THE SHOULDER COMPLEX

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GLENOHUMERAL JOINT

INTRODUCTION

- The GH joint is a **ball-and-socket synovial joint** with 3 rotary and 3 translatory DOF.
- It has a capsule and several associated ligaments and bursae.
- The articulation is composed of the large head of the humerus and the smaller glenoid fossa.
- Because the glenoid fossa of the scapula is the proximal segment of the GH joint, any motions of the scapula will influence GH joint function.

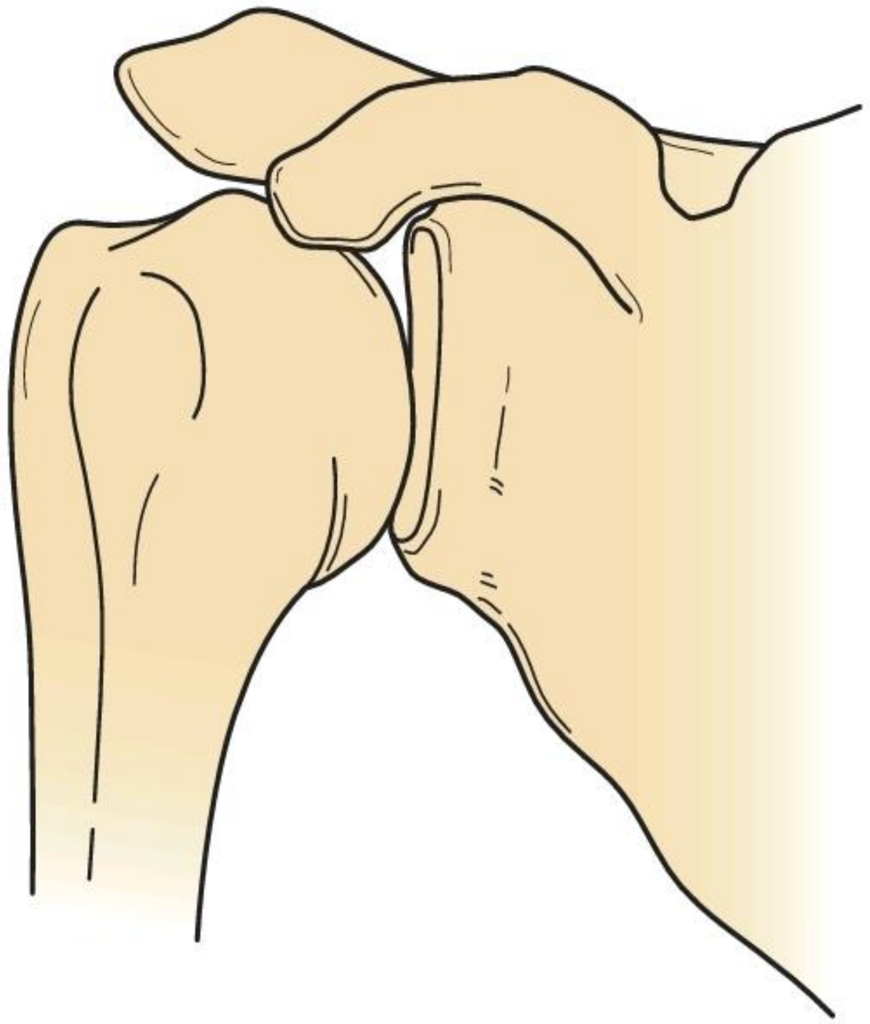


Figure 7–22 The glenohumeral joint.

GH ARTICULATING SURFACES

❖ **Glenoid fossa:**

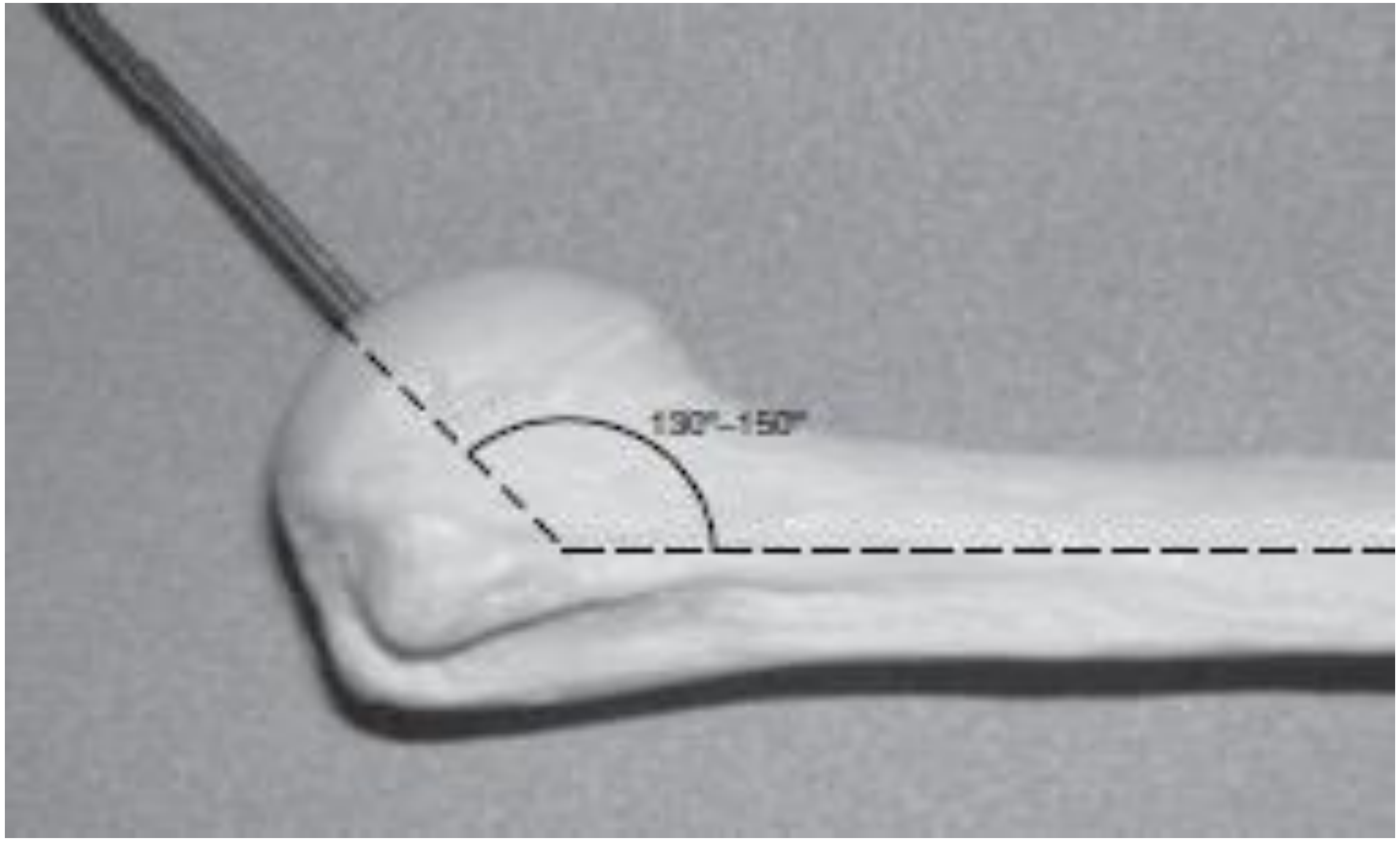
- The glenoid fossa of the scapula serves as the proximal articular surface for this joint.
- The glenoid fossa may be tilted slightly upward or downward when the arm is at the side.
- The fossa also does not always lie in a plane perpendicular to the plane of the scapula; it may be anteverted or retroverted up to 10 degree, with 6 to 7 degree of retroversion most typical.

- With anteversion, the glenoid fossa faces slightly anterior in relation to the plane or body of the scapula and, with retroversion, slightly posterior.
- The curvature of the surface of the glenoid fossa is **greater in the vertical direction than in the horizontal direction**.

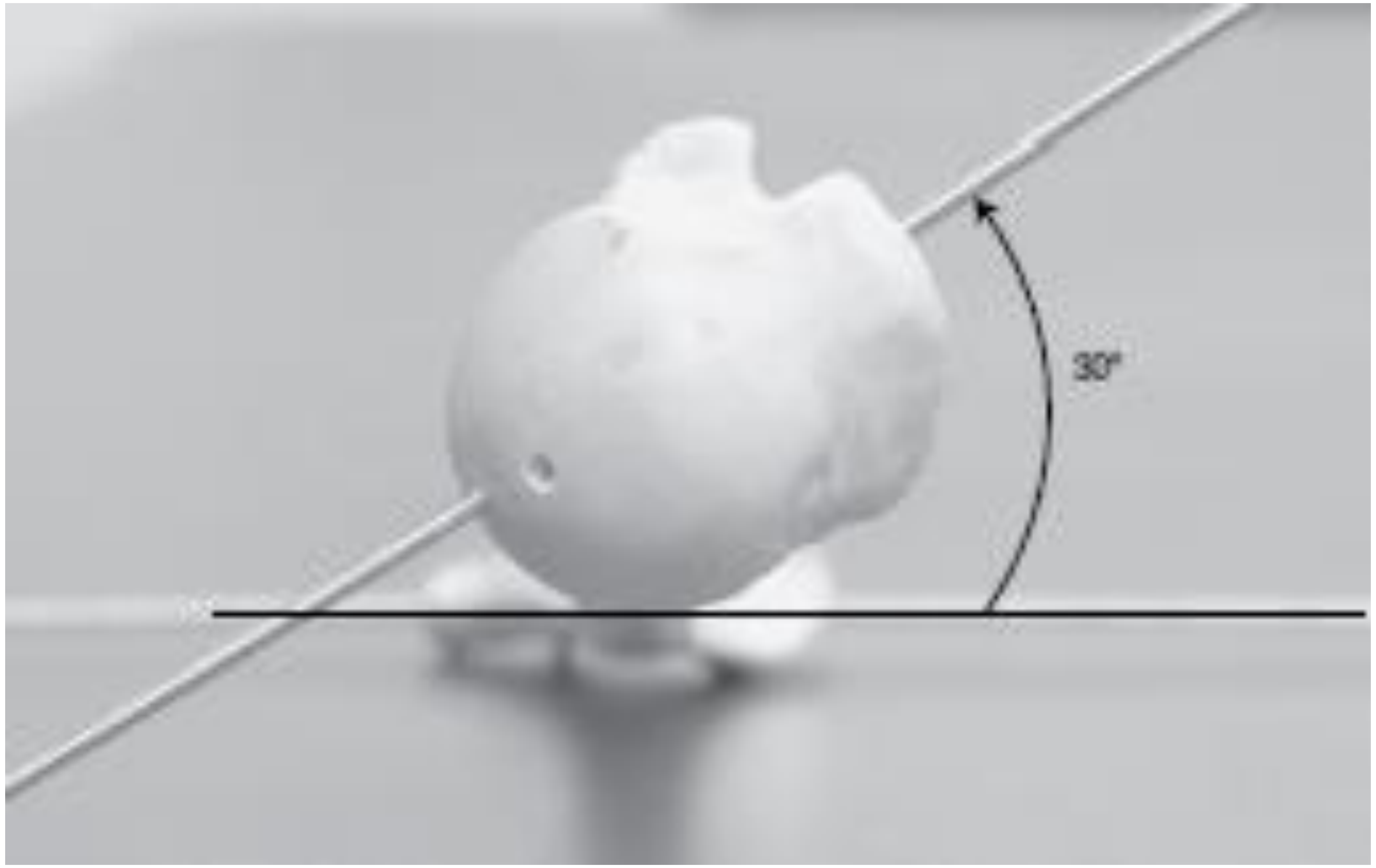
■ **Head of the humerus:**

- The humerus is the distal segment of the GH joint. The humeral head has an articular surface that is larger than that of the proximal glenoid articular surface, forming one third to one half of a sphere.

- As a general rule, the head faces medially, superiorly, and posteriorly with regard to the shaft of the humerus and the humeral condyles.
- An axis through the humeral head and neck in relation to a longitudinal axis through the shaft of the humerus forms an angle of 130 to 150 degree in the frontal plane.
- This is commonly known as the **angle of inclination** of the humerus.


130°–150°

- In the transverse plane, the axis through the humeral head and neck in relation to the axis through the humeral condyles forms an angle. This angle is known as the **angle of torsion**.
- The normal angle is 30 degree.
- The normal posterior position of the humeral head with regard to the humeral condyles may be termed **posterior torsion, retrotorsion,** or **retroversion** of the humerus.


30°

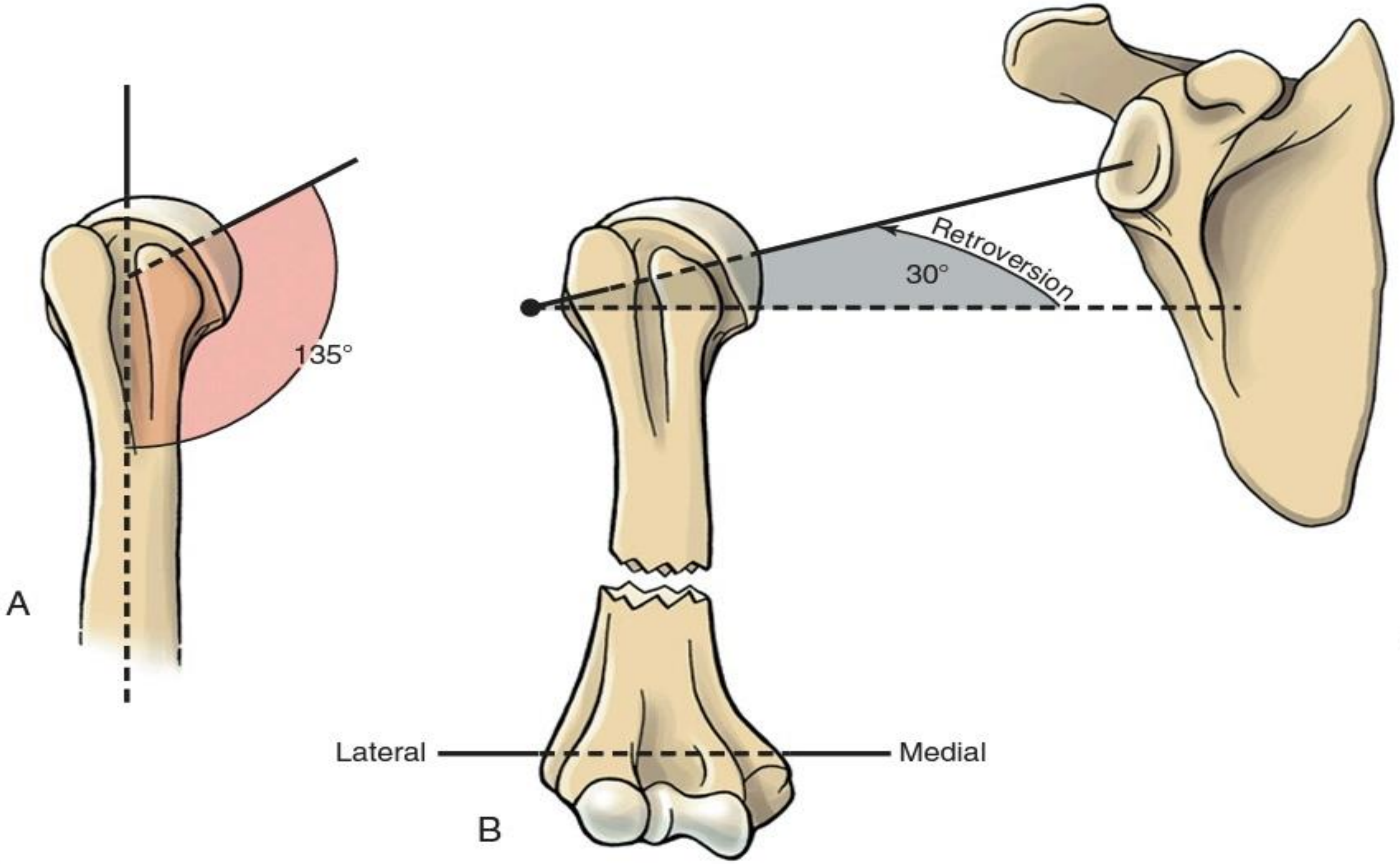


FIG. 5.8 The right humerus showing a 135-degree "angle of inclination" between the shaft and head of the humerus in the frontal plane (A) and the retroversion of the humeral head relative to the distal humerus (B).

