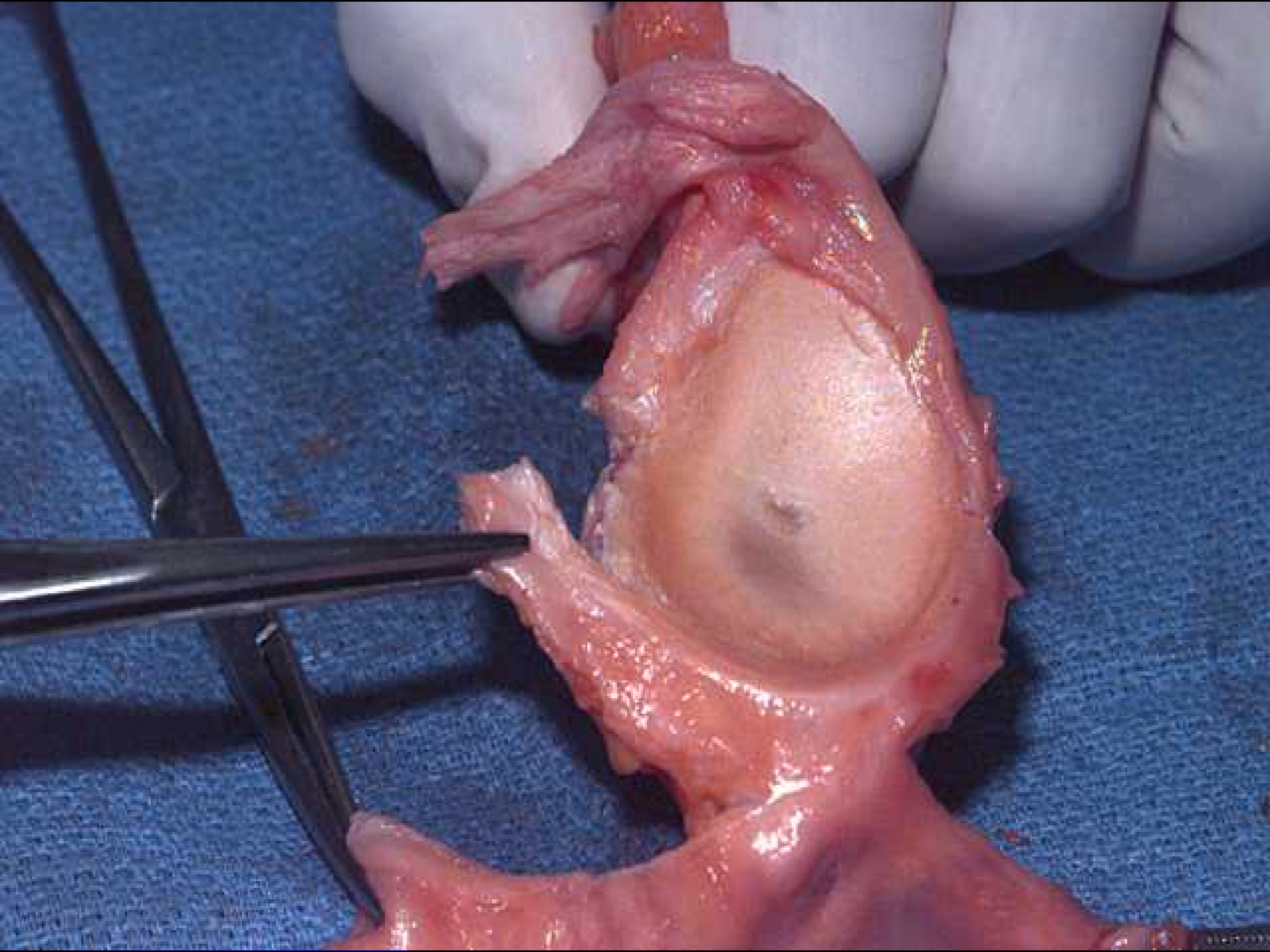
Holzbaur, K. *et al*. (2005) *Ann. Biomed. Eng*. 33:829-40

CONCAVITY COMPRESSION



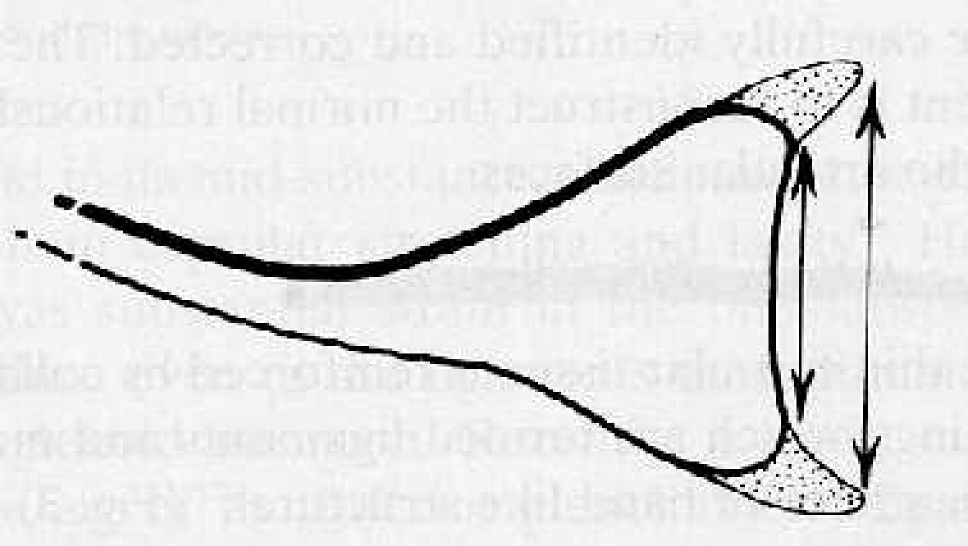


Lippitt, S.B. *et al*. (1993) *JSES* 2:27-35



Glenoid

- Labrum
  - Removal decreases stability by 20%
  - Area of glenoid with labrum 1/3 of humeral surface (1/4 without)



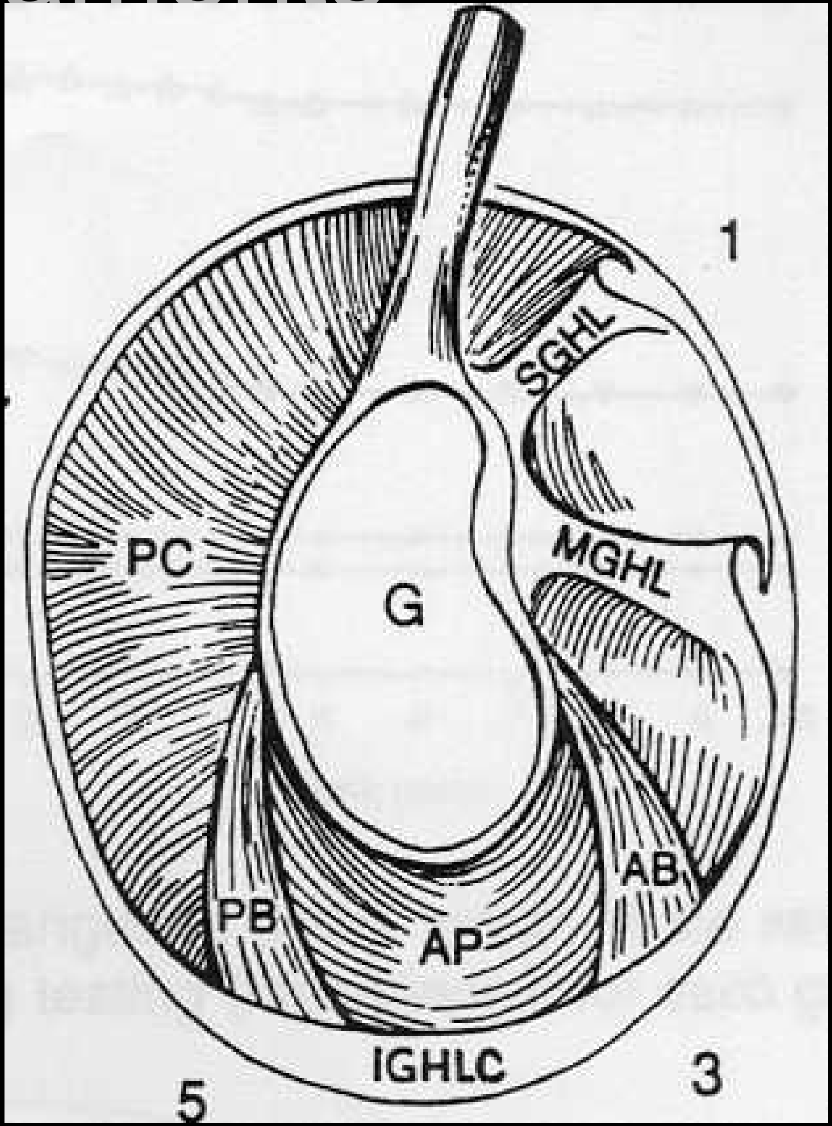
Negative Pressure

- Keeps GH joint congruent
- Release results in instability
- Low-riding head after hemarthrosis

Coracoacromial Arch

- CA ligament and bony structures
- Close relationship to cuff
- Role in prevention of superior migration
- Unclear role in RTC tears

Ligaments



Scapulohumeral Rhythm

- When the arm moves, the shoulder girdle moves as well
- The arm can only move in the first 30 deg. of abduction before scapula moves
- After 30 degrees, the g-h/scapula ROM occurs at a ratio of 2:1
- For every 2 deg. of abduction, the scapula will move laterally, anteriorly and superiorly 1 deg.

Muscular Stability of Shoulder Girdle

- Girdle is designed for mobility, therefore sacrifice stability
- Muscles arranged to provide stability lacking from bony and ligament arrangement
- Stabilizing components tend to pull scapula towards the midline
- Dislocating components tend to pull scapula away from thorax or spine

Glenohumeral Joint

- This is the true shoulder joint
- Ball and socket joint
- Largest ROM and movement potential in the body
  - Reasons for this characteristic include:
    - Shallow joint
    - Lax joint capsule
    - Limited Ligamentous support

Glenohumeral Joint

- Glenoid shallow socket on scapula--faces slightly anterior--consequences???
    - Glenoid labrum--rim of fibrocartilage
        - Deepens socket--increases contact area up to 75%
    - Joint Capsule
- Ligamentous Stability
    - Anterior--glenohumeral ligaments
    - Posterior--only joint capsule

Glenohumeral Joint

- Motions
  - Flexion & Extension--180° flex, 60° ext
    - Flexion limited to 30° when internally rotated
  - Abduction & Adduction--180 ° abd, 75 ° hyperadd
    - Abduction limited to 60 ° when internally rotated
  - Internal and External Rotation--neutral=180 °
    - In abduction, limited to 90 °
  - Horizontal Flexion & Extension--135 ° flex, 45 ° ext

Joint Stability

- When arm is neutral, ligaments are loose, allowing IR and ER
- As arm is externally rotated, the the capsule becomes tighter
- When arm is abducted inferior ligamentous tissue becomes tighter, more so with ER
- In extreme abduction and ER, ligaments become tight around joint, giving stability

Glenohumeral joint

- Humeral head 3x larger than glenoid fossa
- Ball and socket with translation
- 3 degrees of freedom
  - flex/ext
  - abd/add
  - int/ext rot
  - plus
    - horizontal flex/ext
    - horizontal abd/add

Scapulothoracic Articulation

- Elevation/Depression
- Pro/retraction
- up/downward rotation
  - scapular rotation is necessary to keep GH joint in position of max stability

Ligaments and capsule

- Coracoacromial ligament
  - secondary stabilizer as it forms part of the coracoacromial arch

- **Coracohumeral ligament**
- Origin: anterolateral coracoid process Insertion: greater and lesser tuberosities, blends with capsule in rotator interval
- Unclear role in providing stability; may contribute to restraining inferior subluxation with arm at side, Becomes taut with external rotation

- Capsule
  - attached medially to margin of glenoid fossa
  - laterally to circumfrence of anatomical neck of humarus
  - ant cap thicker than post cap
  - 3 types
    - anterior labrial attachment
    - just medial to labrum
    - further medially on glenoid

- Allows for 2-3 mm of distraction
- little contribution to joint stability
- strengthened by GH ligs and RC tendons
- rotator interval
    - between SGHL and MGHL

Glenohumeral ligaments (superior, middle , inferior)

- SGHL
  - O = tubercle on glenoid just post to long head biceps
  - I = humeral head near upper end of lesser tubercle
  - Resists inf subluxation and contributes to stability in post and inf directions

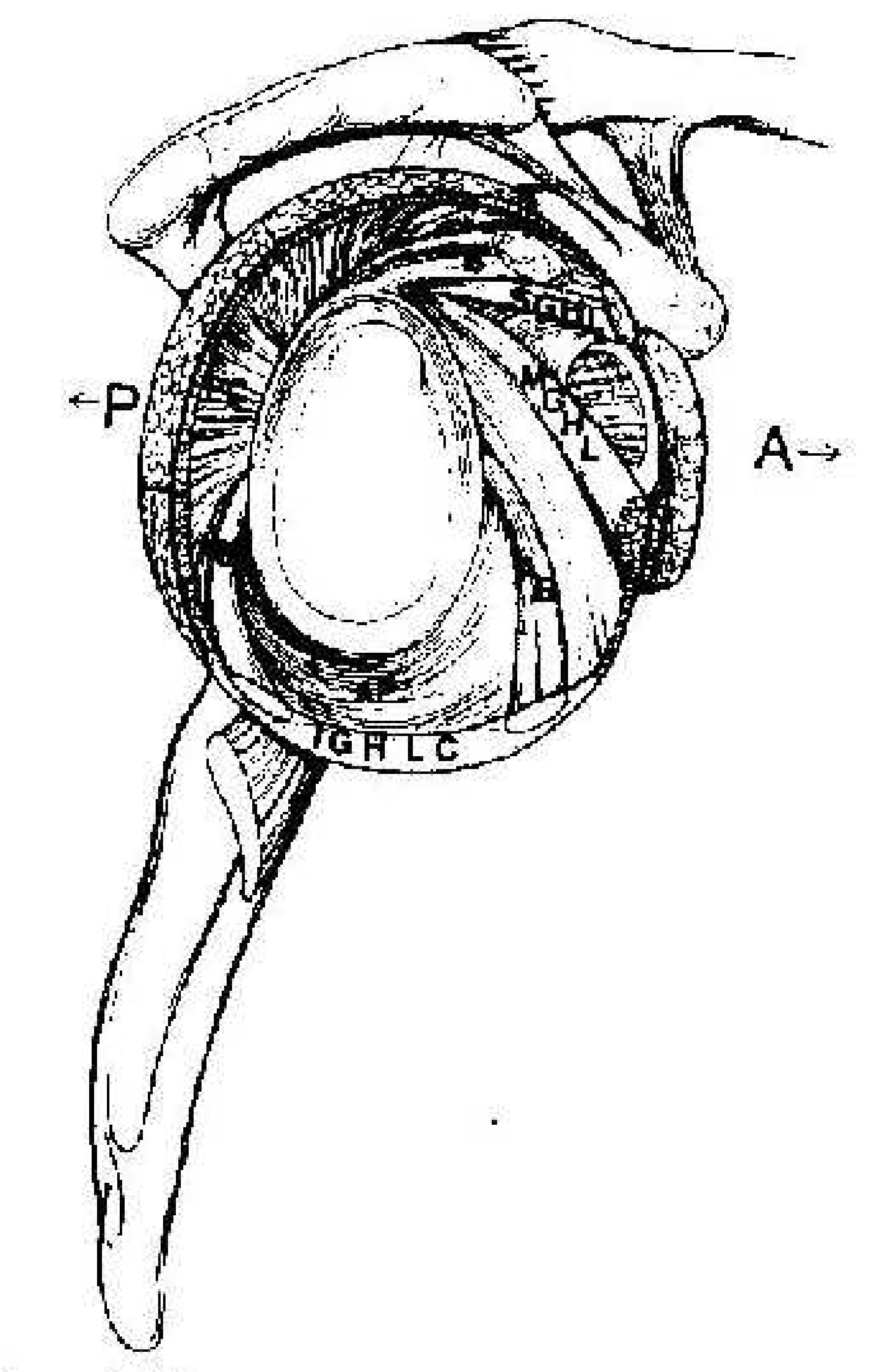
- MGHL
  - O= sup glenoid and labrum
  - I= blends with subscapularis tendon
  - Limits ant excursion instability especially with arm in 45 deg abd position
  - limits ext rotation