■ Glenoid Labrum:

- The total available articular surface of the glenoid fossa is enhanced by an accessory structure, the **glenoid labrum.**
- This structure surrounds and is attached to the periphery of the **glenoid fossa, enhancing the depth or curvature of the fossa by approximately 50%.**
- The glenoid labrum also serves as the attachment site for the glenohumeral ligaments and the tendon of the long head of the biceps brachii.

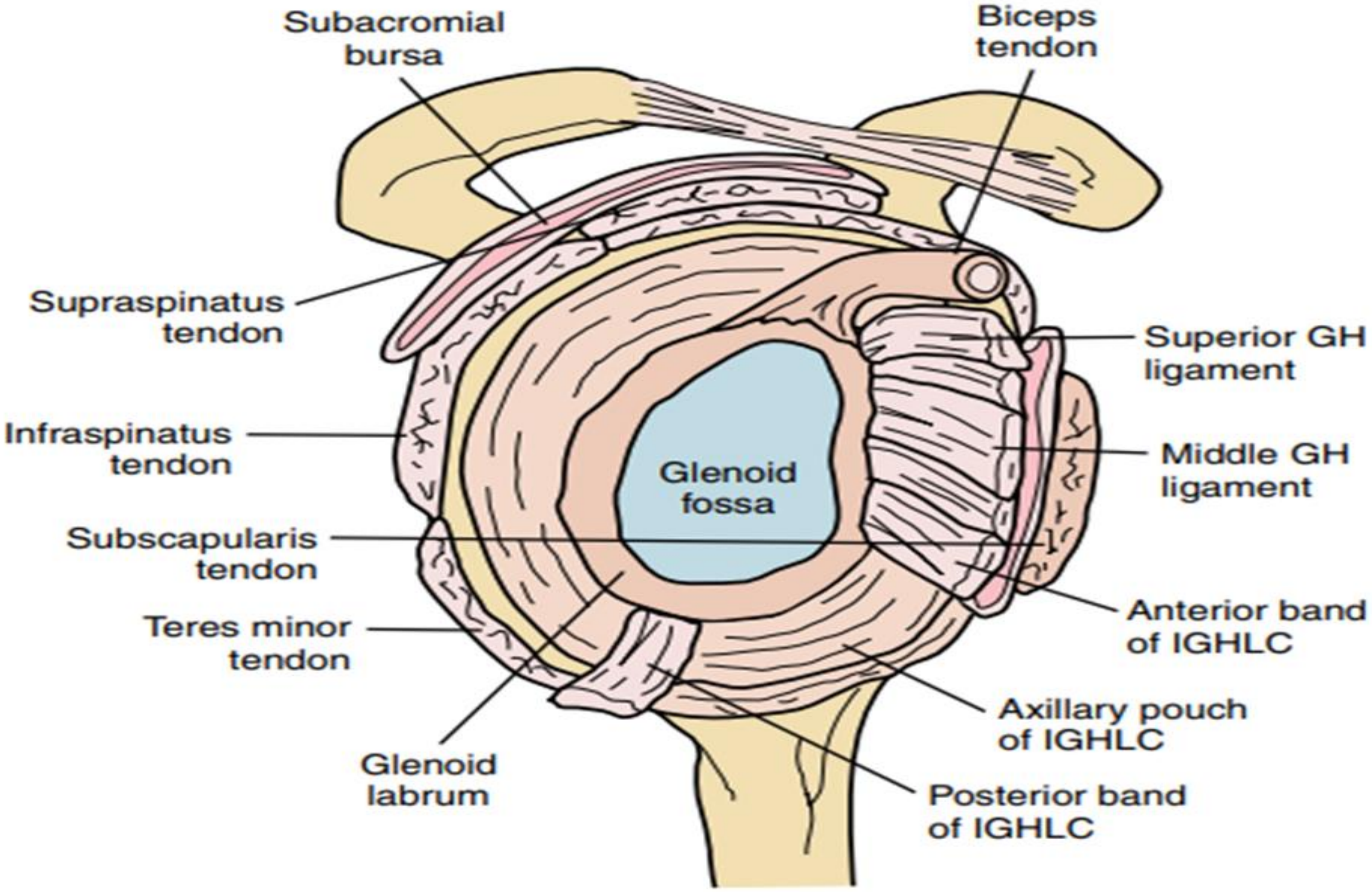


Figure 7–27 In a direct view into the glenoid fossa (humerus removed), it can be seen that the glenoid labrum increases the articular area of the glenoid fossa and serves as the attachment for the glenohumeral (GH) capsule and capsular ligaments. IGHLC, inferior glenohumeral ligament complex.

- The composition of the labrum allows it to perform a variety of functions, including

  - **Resistance to humeral head translations**,
  - **Protection of the bony edges of the labrum**,
  - **Reduction of joint friction, and**
  - **Dissipation of joint contact forces**.

GH CAPSULE AND LIGAMENTS

- The entire GH joint is surrounded by a large, loose capsule that is taut superiorly and slack anteriorly and inferiorly in the resting position.
- The **capsule tightens when the humerus is abducted and laterally rotated,** making this the **close-packed position for the GH joint**.
- The capsular surface area is twice that of the humeral head, and more than 2.5 cm of distraction of the head from the glenoid fossa is possible in the loose-packed position.

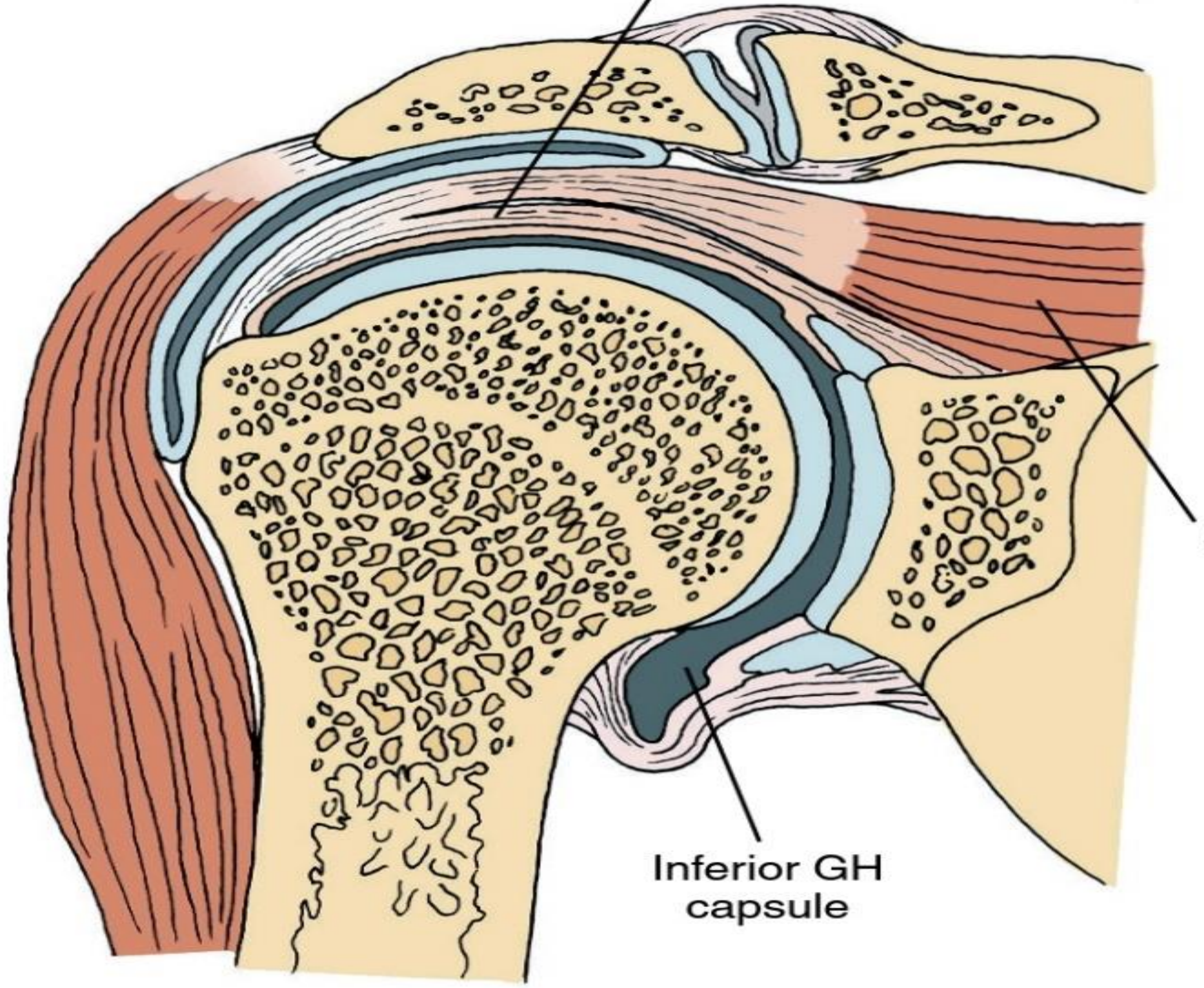


Figure 7–28 When the arm is at rest at the side, the superior capsule is taut while the inferior capsule is slack. GH, glenohumeral.

- The capsule is reinforced by the **<u>superior, middle, and inferior GH ligaments and by the coracohumeral ligament</u>**.
- The superior, middle, and inferior GH ligaments are thickened regions within the capsule tissue itself.
- In addition to these static capsular reinforcements, the rotator cuff muscles and their tendons provide dynamic reinforcement to the capsule through their anatomical proximity to the joint and because the tendons insert directly onto and blend into the GH capsule.

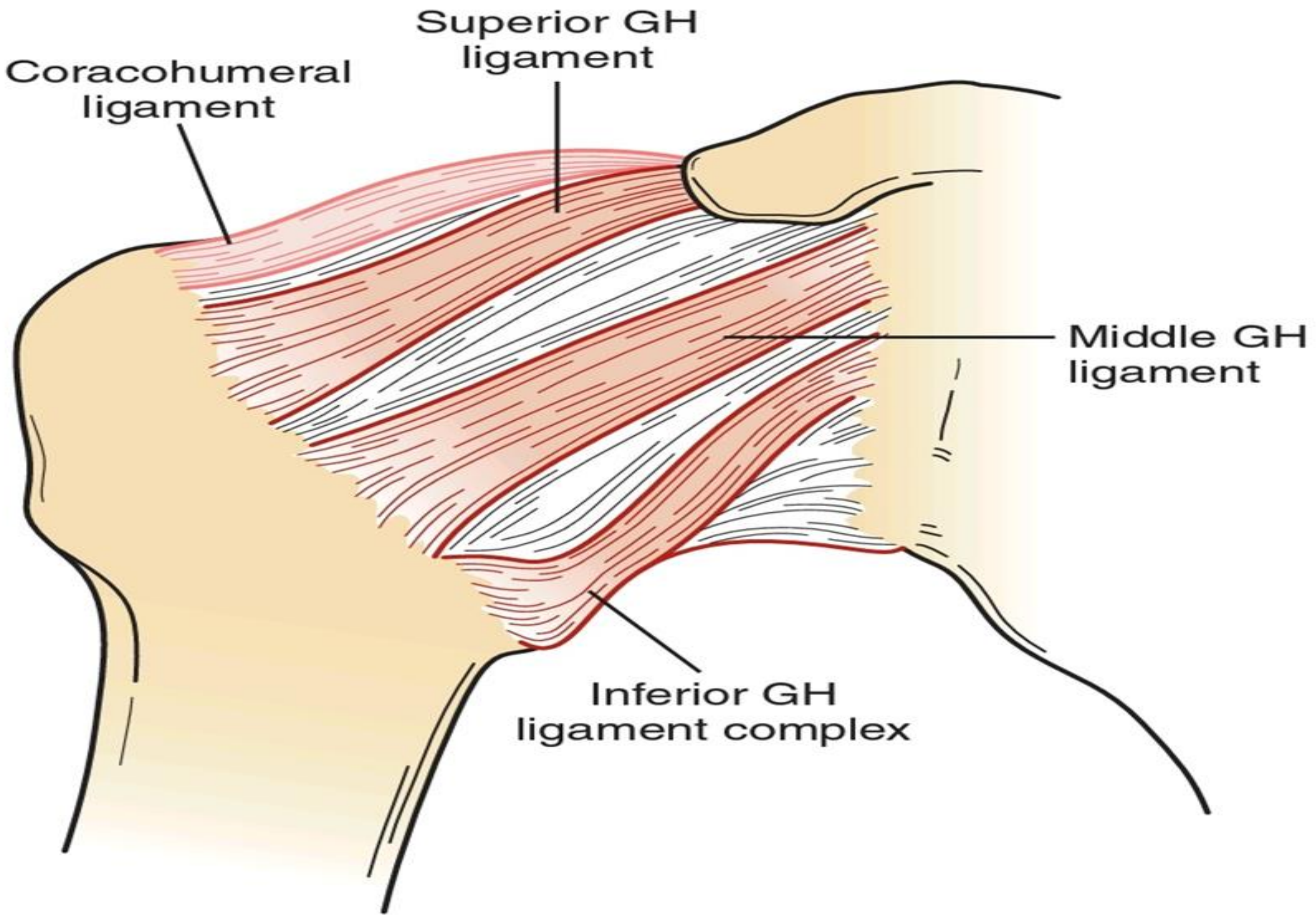


Figure 7–29 The ligamentous reinforcements to the glenohumeral (GH) capsule: the superior, middle, and inferior glenohumeral ligaments, along with the coracohumeral ligament.

- **Even with these reinforcements, the GH joint is vulnerable to dislocations, particularly in the anterior direction**.
- The 3 capsular GH ligaments (superior, middle, and inferior) vary considerably in size, extent, and attachment sites between individuals.
- The **Superior GH ligament** passes from the superior glenoid labrum to the upper neck of the humerus deep to the extracapsular coracohumeral ligament.

- The superior GH ligament, the superior capsule, and the coracohumeral ligament are the interconnected structures that bridge the space between the supraspinatus and subscapularis muscle tendons and form the **Rotator Interval Capsule (RIC).**

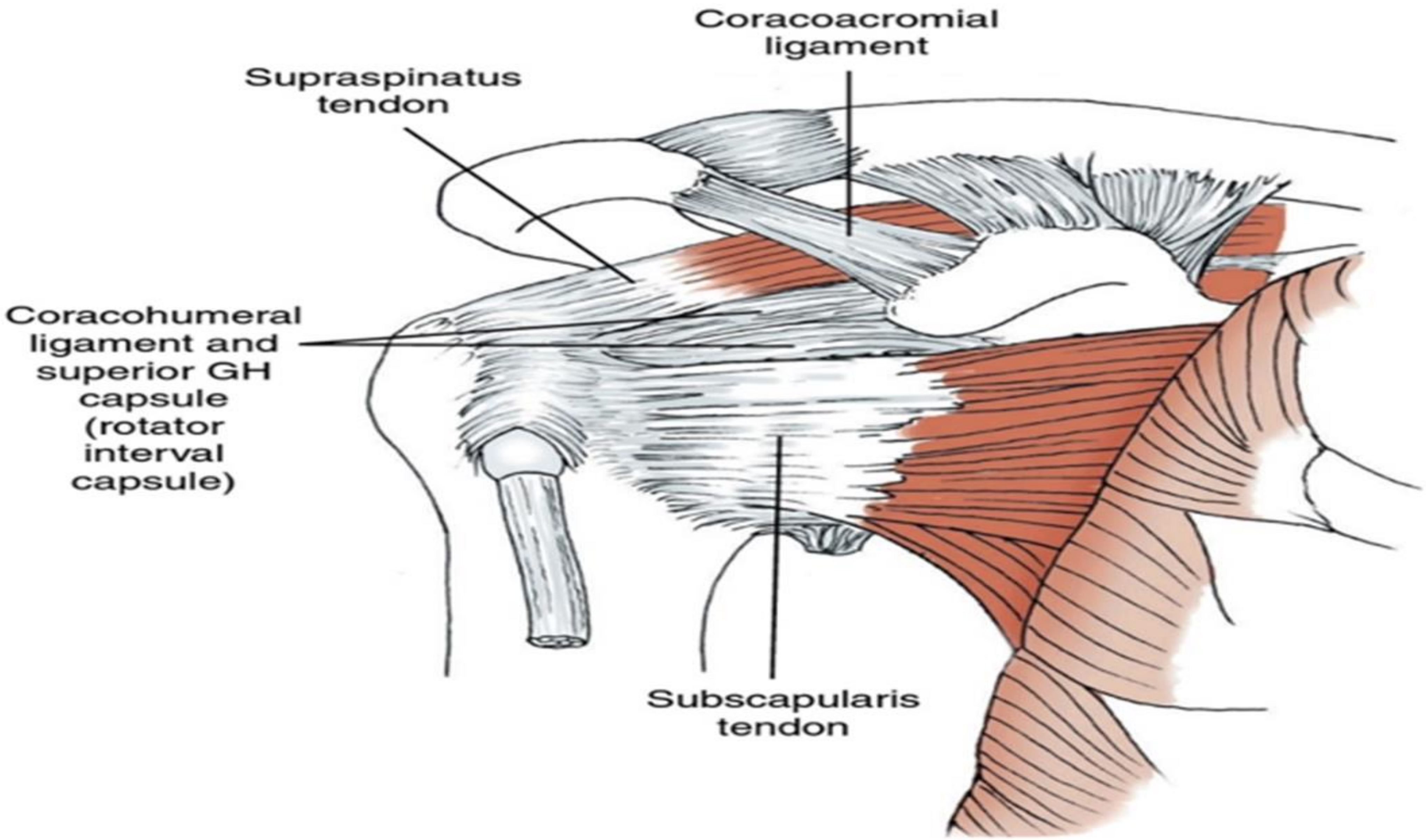


Figure 7–30 The rotator interval capsule is made up of the superior glenohumeral (GH) capsule, superior glenohumeral ligament, and coracohumeral ligament. Together, these structures bridge the gap between the supraspinatus and subscapularis muscle tendons.

- The **Middle GH ligament** runs obliquely from the superior anterior labrum to the anterior aspect of the proximal humerus below the superior GH ligament attachment.
- This ligament are absent in 30% of subjects and also described it as cord-like in nearly 20% of subjects.

- The **Inferior GH ligament** is described as having 3 components and thus has been termed the inferior GH ligament complex (IGHLC).
- The 3 components of the complex are the anterior and posterior ligament bands and the axillary pouch in between.
- The IGHLC shows **position-dependent variability in function**, as well as **variations in viscoelastic behavior**.
- Study of the movement restraint provided by the GH ligaments indicates that each ligament contributes differently to GH stability.

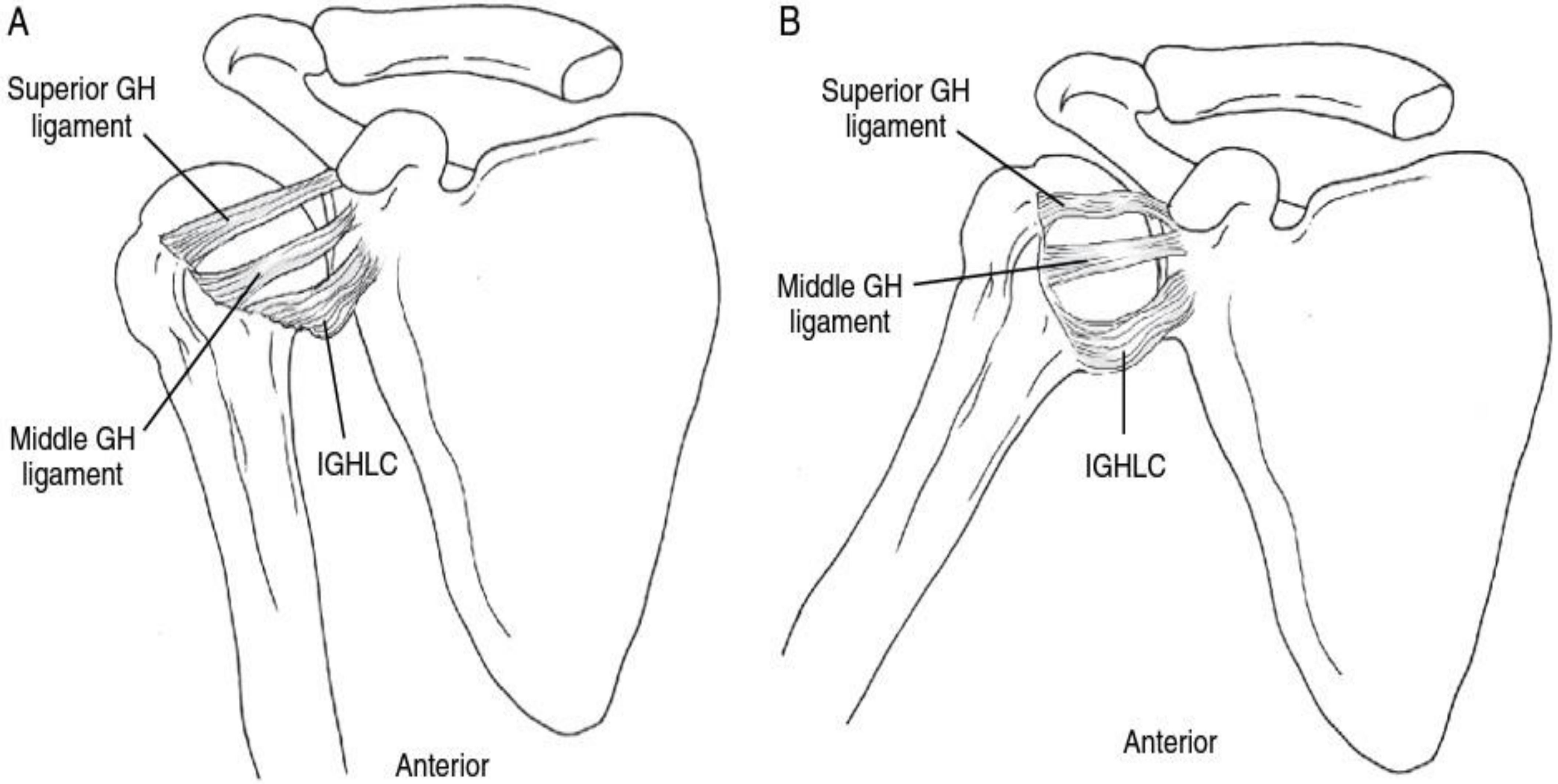
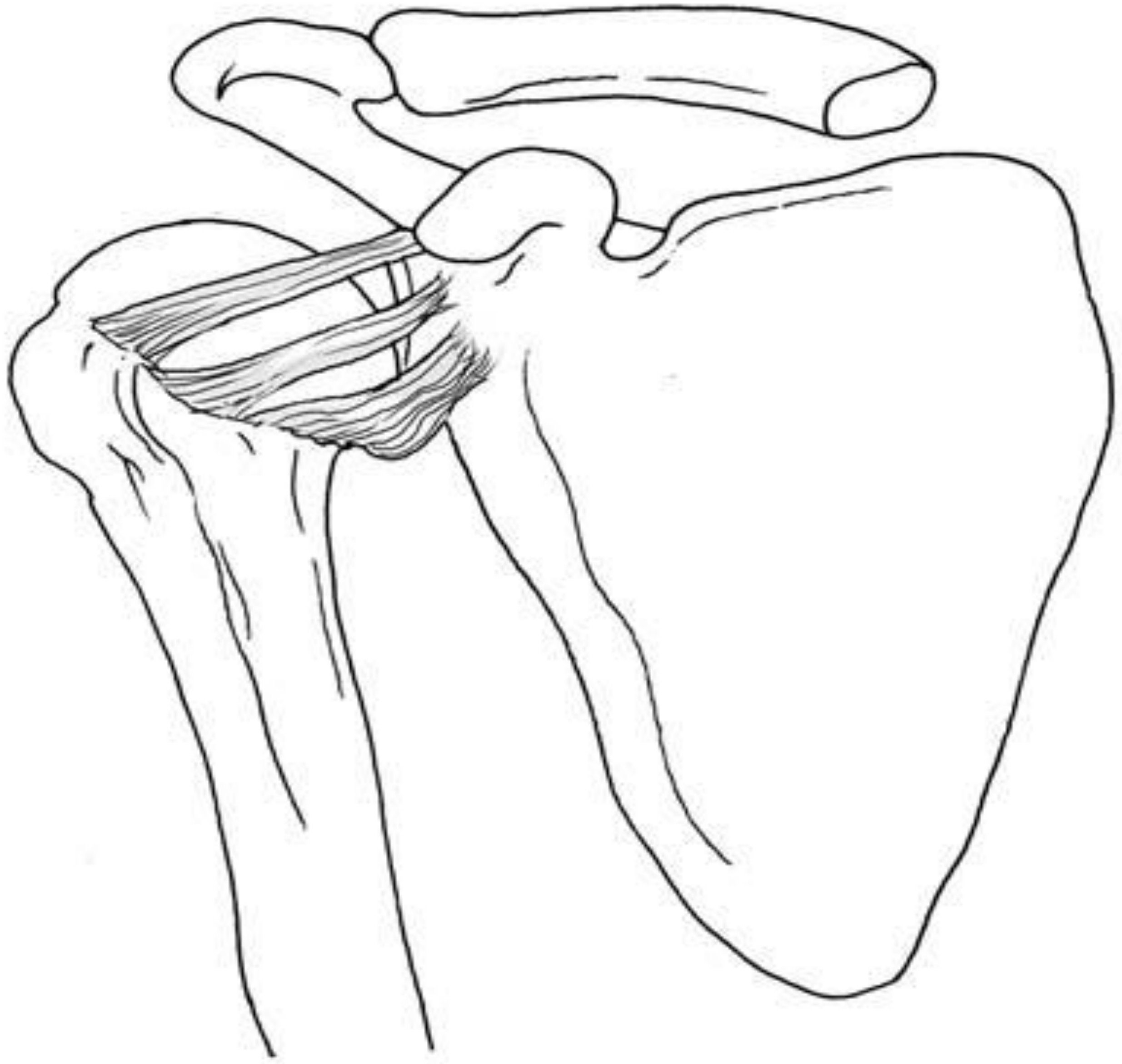


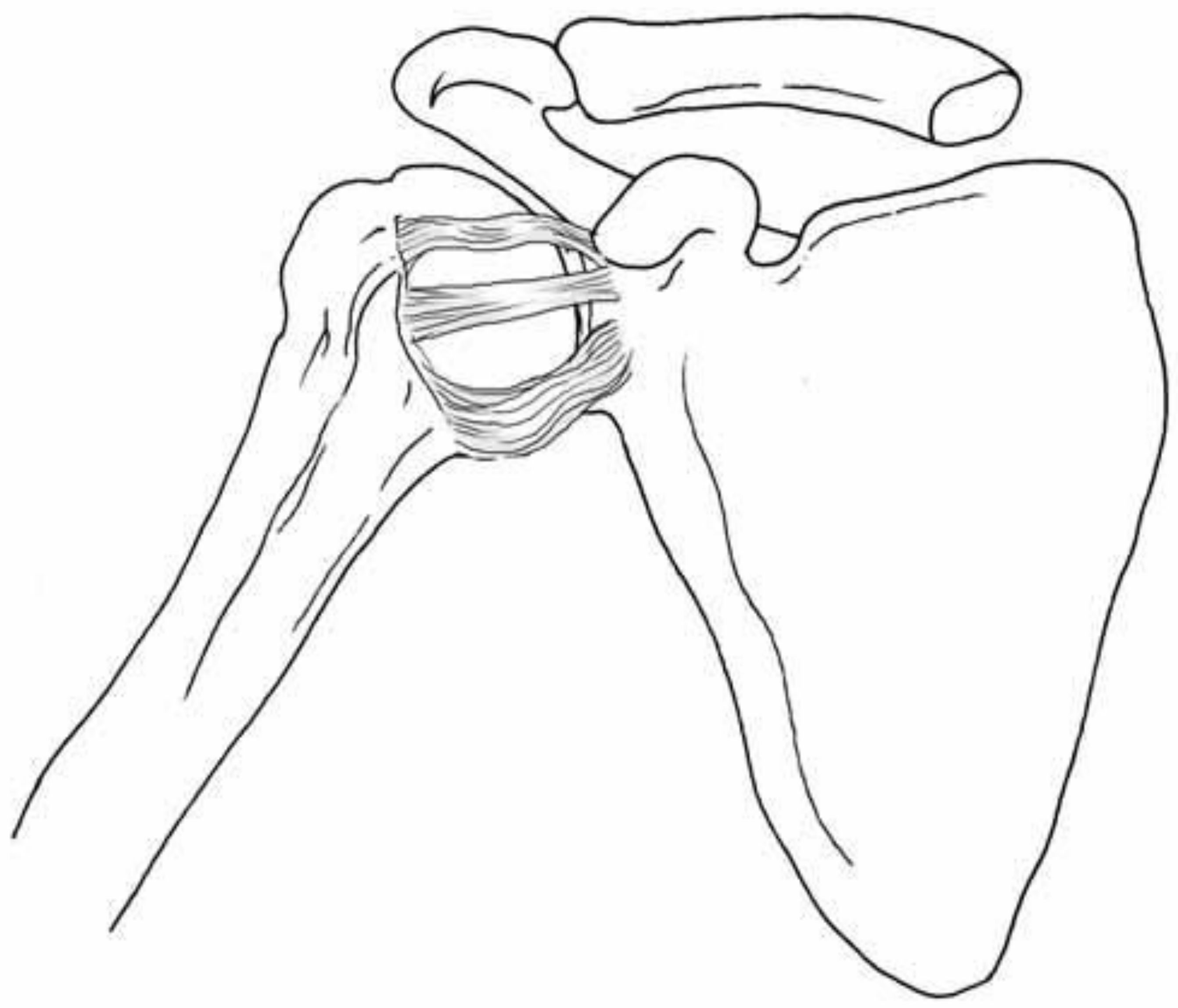
Figure 7–31 The glenohumeral (H) ligaments at rest **(A),** at 45° humeral abduction and neutral rotation **(B),** at 90° humeral abduction and neutral rotation **(C),** at 90° humeral abduction and external rotation **(D),** and at 90° humeral abduction and medial rotation **(E)**. IGHLC, inferior glenohumeral ligament complex.