- IGHL
  - O= ant glenoid rim and labrum
  - I= inf aspect of humeral articular surface and anatomic neck
  - 3 bands, anterior, axillary and posterior
  - IGHL complex acts like a sling and when is the most important single ligamentous stabilizer in the shoulder.
  - Primary restraint is at 45-90 deg abd.

Joint Stability

- When arm is neutral, ligaments are loose, allowing IR and ER
- As arm is externally rotated, the the capsule becomes tighter
- When arm is abducted inferior ligamentous tissue becomes tighter, more so with ER
- In extreme abduction and ER, ligaments become tight around joint, giving stability


BT
SST
M
I


←P
SGHL
MGHL
A→
B
IGHLC

Glenoid Labrum

- Static stabilizer
  - contributes 20% to GH stability
- fibrous tissue
- deepens glenoid(50%), 9mm su AP
- 3purposes:
  - increases surface contact area
  - butress
  - attachment site for GH ligaments

Biomechanics of GH stability

- the normal shoulder precisely constrains the humeral head to the center of the glenoid cavity throughout most of the arc of movement.

Static restraints

- negative intra-articular pressure

(venting capsule increases inferior translation at 0 degrees of abduction)

- ligaments and capsule
- labrum (increases concavity)

- articular surfaces/osseous anatomy

(very little because square area of humeral head is 3X glenoid)

- joint fluid adhesiveness

Dynamic restraints

- Rotator cuff muscles
- deltoid and biceps
- concavity compression

- The humeral head will remained <u>centered</u> in the glenoid fossa if the glenoid and humeral joint surfaces are congruent and if the net humeral joint reaction force is directed within the effective glenoid arc.

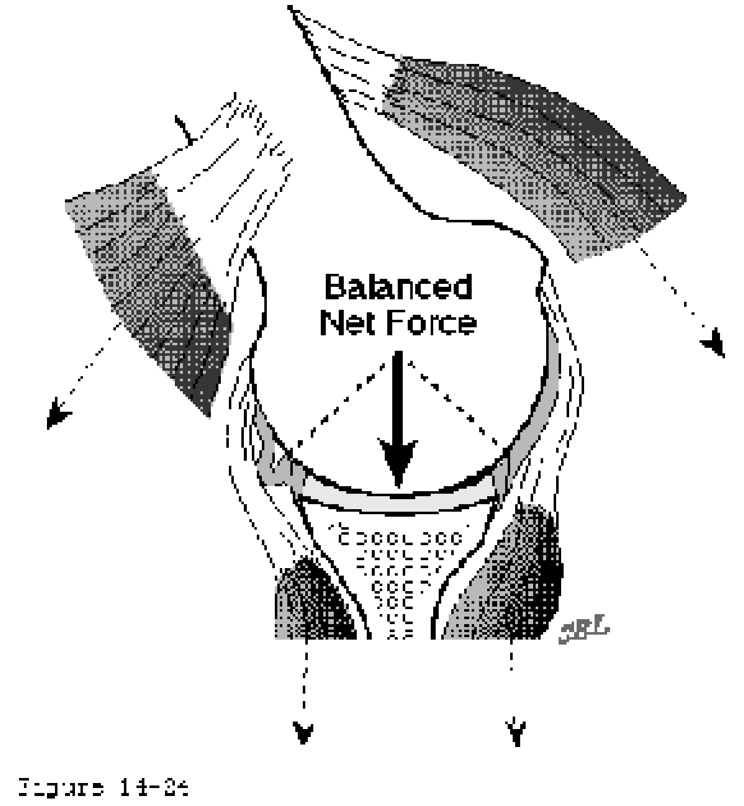


Figure 14-24

-The glenohumeral joint will not dislocate as long as the net <u>humeral joint reaction force</u> is directed within the <u>effective glenoid arc.</u>

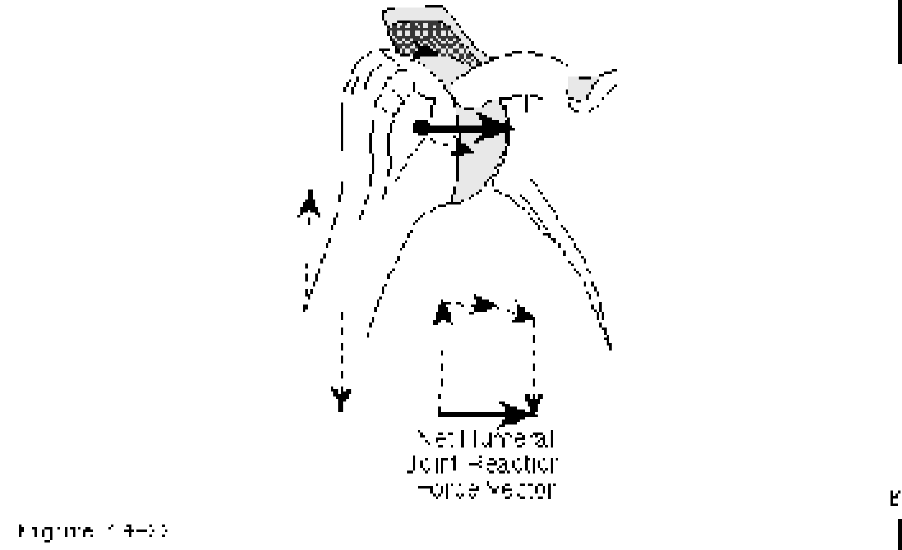


Figure 14-22

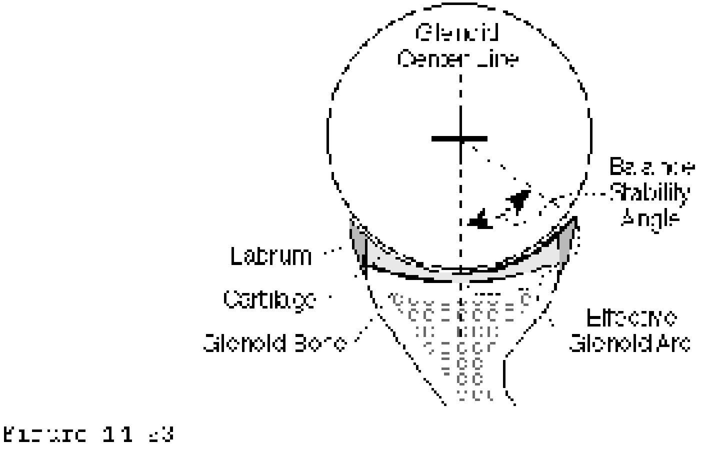


Figure 14-23

The maximal angle that the net humeral joint reaction force can make with the glenoid center line in a given direction is the <u>balance stability angle</u>

Increasing the force of contraction of a muscle whose force direction is close to the glenoid center line, the direction of the net humeral joint reaction force can be aligned more closely with the glenoid fossa.