FUNCTIONS OF LIGAMENT

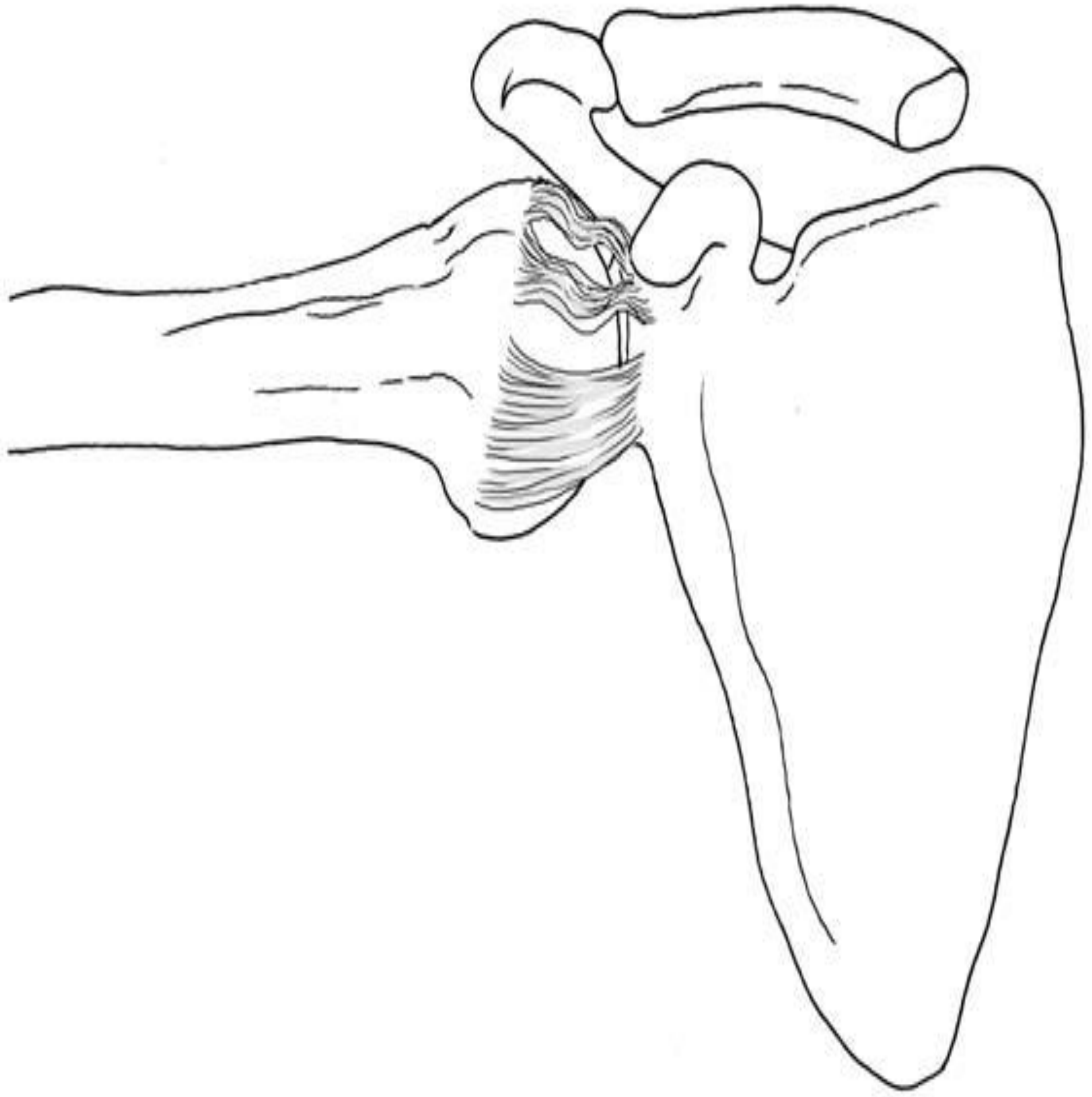
- The **superior GH ligament** and its associated RIC structures contribute most to anterior and inferior joint stability by limiting anterior and inferior translations of the humeral head when the arm is at the side (0° abduction).



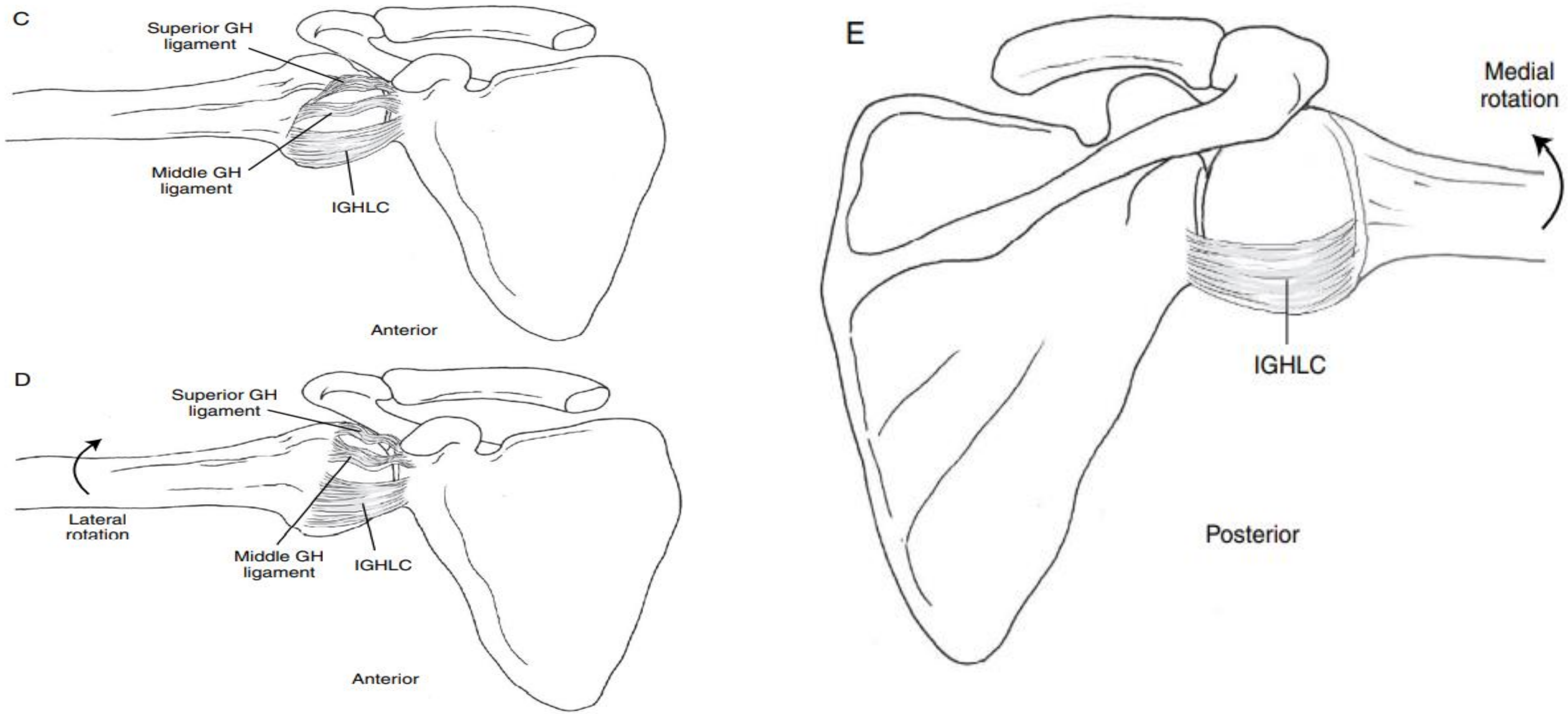
- The **Middle GH ligament** contributes primarily to anterior joint stability by limiting anterior humeral translation with the arm at the side and up to 60° of abduction.



- With abduction beyond 45° or with combined abduction and rotation, the **IGHLC** plays the major role of joint stabilization.
- If **humeral lateral rotation** is added, the anterior band of the IGHLC fans out to provide anterior joint stability and resistance to anterior humeral head translation



- If **humeral medial rotation is added**, the posterior band of the IGHLC fans out and provides posterior joint stability and resistance to posterior humeral head translation.
- In all positions of humeral abduction, lateral or medial rotation of the humerus tightens the capsule and GH ligaments and increases GH joint stabilization.


C
Superior GH ligament
Middle GH ligament
IGHLC
Anterior
D
Superior GH ligament
Lateral rotation
Middle GH ligament
IGHLC
Anterior
E
Medial rotation
IGHLC
Posterior

- The **coracohumeral ligament** originates from the base of the coracoid process and has **2 bands**.
- The 1st band inserts into the edge of the supraspinatus and onto the greater tubercle, joining the superior GH ligament.
- The 2nd band inserts into the subscapularis and lesser tubercle.
- The 2 bands form a tunnel through which the tendon of the long head of the biceps brachii passes.

- As part of the RIC, the **CH ligament** limits inferior translation of the humeral head in the dependent arm position.
- In addition, the **CH ligament** resists humeral lateral rotation with the arm adducted.
- The ligament may also assist in preventing superior translation of the humerus, especially when the dynamic stabilizing force of the rotator cuff muscles is impaired

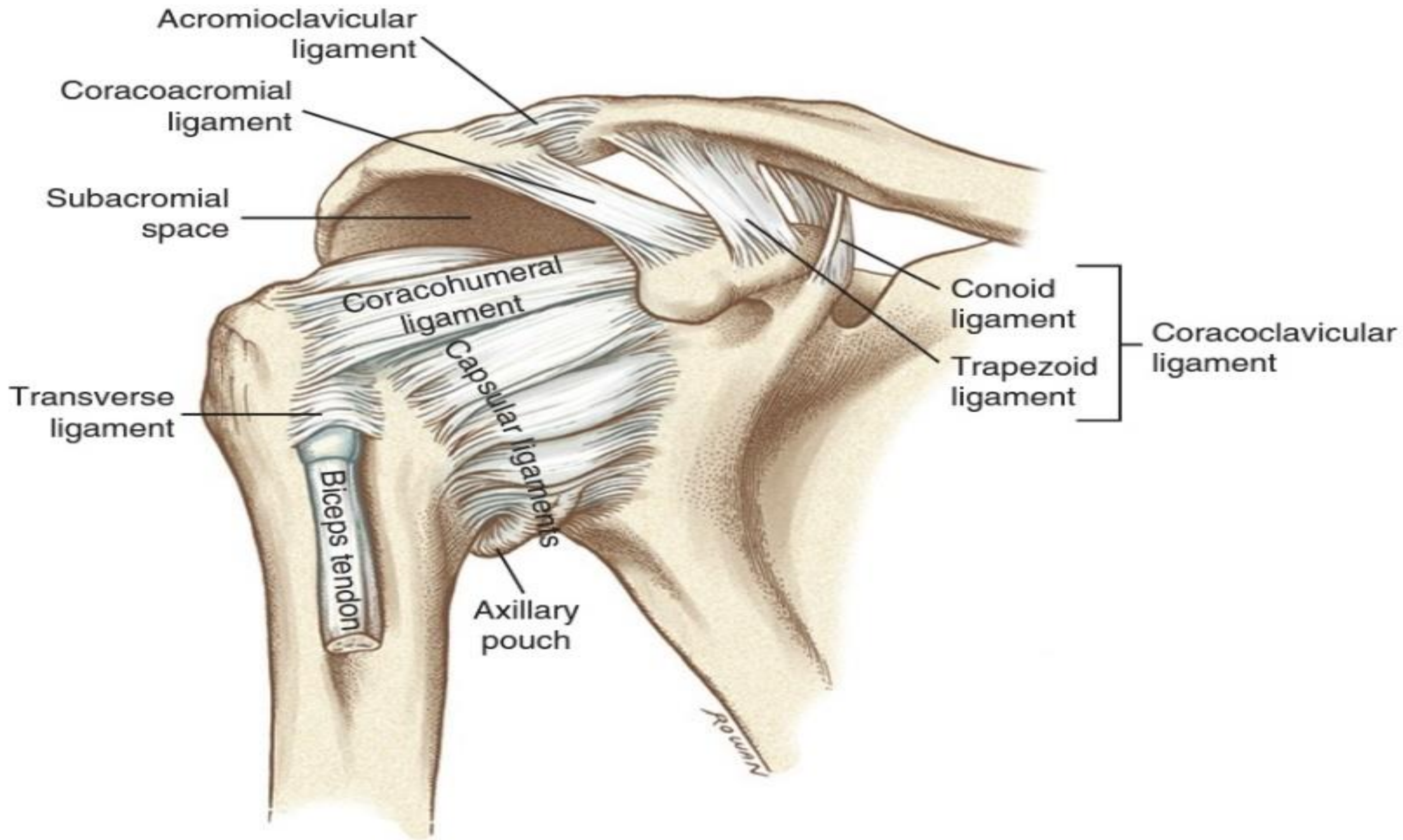


FIG. 5.24 Anterior view of the right glenohumeral joint showing the primary ligaments. Note the subacromial space located between the top of the humeral head and the underside of the acromion.

CORACOACROMIAL ARCH

- The coracoacromial (or suprahumeral) arch is formed by the **coracoid process, the acromion, the coracoacromial ligament, and the inferior surface of the AC joint.**
- The coracoacromial arch forms an osteoligamentous vault over the humeral head and the region between the arch and the humeral head is called the subacromial space.

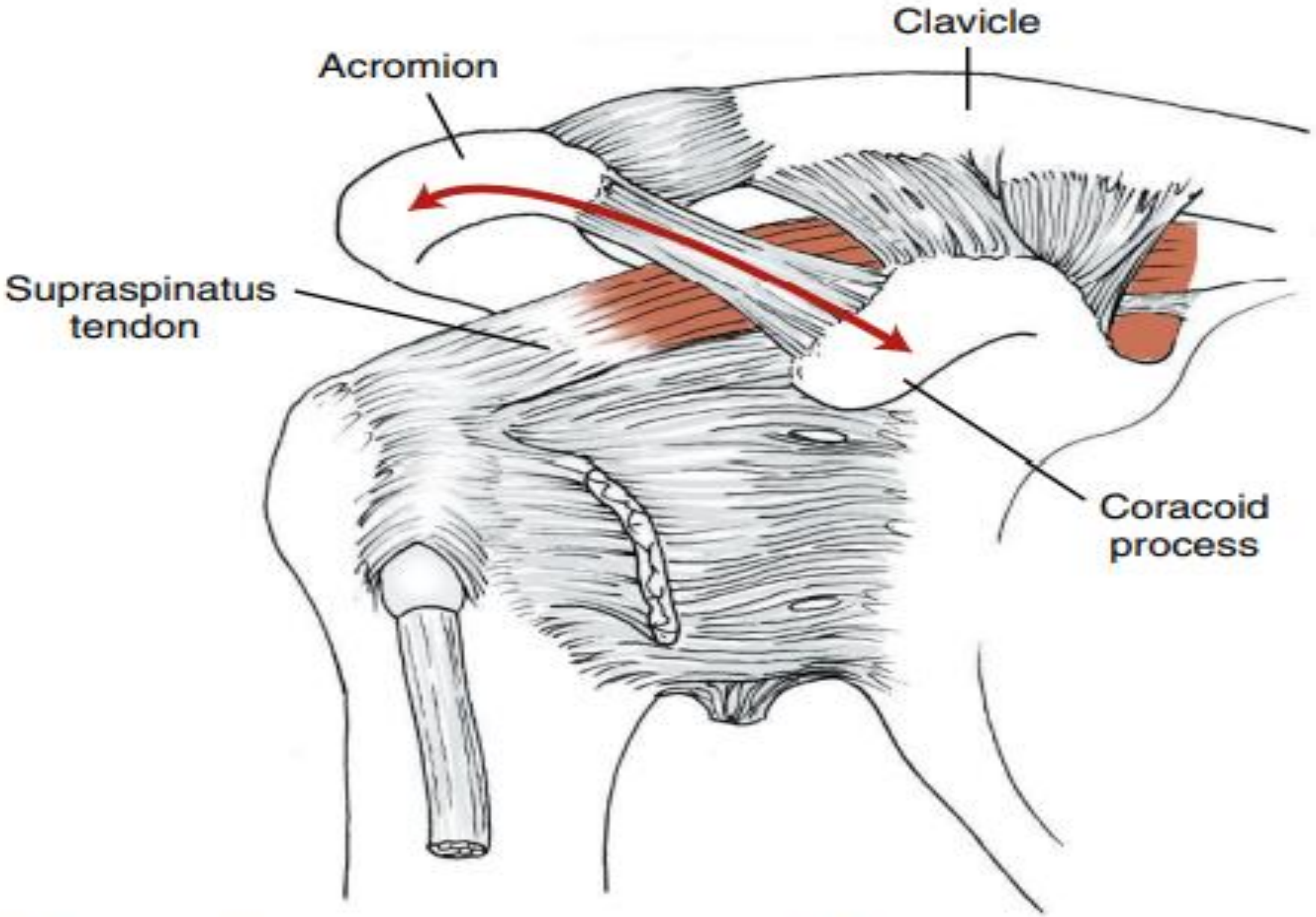


Figure 7–32 The coracoacromial arch is formed by the coracoid process anteriorly, the acromion posteriorly, and the coracoacromial ligament superiorly. Together, these structures form an osteoligamentous arch over the humeral head.