The elements of the rotator cuff are well positioned to contribute to this muscle balance.

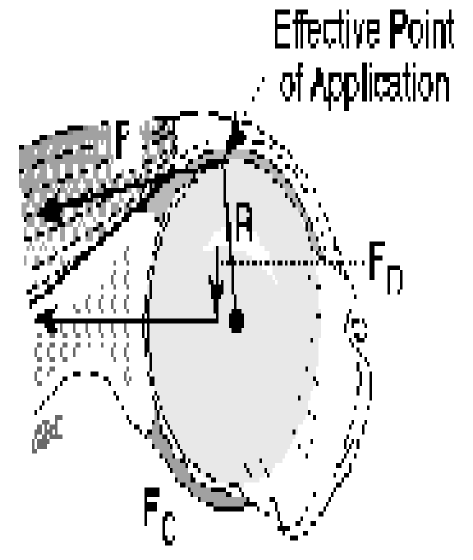


Figure 14-30

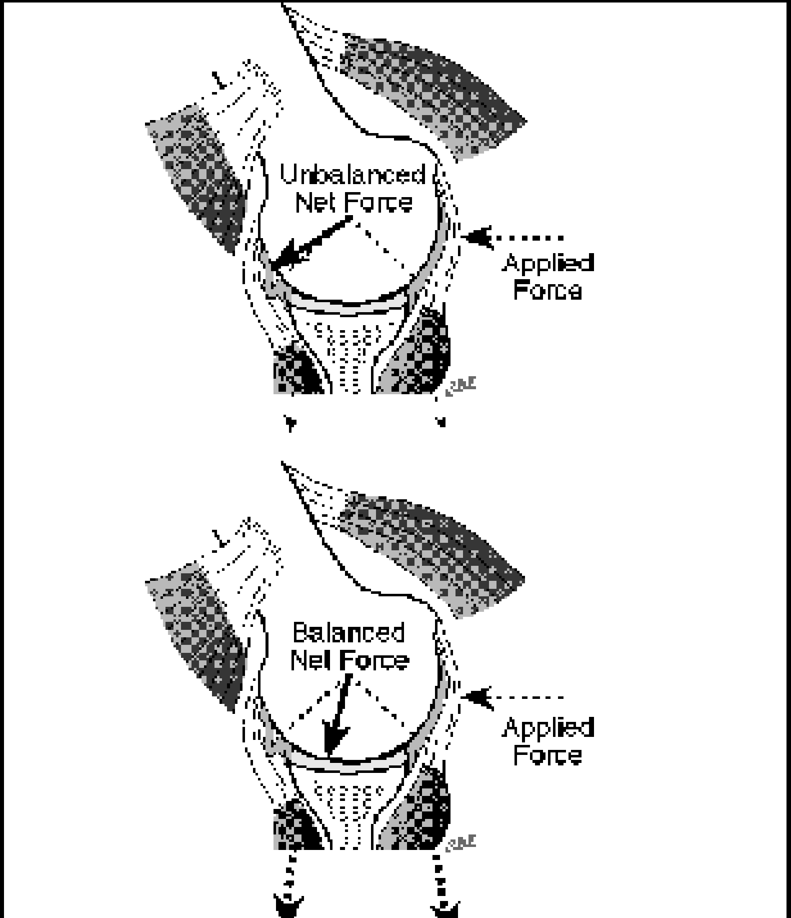


Figure 14-31

Stability ratio

- Maximal displacing force in a given direction(perpendicular to glenoid center line) that can be stabilized by compressive load.
    - Affected by
        - Glenoid/labrum depth
        - rim lesions
        - Glenoid version
        - dynamic stabilizer compromise
            - structural injury, paralysis, imbalance, atrophy etc..

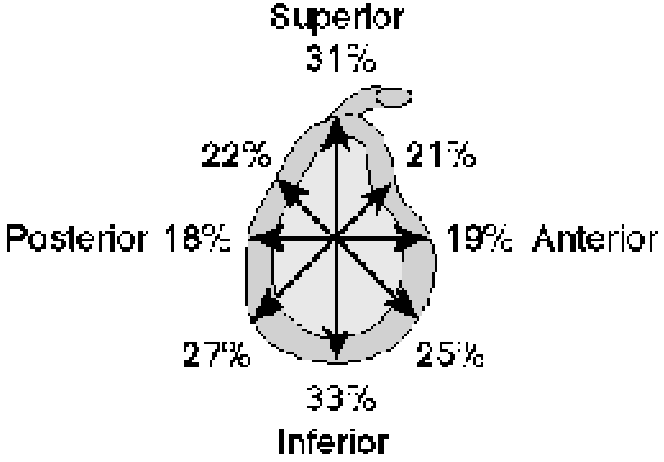
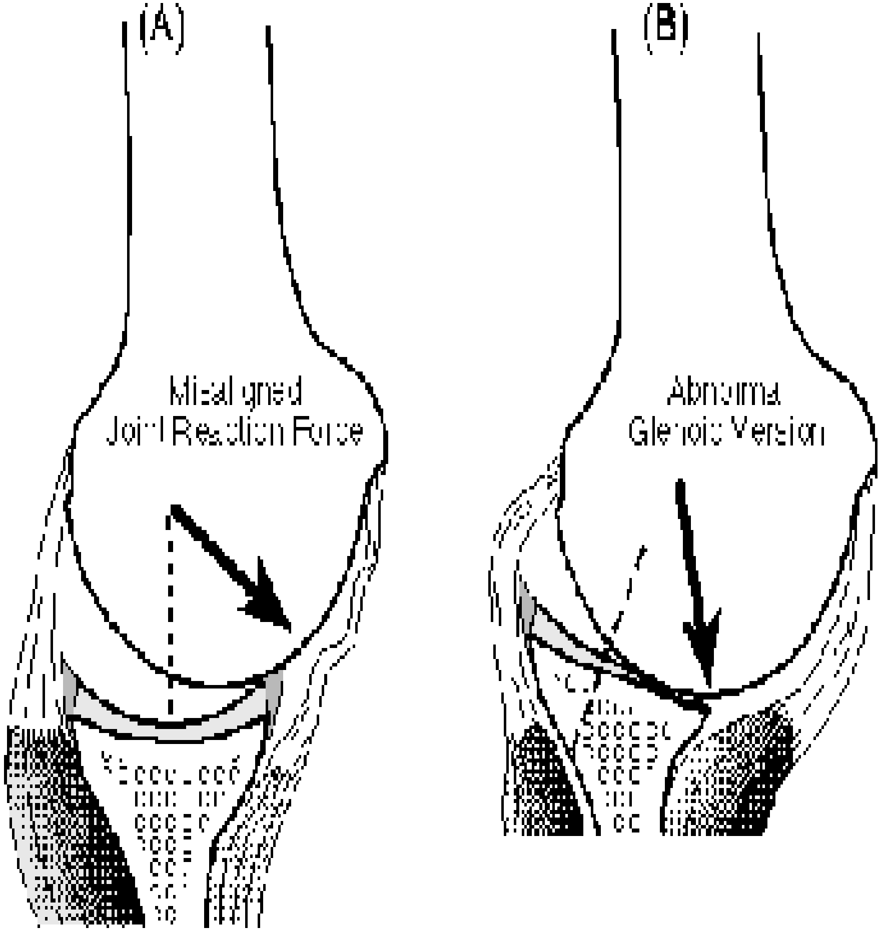


Figure 14-39



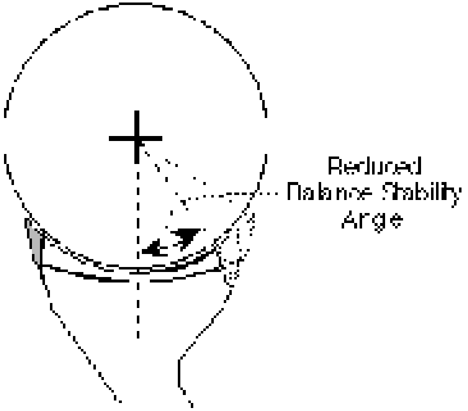


Figure 14-34

Glenoid version

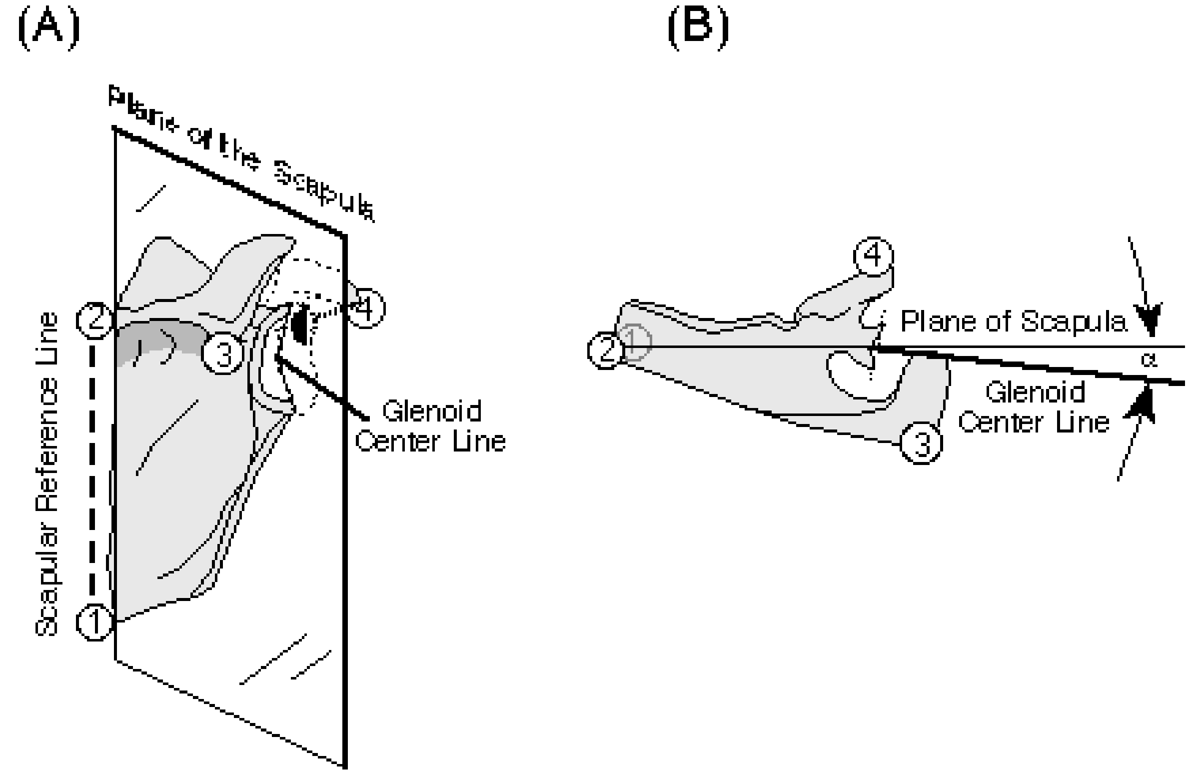


Figure 14-28

Scapular positioning

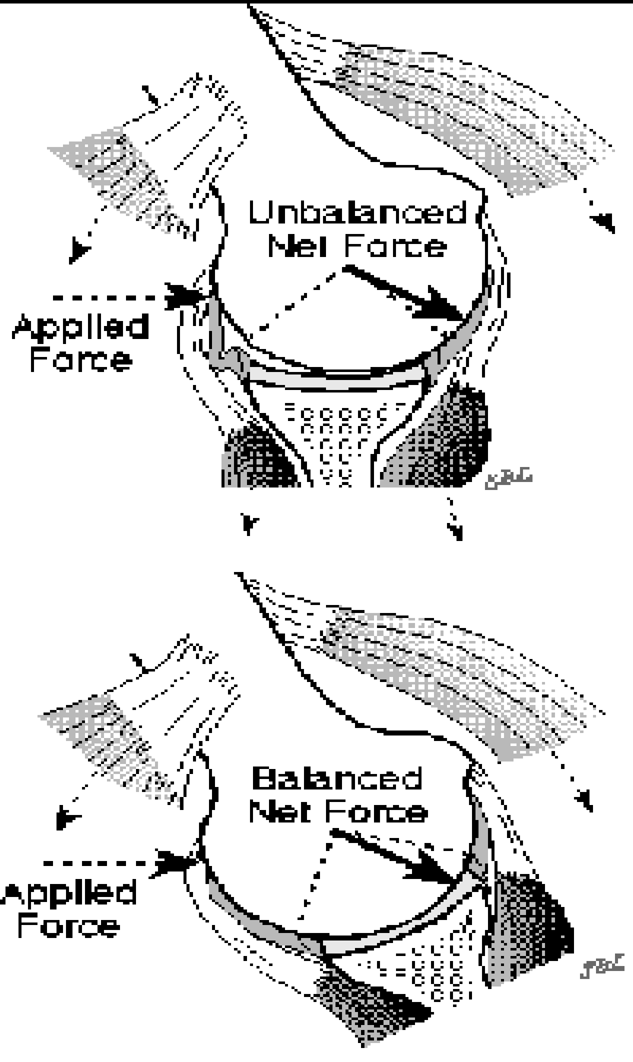
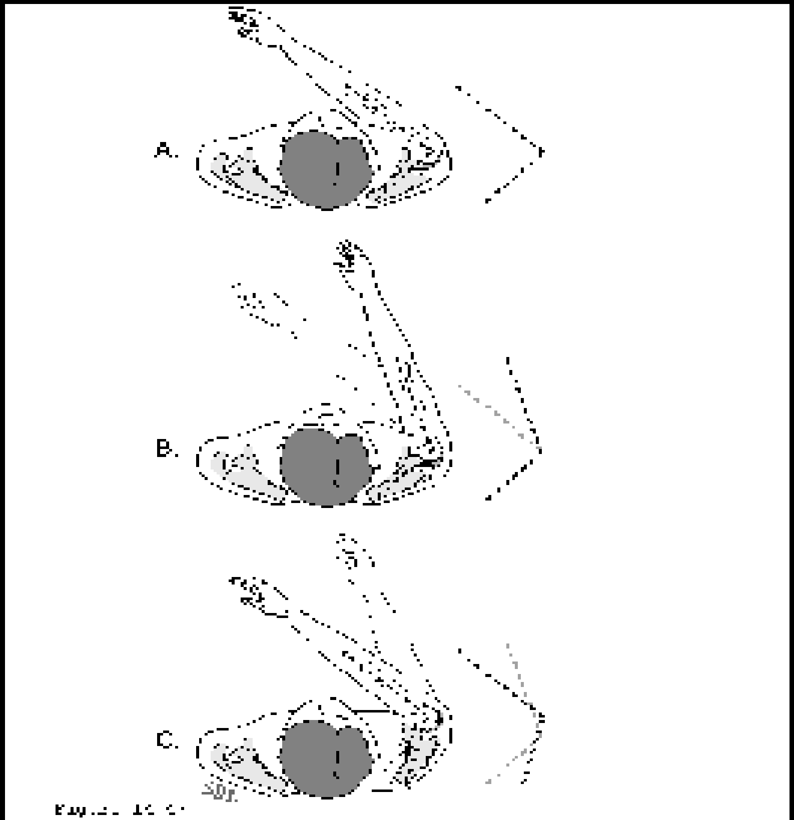