- The subacromial bursa, the rotator cuff tendons, and a portion of the tendon of the long head of the biceps brachii lie within the subacromial space and are protected superiorly from direct trauma by the coracoacromial arch.
- Such trauma could occur through simple daily tasks such as carrying a heavy bag over the shoulder.
- The arch also acts as a physical barrier to superior translatory forces acting on the humeral head, preventing it from dislocating superiorly.

- Although beneficial to joint stability, contact of the humeral head with the undersurface of the arch can simultaneously cause painful impingement or mechanical abrasion of the structures within the subacromial space.
- The supraspinatus tendon is particularly vulnerable because of its location beneath all of the potentially impinging structures except the coracoid process.

- The **subacromial space**, also referred to as the **suprahumeral space** or **supraspinatus outlet**, has been quantified by measuring the superior-to-inferior acromiohumeral interval on radiographs.
- This interval averages **10 mm** in healthy subjects with the arm adducted at the side and decreases to about **5 mm** during elevation of the arm.
- When the subacromial space decreases even more than what has been measured in healthy subjects, the likelihood of impingement of the rotator cuff tendons and subacromial bursa during elevation of the arm increases.

- The space can decrease by anatomical factors such as changes in the shape or slope of the acromion, acromial bone spurs, AC joint osteophytes, a large coracoacromial ligament, or a disproportionately large humeral head.
- Inadequate posterior tilting or inadequate upward rotation of the scapula during arm elevation or excessive superior or anterior translation of the humeral head on the glenoid fossa are believed to bring the humeral head in closer proximity to the acromion, increasing the risk of impingement.

- Abnormal scapular or humeral motions can also functionally reduce the size of the subacromial space.
- Finally, repetitive impingement may lead to inflammation, fibrosis, and thickening of the soft tissues, further reducing the subacromial space during arm elevation.

BURSAE

- Several bursae are associated with the shoulder complex in general and with the GH joint specifically, reflecting the presence of frictional forces between anatomical structures.
- Although all bursae at the shoulder contribute to function, the most important are the **subacromial bursae** and the **subdeltoid bursae**.
- These bursae separate the supraspinatus tendon and head of the humerus from the acromion, coracoid process, coracoacromial ligament, and deltoid muscle.

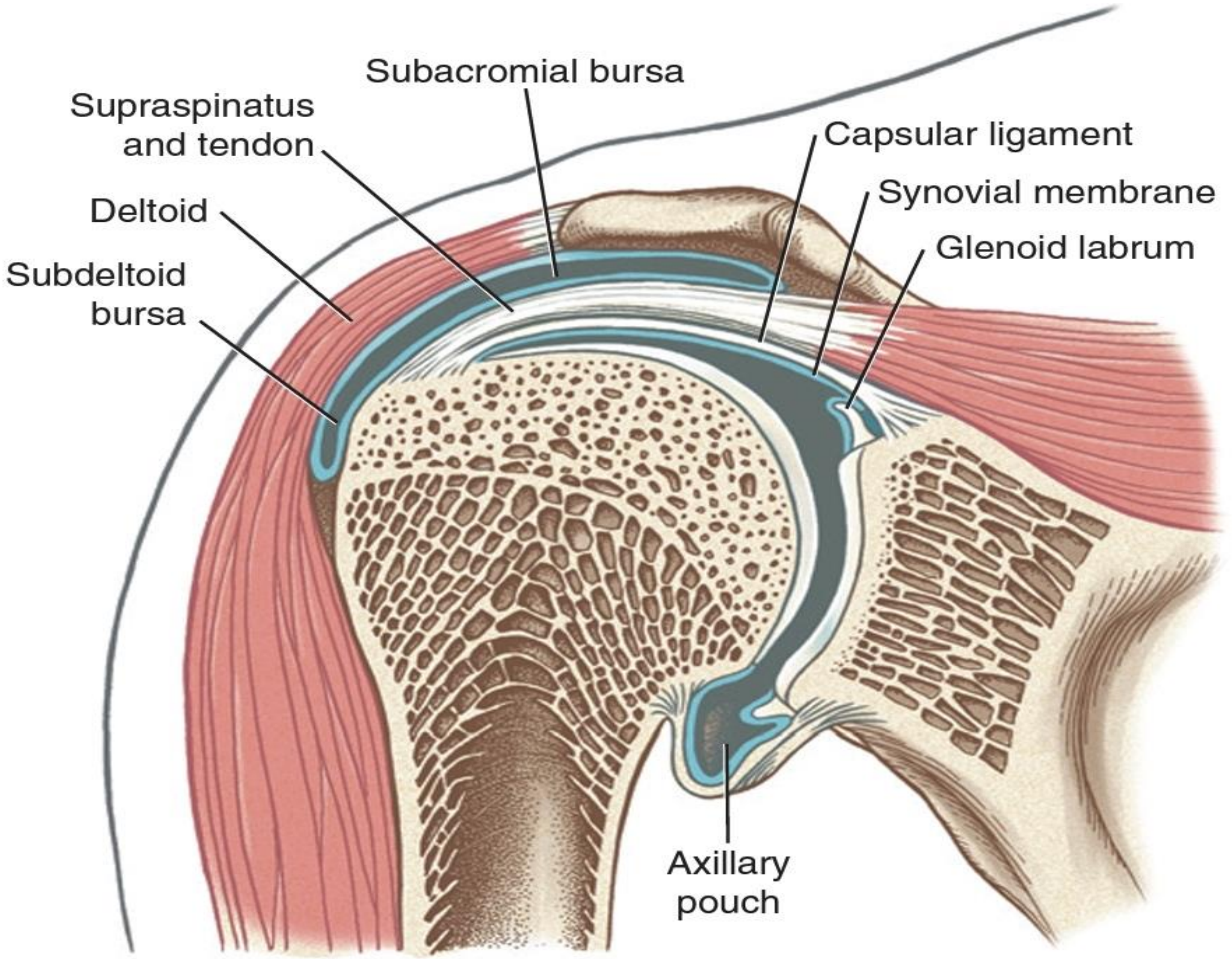


FIG. 5.29 An anterior view of a frontal plane cross-section of the right glenohumeral joint. Note the subacromial and subdeltoid bursa within the subacromial space. Bursa and synovial lining are depicted in blue. The deltoid and supraspinatus muscles are also shown.

- The subacromial bursa reduces friction to permit smooth gliding between the humerus and supraspinatus tendon and the surrounding structures.
- Interruption or failure of this gliding mechanism is a common cause of pain and decreased GH motion, although it rarely occurs as a primary problem.
- **Subacromial bursitis** is most commonly secondary to inflammation or degeneration of the supraspinatus tendon.
- However, when inflamed, the subacromial bursa may decrease the subacromial space available for rotator cuff tendon clearance.

GH MOTIONS

The GH joint is usually described as having 3 rotational DOF:

1. Flexion/extension,
2. Abduction/ adduction, and
3. Medial/lateral rotation.

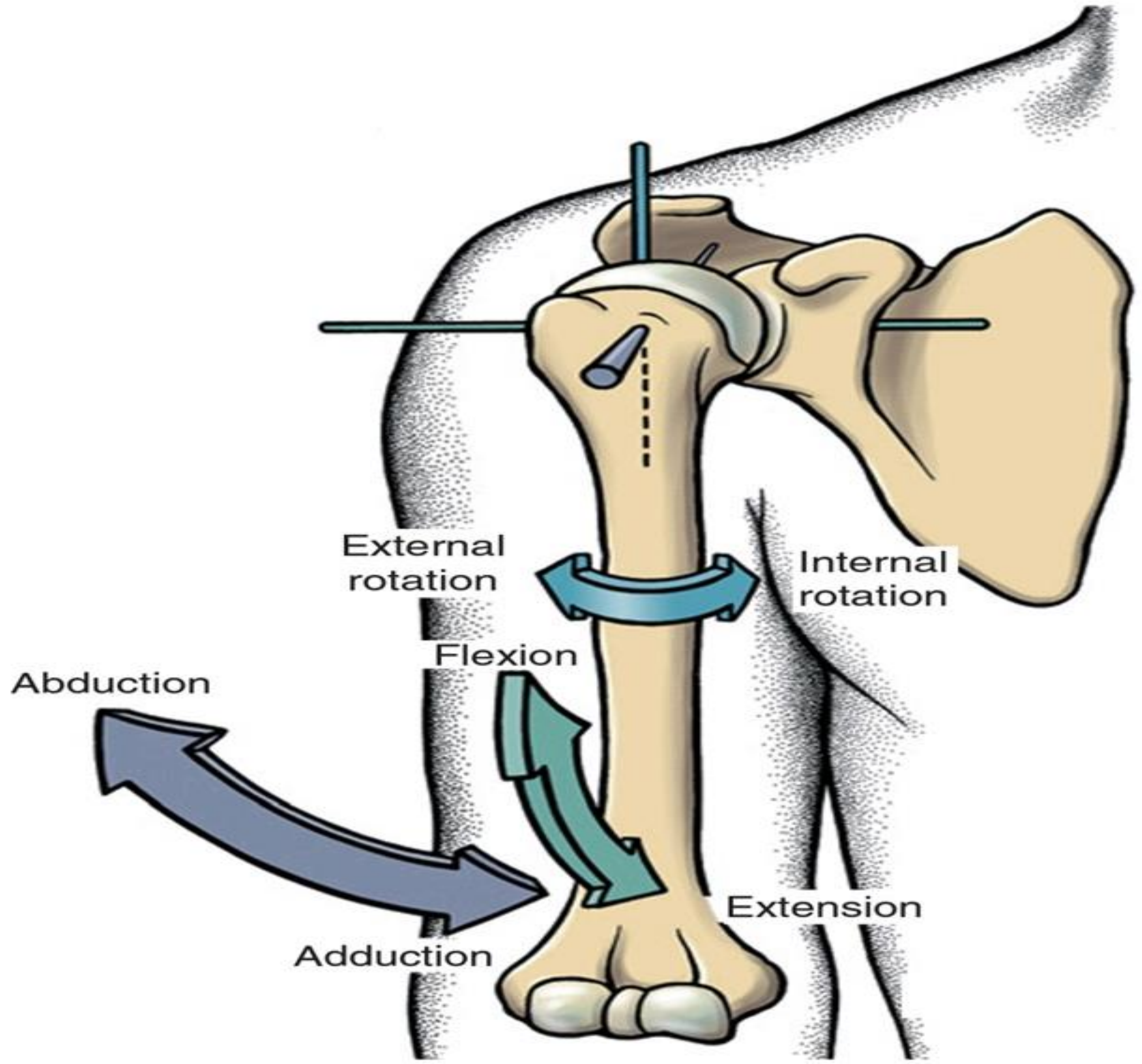


FIG. 5.30 The osteokinematics of the glenohumeral joint includes abduction and adduction *(purple)*, flexion and extension *(green)*, and internal and external rotation *(blue)*. Note that each axis of rotation is color-coded with its corresponding plane of movement.

FLEXION AND EXTENSION

- Flexion and extension at the GH joint are defined as a rotation of the humerus within the near sagittal plane around a near medial-lateral axis of rotation.
- The arthrokinematics involve primarily a **spinning motion** of the humeral head around the glenoid fossa.
- Tension within the stretched posterior capsule may cause a slight anterior translation of the humerus at the extremes of flexion.
- At least 120 degrees of flexion are available to the GH joint.

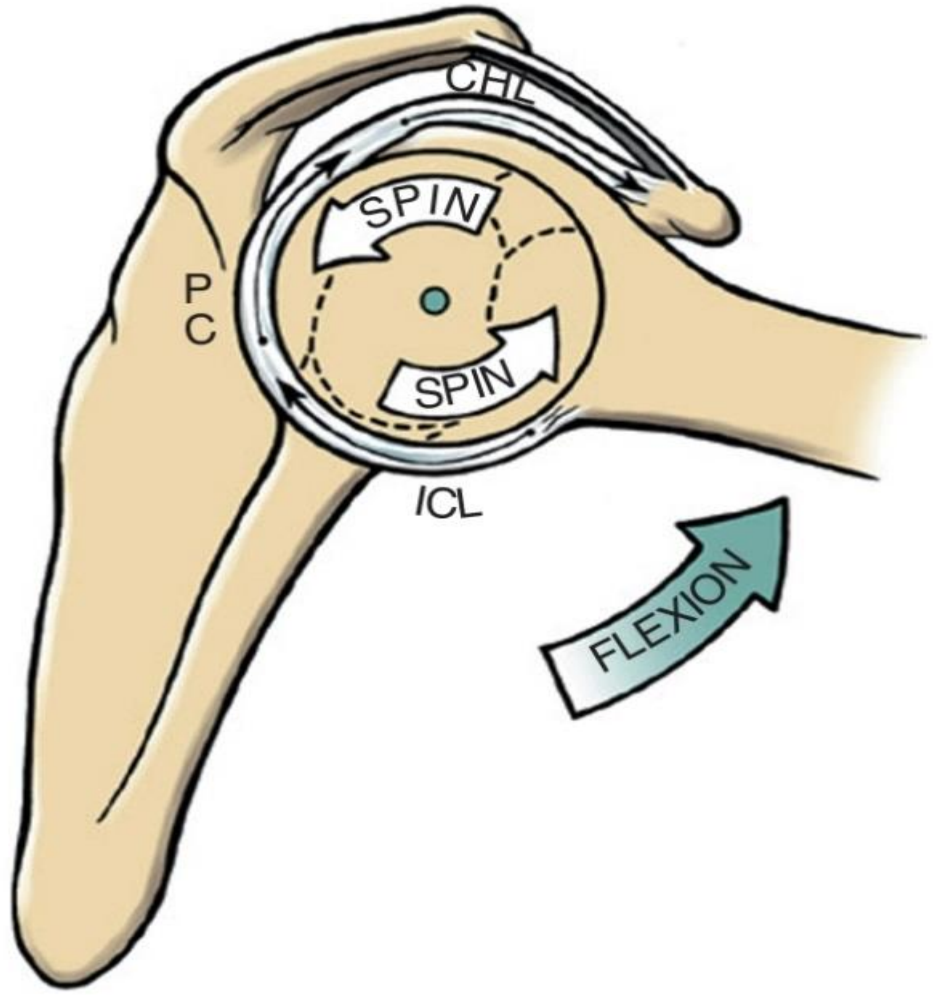


FIG. 5.34 Side view of flexion in the near sagittal plane of the right glenohumeral joint. A point on the head of the humerus is shown spinning around a point on the glenoid fossa. Stretched structures are shown as *long thin arrows*. *PC,* posterior capsule; *ICL,* inferior capsular ligament; *CHL,* coracohumeral ligament.

- Flexing the shoulder to nearly 180 degrees includes an accompanying upward rotation of the ST joint.
- Full extension of the shoulder occurs to a position of about 65^0 actively (and 80^0 passively) behind the frontal plane.
- The extremes of this passive motion likely stretch the capsular ligaments, causing a slight anterior tilting of the scapula.
- This forward tilt may enhance the extent of a backward reach.

ABDUCTION AND ADDUCTION

- Abduction and adduction are traditionally defined as rotation of the humerus in the near **frontal plane** around an **anterior-posterior** axis.
- Normally, the healthy person has about 120 degrees of abduction at the GH joint.
- Full abduction of the shoulder complex requires a simultaneous approximate 60 degrees of upward rotation of the scapula.

- The arthrokinematics of abduction involve the convex head of the humerus **rolling superiorly** while simultaneously **sliding inferiorly**.
- The roll-and-slide arthrokinematics are essential to the completion of full-range abduction.

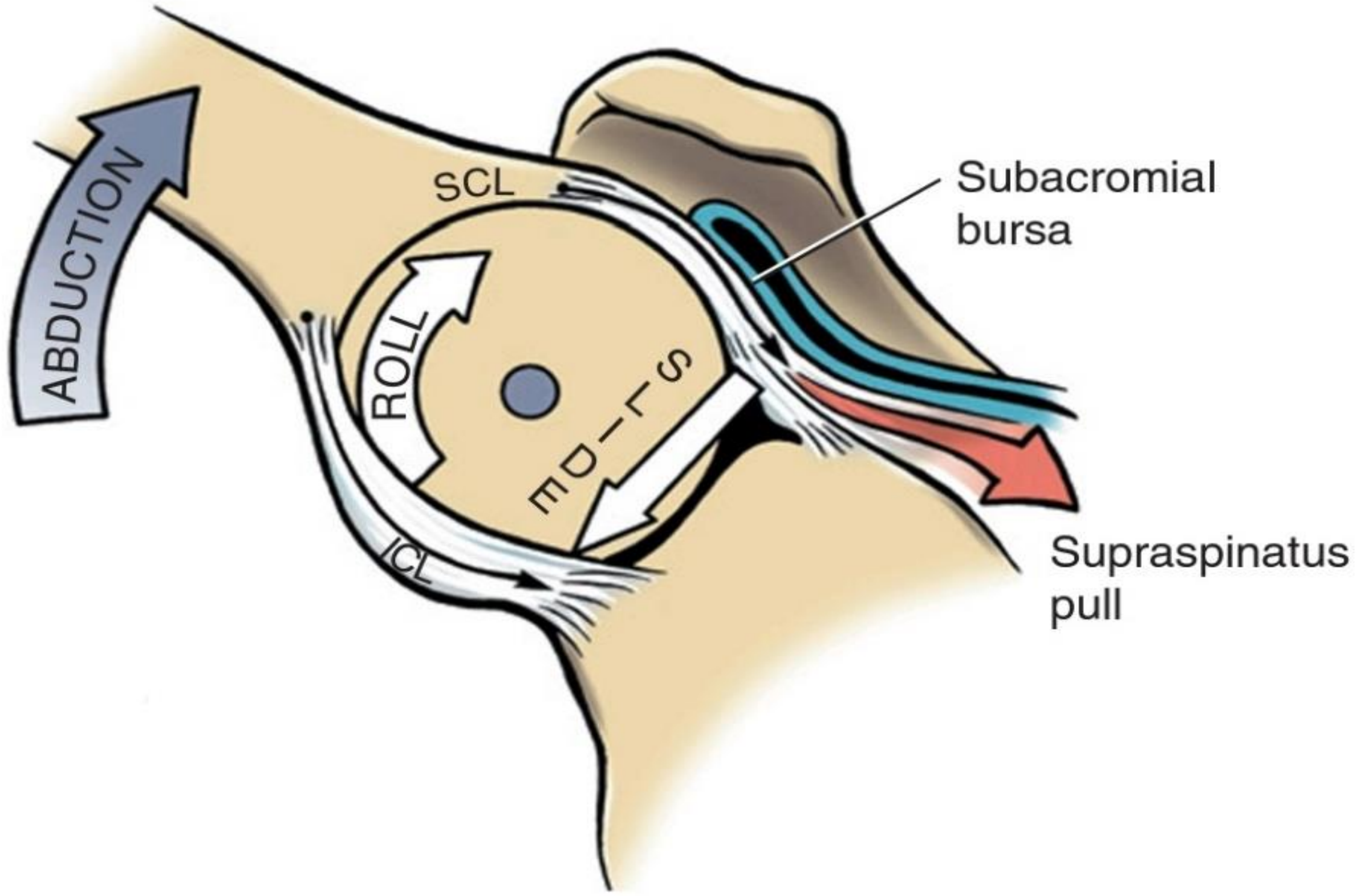


FIG. 5.31 The arthrokinematics of the right glenohumeral joint during active abduction. The supraspinatus is shown contracting to direct the superior roll of the humeral head. The taut inferior capsular ligament *(ICL)* is shown supporting the head of the humerus like a hammock (see text). Note that the superior capsular ligament *(SCL)* remains relatively taut because of the pull from the attached contracting supraspinatus. Stretched tissues are depicted as long black arrows.

Internal and External Rotation

- From the anatomic position, internal and external rotation at the GH joint is defined as an axial rotation of the humerus in the **horizontal plane**.
- This rotation occurs around a **vertical or longitudinal axis** that runs through the shaft of the humerus.
- During ER the humeral head simultaneously **rolls posteriorly** and **slides anteriorly** on the glenoid fossa.

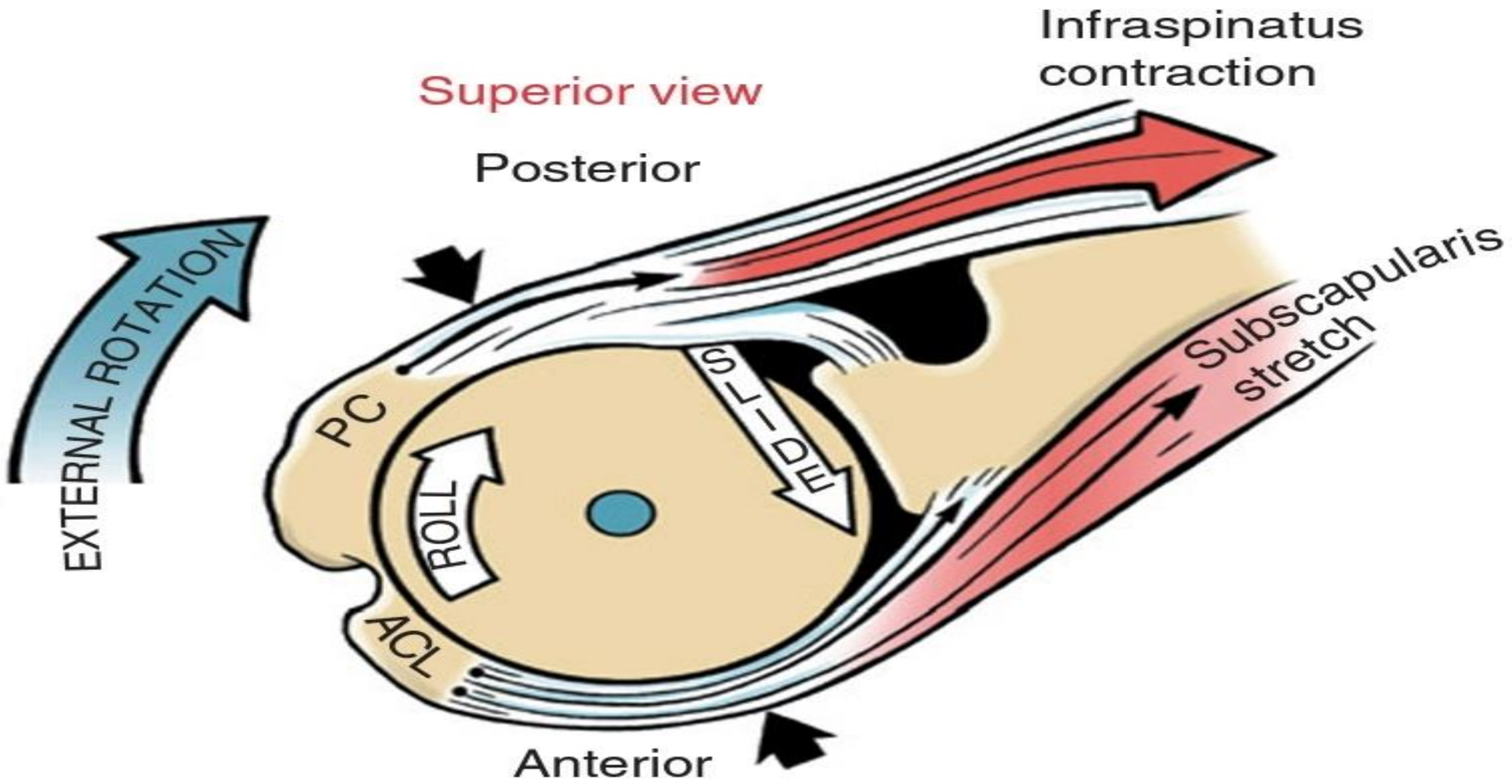


FIG. 5.35 Superior view of roll-and-slide arthrokinematics during active external rotation of the right glenohumeral joint. The infraspinatus is shown contracting *(dark red),* causing the posterior roll of the humerus. The subscapularis muscle and anterior capsular ligament *(ACL)* generate passive tension from being stretched. The posterior capsule *(PC)* is pulled relatively taut because of the pull of the contracting infraspinatus muscle. The two large bold black arrows represent forces that centralize and thereby stabilize the humeral head during external rotation. Stretched tissues are depicted as *thin, elongated arrows.*

- From an adducted position, about 75–85^0 of IR and 60–70^0 of ER are usually possible, but much variation can be expected.
- In a position of 90 degrees of abduction, the ER ROM usually increases to near 90 degrees.
- From the anatomic position, full IR and ER of the shoulder includes varying amounts of scapular protraction and retraction, respectively.

STATIC STABILIZATION OF THE GH JOINT IN THE DEPENDENT ARM

- Given the incongruence of the GH articular surfaces, bony geometry alone cannot maintain joint stability with the arm relaxed at the side, requiring the contribution of other mechanisms.
- With the humeral head resting on the fossa, **gravity** imparts a **caudally directed translatory force** on the humerus.

- To maintain equilibrium, a **cranially directed force** is needed and could be supplied by active contraction or passive tension of muscles such as the deltoid, supraspinatus, or the long heads of the biceps brachii and triceps brachii.
- All muscles of the shoulder complex are electrically silent in the relaxed, unloaded limb, even when the limb is tugged vigorously downward.

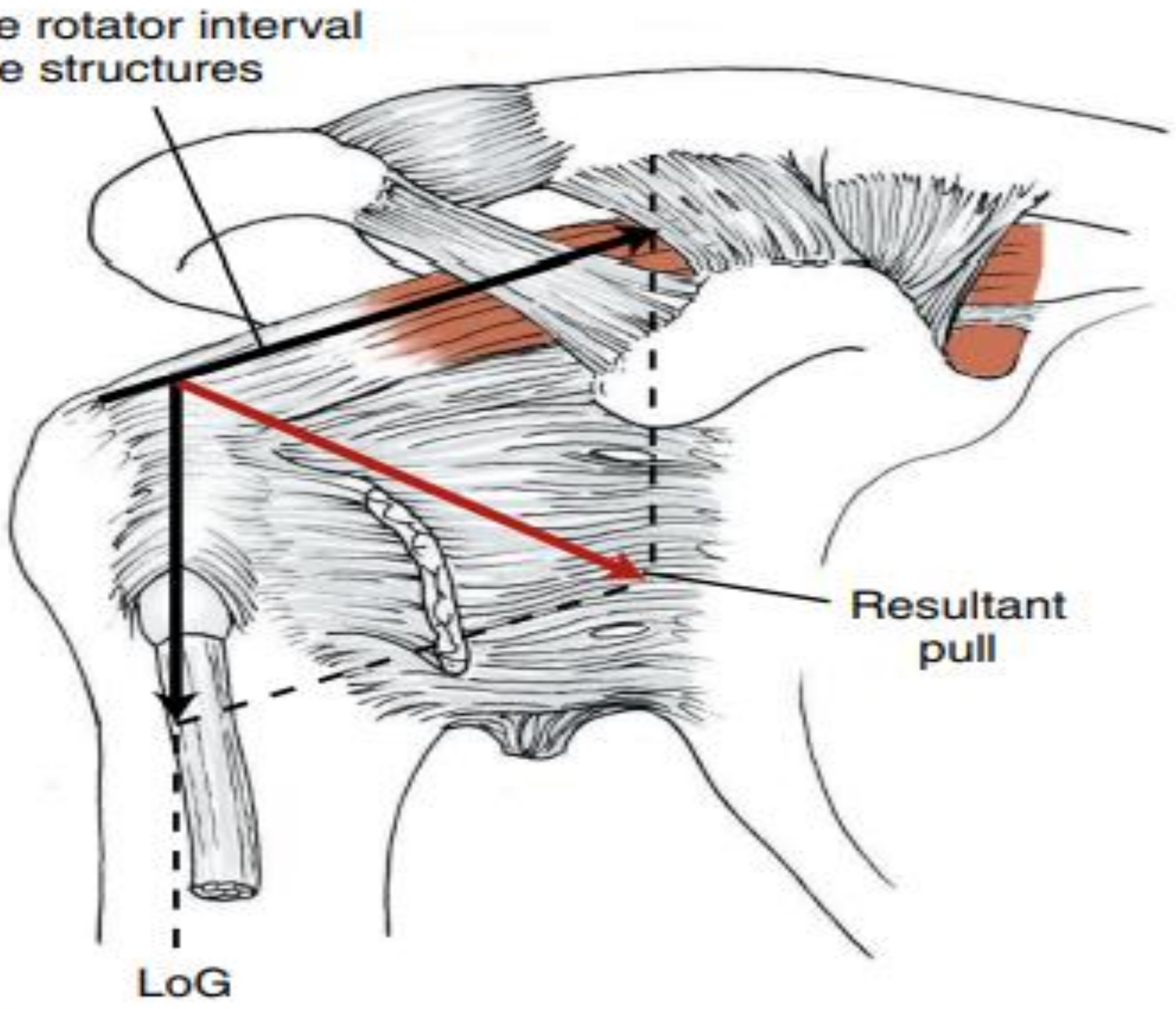


Figure 7–35 Mechanism for stabilization of the dependent arm. With the arm relaxed at the side, the downward pull of gravity on the arm (vector extended from the center of gravity of the upper extremity) is opposed by the passive tension in the rotator interval capsule. The resultant of these forces stabilizes the humeral head on the glenoid fossa.

- The mechanism of joint stabilization, therefore, appears to be passive, and the structures of the RIC (superior capsule, superior GH ligament, and CH ligament) that are taut when the arm is at the side possess both the magnitude and orientation for this function.
- The resultant vector formed from the gravity and RIC vectors creates a force that compresses the humeral head into the lower portion of the glenoid fossa and prevents inferior humeral head translation.

- In addition to **passive tension from the rotator interval capsule**, 2 other mechanisms help provide static stability to the GH joint with the arm at the side.
- In a healthy GH joint, the **capsule is airtight** and there is **negative intra-articular pressure.** This negative pressure creates a relative vacuum that resists the inferior humeral translation caused by the force of gravity.
- Loss of intra-articular pressure, produced by venting the capsule or tears in the glenoid labrum, results in large increases in inferior humeral translations.

- The **degree of glenoid inclination** also influences GH joint stability with the arm in the dependent position.
- **A slight upward tilt of the glenoid fossa**, either anatomically in the structure of the scapula or through scapular upward rotation, will produce a partial bony block against humeral inferior translation.
- When these passive forces are inadequate for GH joint stabilization, as may occur in the heavily loaded arm, the supraspinatus is recruited to provide active assistance.

- Without the reinforcing passive tension of the intact supraspinatus muscle, the sustained load on the structures of the RIC apparently causes these structures to gradually stretch (become plastic), which results in a loss of joint stability.