Figure 14-09

Ligamentous stabilization

- Check reins
  - ballanced force exceeds ballanced stability angle.



Countervailing force

-compresses humeral head into glenoid fosssa and resists displacement in direction of tight ligament

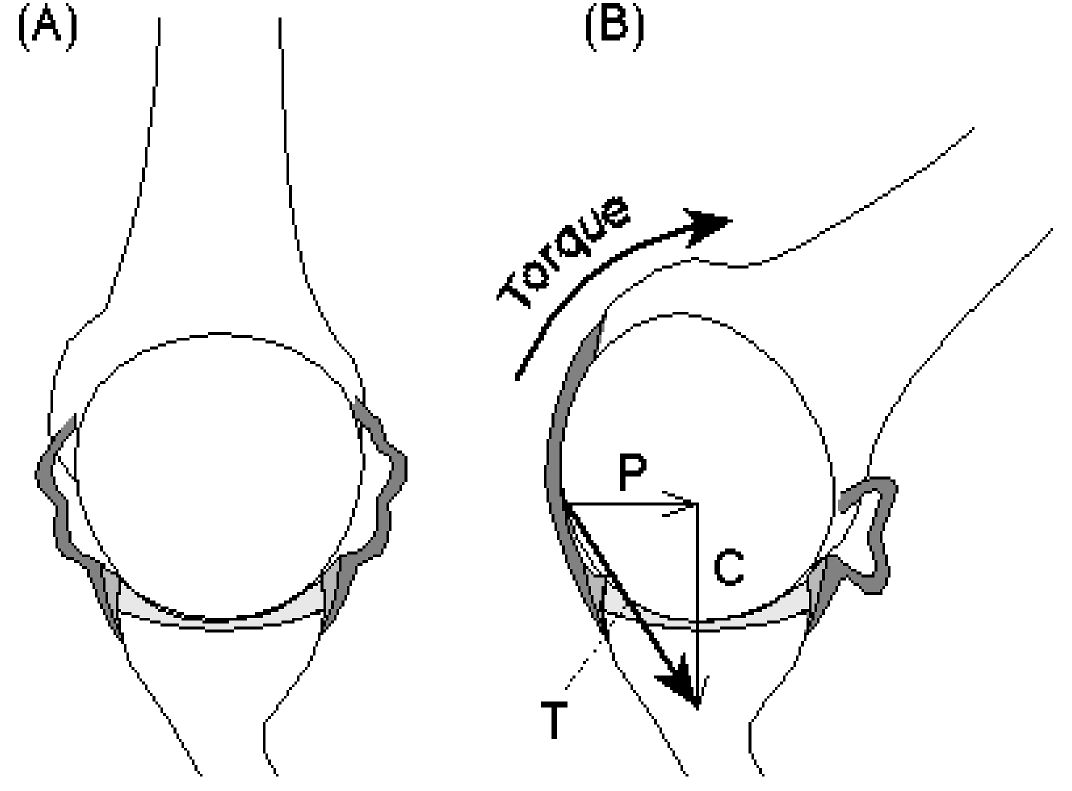


Figure 14-48

Types of instability

- Congenital
- Acute
- Cronic
- Recurrent
- Traumatic
- Atraumatic

Static Shoulder Stabilizers

- Bony Architecture
- Glenoid Labrum
- Negative Intraarticular pressure
- Glenohumeral Ligaments

Dynamic Shoulder Stabilizers

- Rotator Cuff
- Proprioception
- Biceps Tendon
- Scapulothoracic Motion

Bony Architecture

- Humeral & glenoid surfaces are quite congruent
- Glenoid articular surface is thickest at the periphery increasing congruency
- Little impact on shoulder stability

Glenoid Labrum

- Variable size and shape
- Deepens glenoid
- Increases surface area
- Creates a buttress
- Attachment of GH ligaments

Intraarticular Pressure

- Negative intaarticular pressure (vacuum effect)
- Venting the capsule reduces translation force requirements
- Greater relative importance in neutral position & early ROM

Glenohumeral Ligaments

- Descrete thickenings of the capsule
- Tension at extremes of motion
- Primary static stabilizers
- IGHL complex - primary AP stabilizer in abduction

Shoulder Stabilizing Mechanisms

Turkel , et al
JBJS 1981

"…as the shoulder approaches 90 of abduction, the IGHL prevents dislocation during ER…"

Anatomy of the IGHL Complex

O’Brien SJ, et al
AJSM, 1990

- ‘Hammock’ providing A/P stability to the abducted shoulder
- Stability may require **accurate** re-establishment of the normal ligament

Rotator Cuff

- Joint compression effect
- Preload GH ligaments
- Increased importance in unstable shoulder
- Rationale for conservative treatment

Biceps Tendon

- Joint compression effect
- Contributes to anterior stability
- Created SLAP lesion leads to increased IGHL strain in Abd/ER

“Essential Lesion”

- Bankart Lesion
- Humeral avulsion
- IGHL stretch injury

ALPSA Lesion

Neviaser TJ
Arthroscopy, 1993

- Anterior Labral Ligamentous Periosteal Sleeve Avulsion
- Common variant of a Bankart lesion
- Medial/inferior periosteal sleeve migration
- Position of the healed ligament is critical
- Avoid medial reattachment

ALPSA Lesion

Neviaser TJ
Arthroscopy, 1993

- Common variant of a Bankart lesion
- Medial/inferior periosteal sleeve migration
- Position of the healed ligament is critical
- Avoid medial reattachment

Bankart Lesion Biomechanics

Speer KP, et al
JBJS 1994

- Cadaveric Study
- Bankart lesion alone does not allow complete dislocation of the shoulder
- <u>Postulate</u>: Capsular stretch is necessary for complete dislocation

Tensile Properties of IGHL

Bigliani, et al
J Ortho Research, 1992

- Cadaveric Study (elderly specimen)
- Significant capsular stretch occurred before failure, regardless of failure mode
- Elogation rates 0.4 mm/s & 4.0 mm/s

Capsular Stretch??