DYNAMIC STABILIZATION OF THE GH JOINT

1. THE DELTOID AND GLENOHUMERAL STABILIZATION

- It is generally accepted that the deltoid muscle is a prime mover (along with the supraspinatus) for GH abduction.
- The anterior deltoid is also considered the prime mover in GH flexion.
- Both abduction and flexion are elevation activities with many biomechanical similarities.

- The segment or segments of the deltoid that participate in elevation will vary with role and function.
- However, examination of the resultant line of action of the deltoid muscle in abduction can be used to highlight the stabilization needs of the GH joint in elevation activities.
- The force vectors of the 3 segments of the deltoid acting together coincide with the fibers of the middle deltoid.

- When the muscle force vector (FD) is resolved into its parallel (Fx) and perpendicular (Fy) components in relation to the long axis of the humerus, the parallel component directly cephalad (superiorly) is by far the larger of the 2 components.

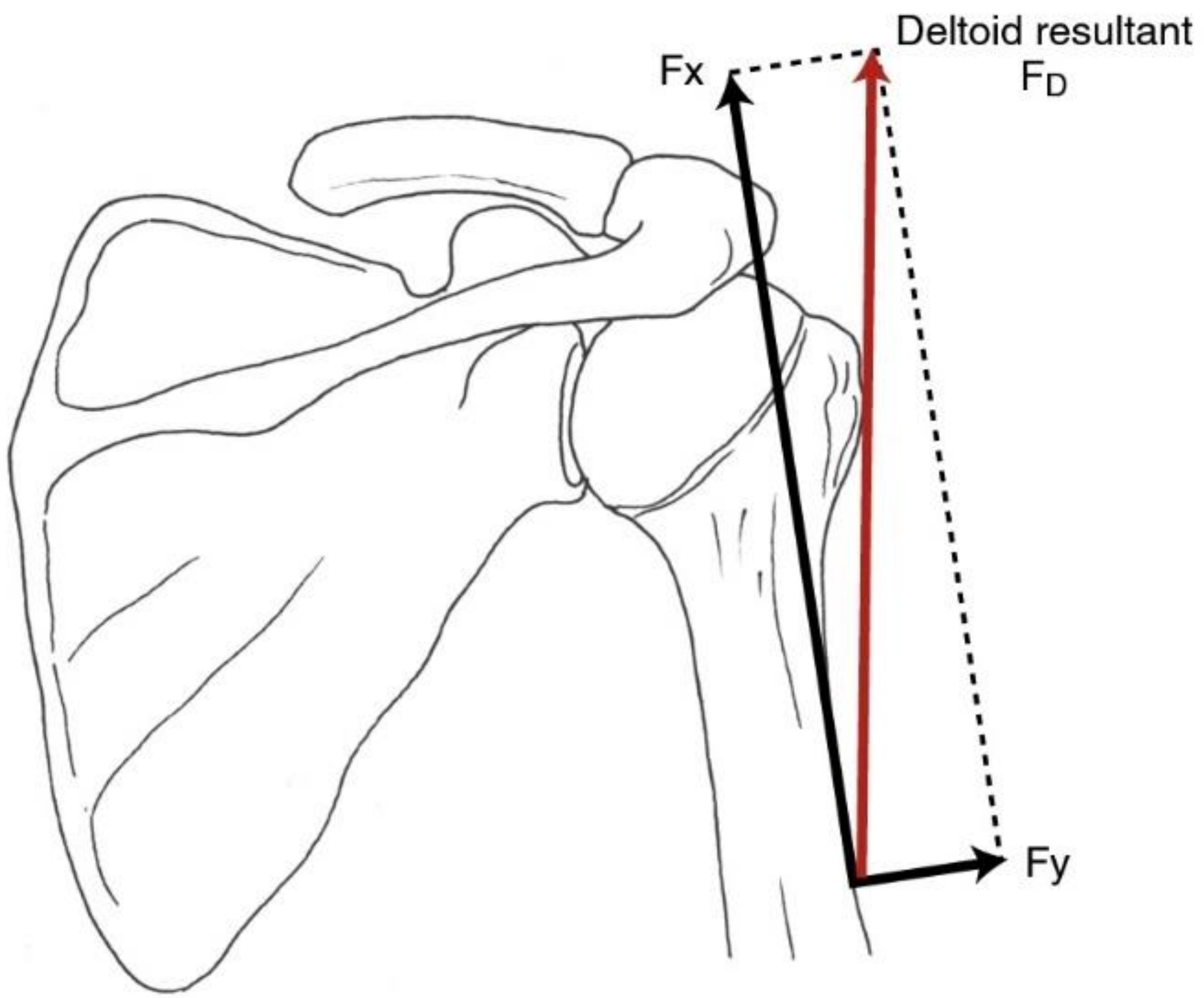


Figure 7–36 The action line of all three segments of the deltoid follows the line of pull of the middle deltoid. The resultant (F_D) resolves into a very large translatory component (Fx) and a small rotary component (Fy) so that an isolated contraction of the deltoid would cause the deltoid to produce more superior translation than rotation of the humerus.

- That is, the **majority of the force of contraction of the deltoid** from this initial position causes the humerus and humeral head to **translate superiorly**; only a small proportion of force is applied perpendicular to the humerus and directly contributes to rotation (abduction) of the humerus with a large moment arm.
- At many other joints, a force component parallel to the long bone has a stabilizing effect because the parallel component contributes to joint compression.

- However, when the arm is at the side, the glenoid fossa is not in line with the shaft of the humerus.
- Consequently, the **force (Fx)** applied parallel to the long axis of the bone in this position **creates a shear force** (approximately parallel to the contacting articular surfaces) rather than a stabilizing (compressive) effect.
- The large superiorly directed force of the deltoid, if unopposed, would cause the humeral head to impact the coracoacromial arch before much abduction had occurred.

- The rotary torque produced by the relatively small perpendicular component of the deltoid (Fy) will not be particularly effective until the translatory forces are in equilibrium.
- If the humeral head migrated upward into the coracoacromial arch, the inferiorly directed contact force of the arch would offset the Fx component of the deltoid, theoretically permitting rotation of the humeral head to continue.

2. THE ROTATOR CUFF AND GLENOHUMERAL STABILIZATION

- The supraspinatus, infraspinatus, teres minor, and subscapularis muscles and tendons compose the rotator cuff (**SITS muscles**).
- These muscles are considered to be part of a "cuff" because the inserting tendons of each muscle of the cuff blend with and reinforce the GH capsule.
- Also, all have lines of action that significantly contribute to the dynamic stabilization of the GH joint.

- The resultant force vectors of the 4 segments of the rotator cuff (the superiorly located supraspinatus, posteriorly located infraspinatus and teres minor, and the more anteriorly located subscapularis muscles).

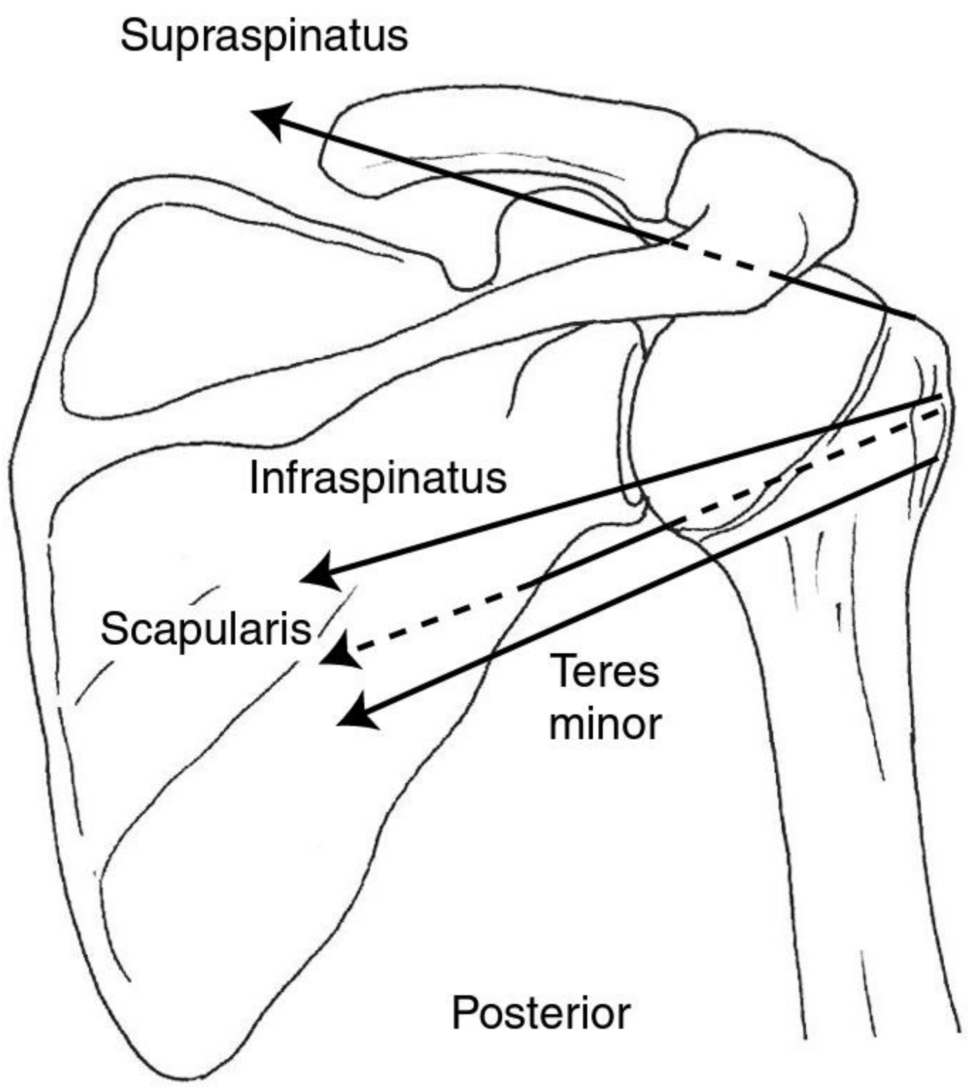


Figure 7–37 The action lines of the four segments of the rotator cuff: the supraspinatus, infraspinatus, teres minor, and subscapularis muscles.

- If any one (or all three) of the vector pulls of the infraspinatus, teres minor, or subscapularis muscles is resolved into its components, it can be seen that the perpendicular force component (Fy) not only tends to cause at least some rotation of the humerus, given its orientation to the long axis of the bone, but it also compresses the head into the glenoid fossa.
- Although the ITS muscles of the rotator cuff are important **GH joint compressors**, equally critical to the stabilizing function of these particular muscles is the inferior (caudal) translatory pull (Fx) of the muscles.

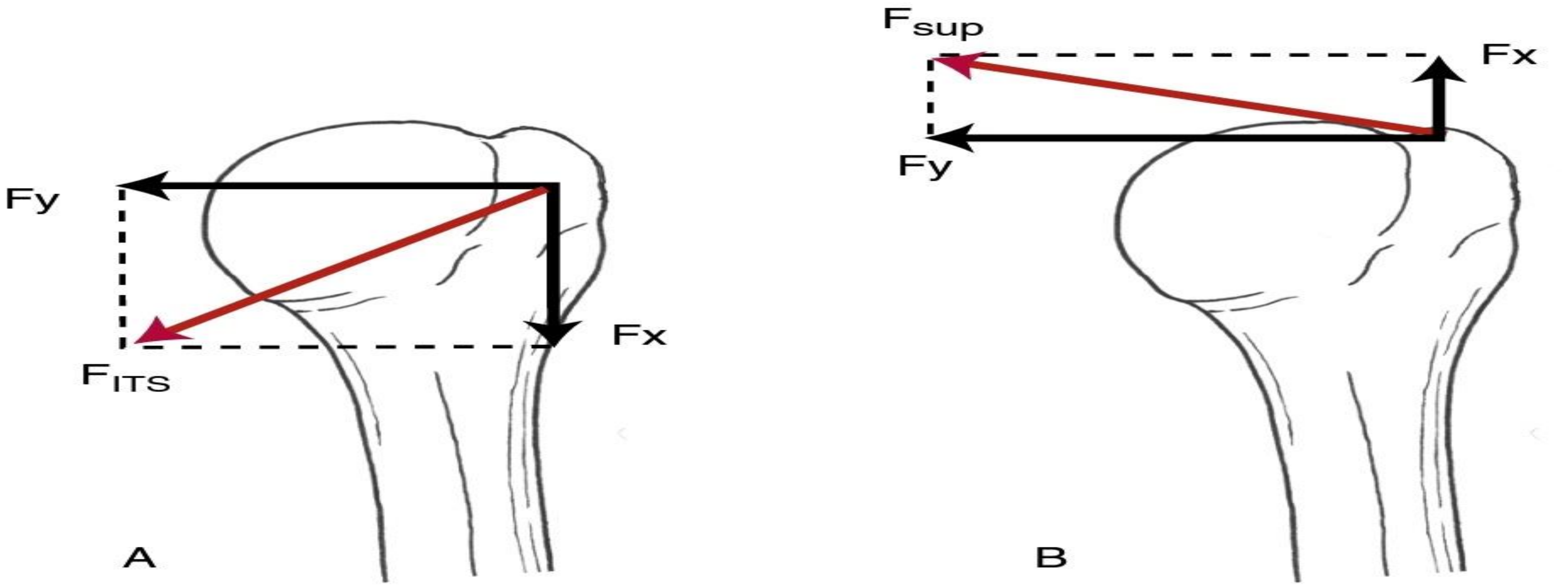


Figure 7–38 **A.** The infraspinatus, teres minor, and subscapularis muscles individually and together (ITS) have a similar line of pull. The perpendicular component (Fy) compresses as well as rotates, and the parallel component (Fx) helps offset the superior translatory pull of the deltoid. **B.** The supraspinatus (sup) has a superiorly directed parallel translatory component (Fx) and a perpendicular component (Fy) that is more compressive than that of the other rotator cuff muscles and can independently abduct the humerus.

- The sum of the 3 negative (inferior) translatory components of these 3 muscles of the rotator cuff nearly **offsets the superior translatory force of the deltoid muscle**.
- The teres minor and infraspinatus muscles, in addition to their stabilizing role, contribute to abduction of the arm by providing the lateral rotation that typically occurs with elevation of the humerus to help clear the greater tubercle from beneath the acromion.
- Infraspinatus and subscapularis muscles add to the **abduction torque**, whereas the teres minor muscle adds to the **lateral rotary torque**.

3.THE SUPRASPINATUS AND GH STABILIZATION

- Although the supraspinatus muscle is part of the rotator cuff, the line of action of the supraspinatus muscle, unlike the action lines of the other 3 rotator cuff muscles, has a **superior (cephalad) translatory component**, rather than the inferior (caudal) component found in the other muscles of the cuff.
- Given its line of pull, the supraspinatus is not able to offset the upward dislocating action of the deltoid.