Harryman, DT (Letter to Grana)
Arthroscopy, 1994

- Questions whether capsular stretch is part of the essential lesion of traumatic instability
- There are "… no clinical studies that document… persistent capsule laxity…"
- Any persistent capsule laxity can be eliminated by working within the avulsion

Capsular Elasticity & Volume

Sperber A, et al
Arthroscopy, 1994

- In vivo study
- Evaluated capsular elasticity & joint volume by measured saline infusion
- Found no difference between stable & unstable shoulders

Biomechanics Static Stabilizers

- Articular curvature between the glenoid and humeral head
- Superior glenohumeral ligament (SGHL) and coracohumeral ligament (CHL)
  - To resist inferior translation
- Middle glenohumeral ligament (MGHL)
  - To limit anterior translation
- IGHLC
  - Primary restraint to anterior and posterior translation

Biomechanics Dynamic Stabilizers

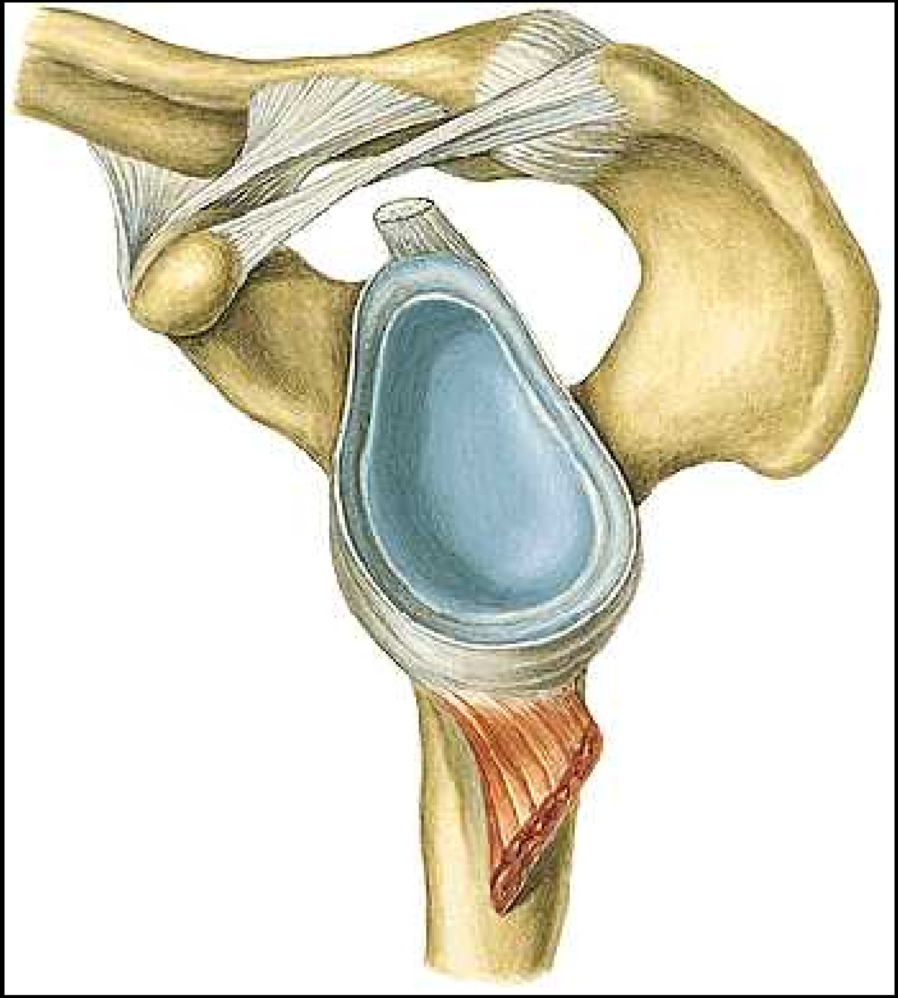
- Rotator cuff muscles
    - Center the humeral head on the glenoid
    - Maintain joint stability
- The capsuloligamentous structures (proprioception) provide afferent feedback for reflexive muscular control of the rotator cuff and biceps

Clasification of Anterior Instability

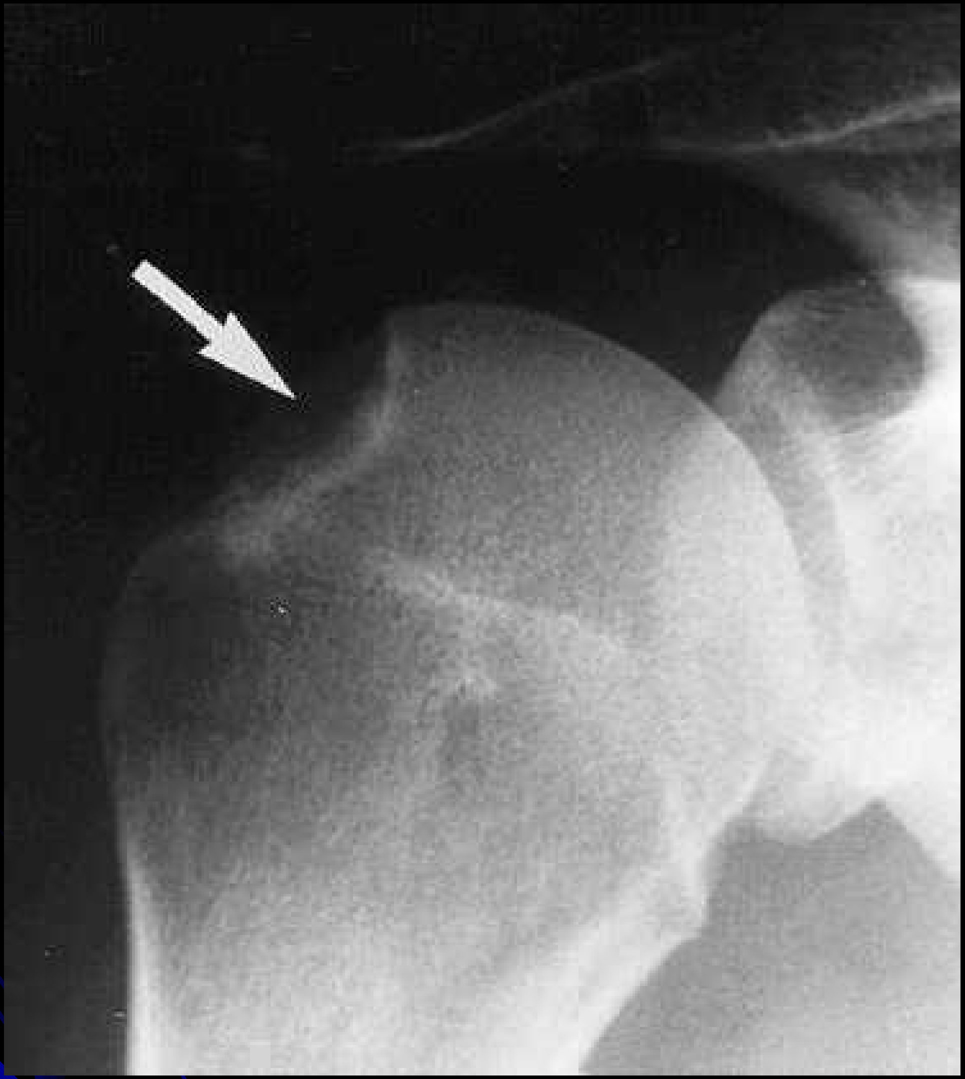
- Direction
  - Anterior
  - Posterior
  - Inferior
  - Multidirectional
- Cause
  - Traumatic
    - Acute
    - Repetitive
  - Nontraumatic
- Degree
  - Subluxation
  - Dislocation
- Frequency
  - Acute
  - Recurrent
- Patient control
  - Voluntary
  - Involuntary

A-C Joint

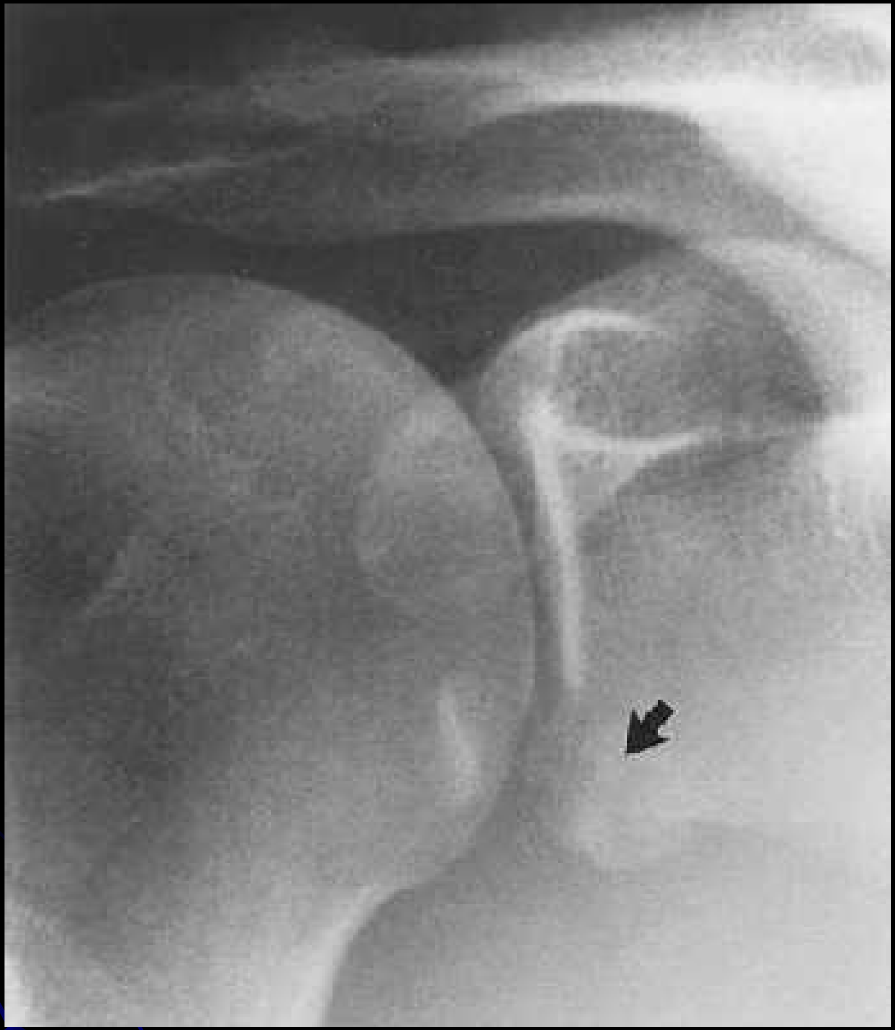
- Ligaments
  - A-C
  - C-C

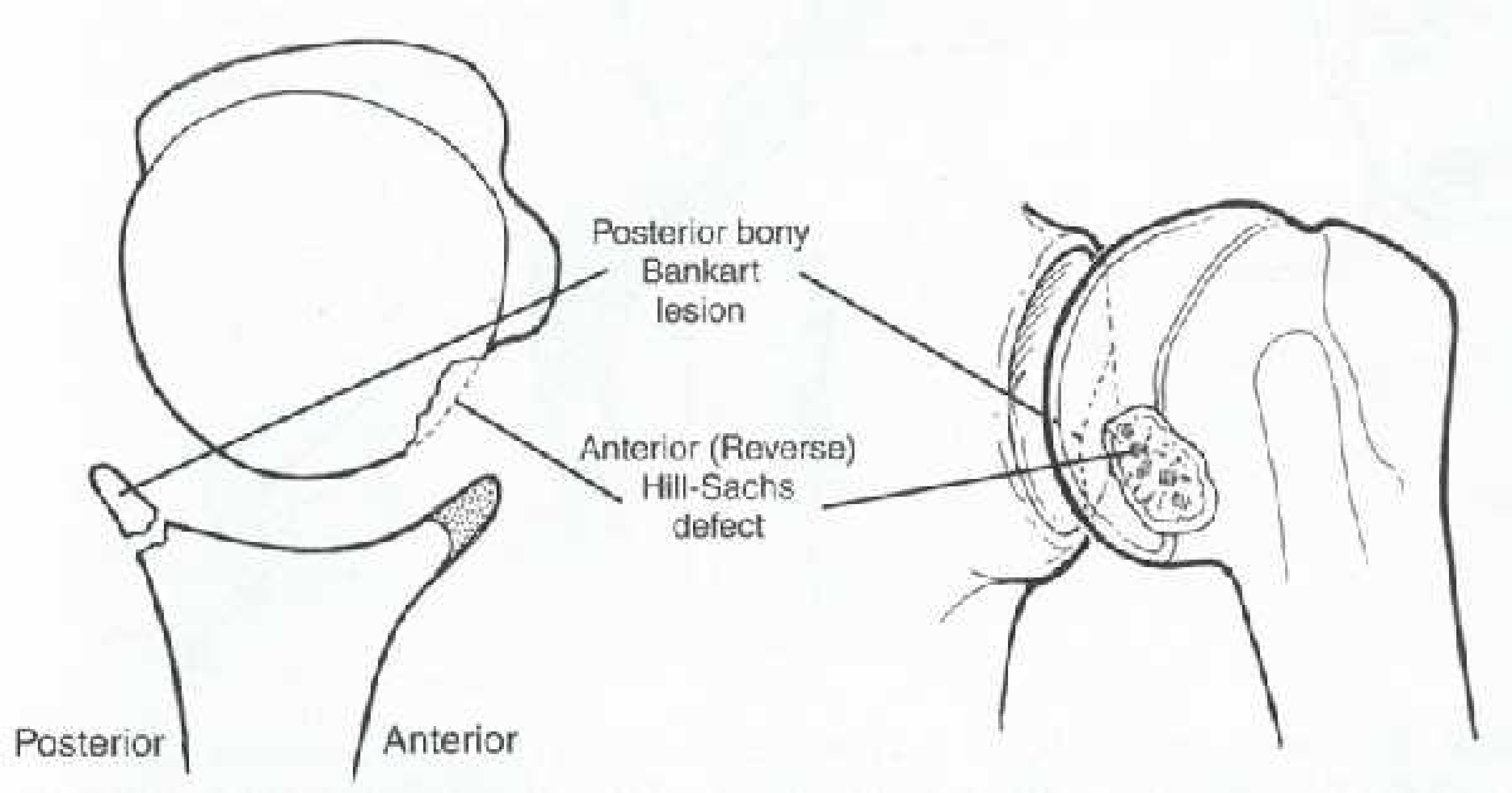


Hill – Sachs Lesion



Bony Bankhart Lesion




Posterior bony
Bankart
lesion
Anterior (Reverse)
Hill-Sachs
defect
Posterior
Anterior

Shoulder stability:

- Instability or imbalance often causes injury
- VIP to maintain humeral head position relative to glenoid during motion
- Dynamic stabilizers:
    - Axial skeleton to humerus: latissimus dorsi and pectoralis major
    - Scapula to humerus: deltoid, teres major, coracobrachialis, subscapularis, supraspinatus, infraspinatus, and teres minor
    - Glenoid: biceps and triceps
    - RTC and long head of biceps = control position and prevent excessive displacement of humeral head
        - Compression and depression

Scapular stability and mobility:

- Scapular muscles dynamically position the glenoid relative to the moving humerus to provide a stable base for the RTC to function
  - Elevation: levator scapula and upper trapezius
  - Adduction: middle trapezius and rhomboids
  - Adduction & depression: lower trapezius
  - Depression: pectoralis minor
  - Abduction & upward rotation: serratus anterior