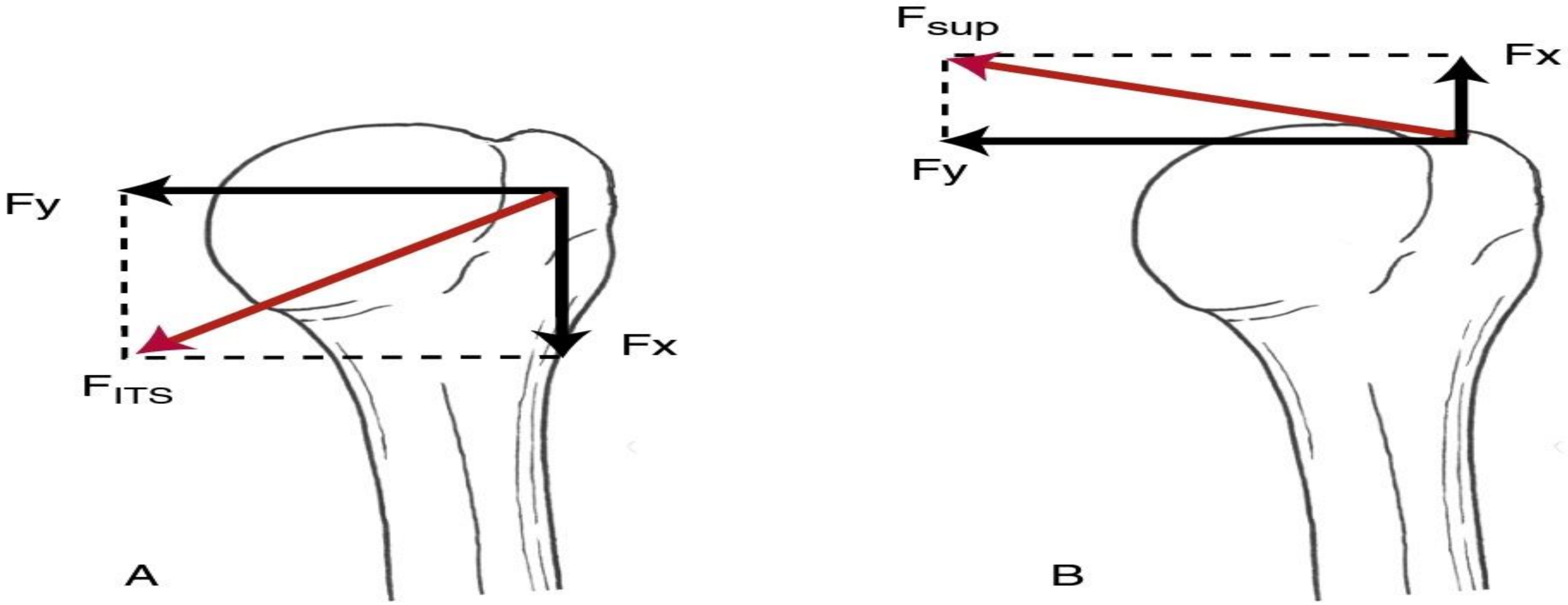


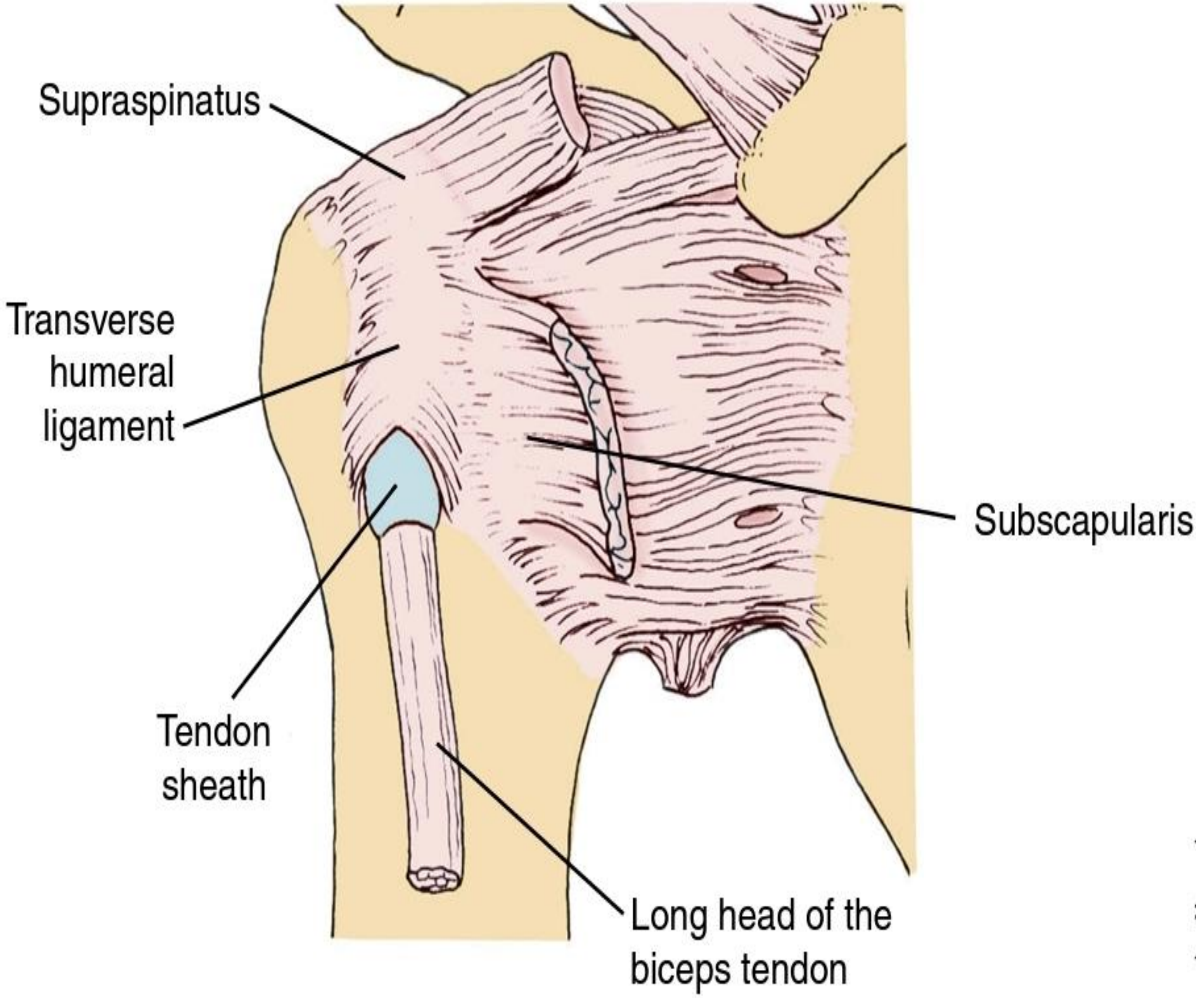
Figure 7–38 **A.** The infraspinatus, teres minor, and subscapularis muscles individually and together (ITS) have a similar line of pull. The perpendicular component (Fy) compresses as well as rotates, and the parallel component (Fx) helps offset the superior translatory pull of the deltoid. **B.** The supraspinatus (sup) has a superiorly directed parallel translatory component (Fx) and a perpendicular component (Fy) that is more compressive than that of the other rotator cuff muscles and can independently abduct the humerus.

- The supraspinatus is still an **effective stabilizer of the GH joint**, however because of the more superior location of the supraspinatus results in a line of action that lies farther from the GH joint axis than the action lines of the other rotator cuff muscles.
- The **larger supraspinatus MA** is capable of independently producing a full or nearly full range of GH joint abduction while simultaneously stabilizing the joint.
- Gravity acts as a stabilizing synergist to the supraspinatus by offsetting the small upward translatory pull of the muscle.

4. THE LONG HEAD OF THE BICEPS BRACHII AND GH STABILIZATION

- The long head of the biceps brachii runs superiorly from the anterior shaft of the humerus through the bicipital groove between the greater and lesser tubercles to attach to the supraglenoid tubercle and superior labrum.
- It enters the GH joint capsule through an opening between the supraspinatus and subscapularis muscles, where it penetrates the capsule but not the synovium.

- Within the bicipital groove, the biceps tendon is enveloped by a tendon sheath and tethered there by the **transverse humeral ligament** that runs between the greater and lesser tubercles.



- The long head of the biceps brachii, because of its position at the superior capsule and its connections to structures of the rotator interval capsule, is sometimes considered to be part of the reinforcing cuff of the GH joint.
- **The biceps muscle is capable of contributing to the force of flexion and can, if the humerus is laterally rotated, contribute to the force of abduction.**

COSTS OF DYNAMIC STABILIZATION OF THE GH JOINT

- When all stabilization forces and factors are intact and properly functioning, the head of the humerus rotates into flexion or abduction around a relatively stable axis with minimal translation.
- Over time, however, even normal stresses resulting from the complex dynamic stabilization process may lead to **degenerative changes or dysfunction at the GH joint.**

- The supraspinatus muscle is a particularly key structure in dynamic stabilization.
- The supraspinatus is either passively stretched or actively contracting when the arm is at the side (depending on load); it also participates in humeral elevation throughout the ROM.
- Consequently, the tendon is under tension most of a person's waking hours and is vulnerable to **tensile overload** and **chronic overuse**.

- **<u>Mechanical compression and impingement</u>** of the stressed supraspinatus tendon may occur on either the superior or inferior surface when the subacromial space is reduced by osteoligamentous factors.
- The **supraspinatus tendon** is the **most vulnerable** of the cuff muscles.
- **Symptomatic and asymptomatic partial or full thickness rotator cuff tears** are seen in many people over the age of 70.
- **<u>Rotator cuff tendonopathy or tears</u>** typically produce pain between 60° and 120° of humeral elevation in relation to the trunk. (Painful arc).

- **Degenerative changes in the AC joint** may result in pain in the same area of the shoulder as pain from supraspinatus or rotator cuff lesions.
- Pain due to AC degeneration is more typically found when the arm is raised beyond the painful arc or when the arm is adducted across the body, compressing the AC joint surfaces.
- The **long head of the biceps brachii** similarly can produce pain in the antero-superior shoulder.

- Because the long head of the biceps tendon also passes directly beneath the impinging structures of the coracoacromial arch, it is subject to some of the same degenerative changes and the same trauma seen in the tendons of the rotator cuff.
- If the **bicipital tendon sheath is worn or inflamed**, or if the tendon is **hypertrophied**, the gliding mechanism may be interrupted and pain produced.

- **A tear in the transverse humeral ligament** may result in the tendon of the long head popping in and out of the bicipital groove with rotation of the humerus, a potentially wearing and painful micro trauma.
- **Mechanical deviations in GH stabilization** factors may result in injury to other structures of the joint besides the rotator cuff (e.g., the **glenoid labrum**) and to **subluxation of the GH joint**.
- **Dislocation of the GH joint** can also occur; in fact, it is the most frequently dislocated of all the joints in the body.

INTEGRATED FUNCTION OF THE SHOULDER COMPLEX

- The shoulder complex acts in a coordinated manner to provide the smoothest and greatest ROM possible to the upper limb.
- <u>Motion available to the GH joint alone would not account for the full range of elevation (abduction or flexion) available to the humerus.</u>
- <u>The remainder of the range is contributed by the scapula on the thorax through the SC and AC joints</u>.

Combined scapulohumeral motion

(1) Distributes the motion between the joints, permitting a large ROM with less compromise of stability.

(2) Maintains the Glenoid fossa in an optimal position in relation to the head of the humerus, increasing joint congruency while decreasing shear forces.

(3)Permits muscles acting on the humerus to maintain a good length-tension relationship while minimizing or preventing active insufficiency of the GH muscles.

ST AND GH CONTRIBUTIONS

- The scapula on the thorax contributes to elevation (flexion and abduction) of the humerus by **upwardly rotating the glenoid fossa 50° to 60° from its resting position.**
- If the humerus were immobile at the GH joint, the scapula alone would theoretically result in up to 60° of elevation of the humerus relative to the thorax.
- The humerus, of course, is not immobile but can move independently on the glenoid fossa.

- The GH joint contributes 100° to 120° of flexion and 90° to 120° of abduction.
- The combination of scapular and humeral movement results in a maximum range of elevation of 150° to 180°.
- An overall ratio of 2° of GH to 1° of ST motion during arm elevation is commonly described, and this combination of concomitant GH and ST motion is most commonly referred to as **Scapulohumeral rhythm.**

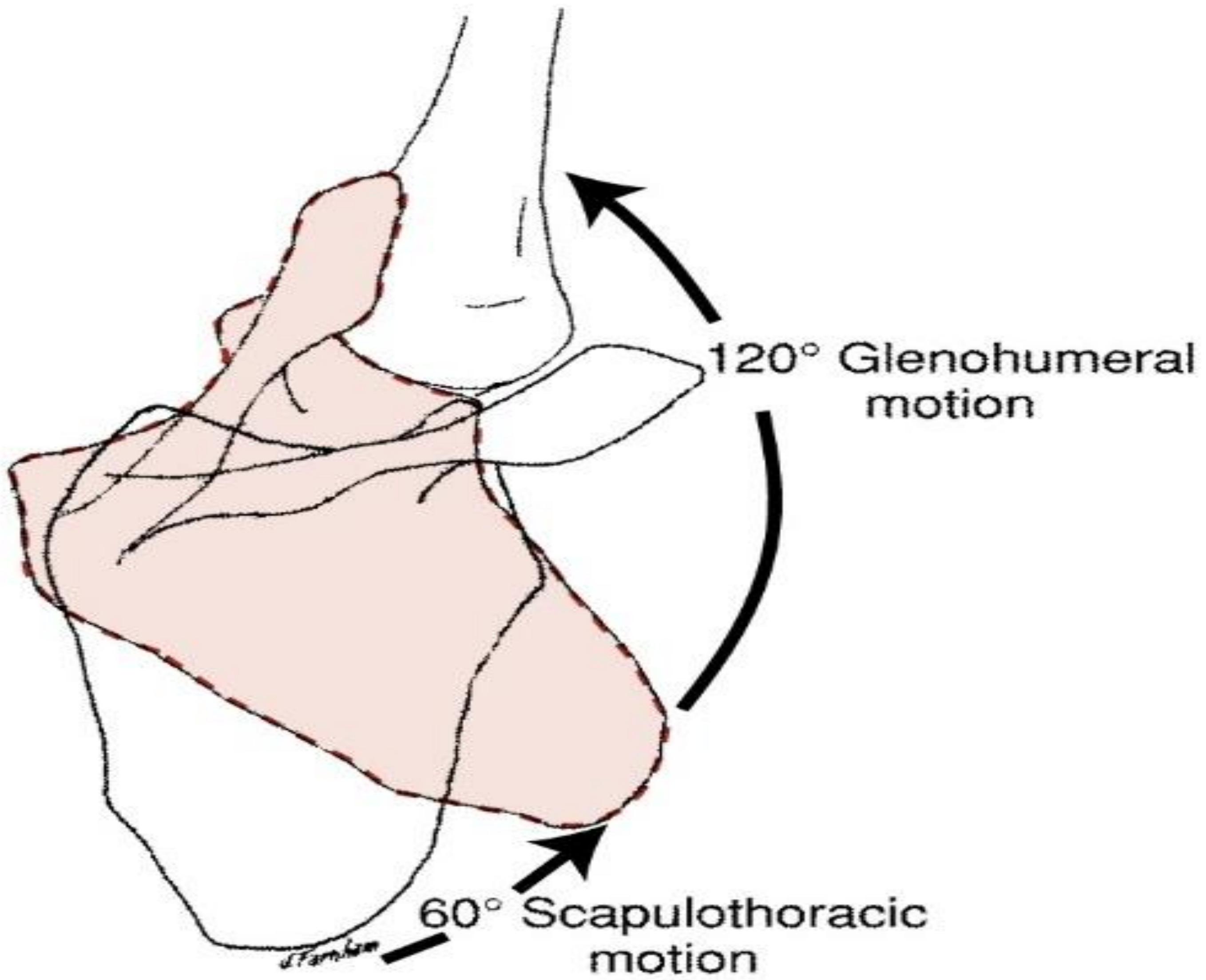


Figure 7–40 When the total range of elevation is considered to be 180º, it is common to attribute 120° of the ROM to the humerus at the glenohumeral joint and 60° to the scapula on the thorax—with the two segments moving concomitantly rather than sequentially.

- According to the 2-to-1 ratio framework, flexion or abduction of 90° in relation to the thorax would be accomplished through approximately 60° of GH and 30° of ST motion.
- It must also be recognized, however, that elevation of the arm is accompanied not only by elevation of the humerus but also by lateral rotation of the humerus in relation to the scapula.
- During flexion, an average of **51° of lateral rotation** has been reported.

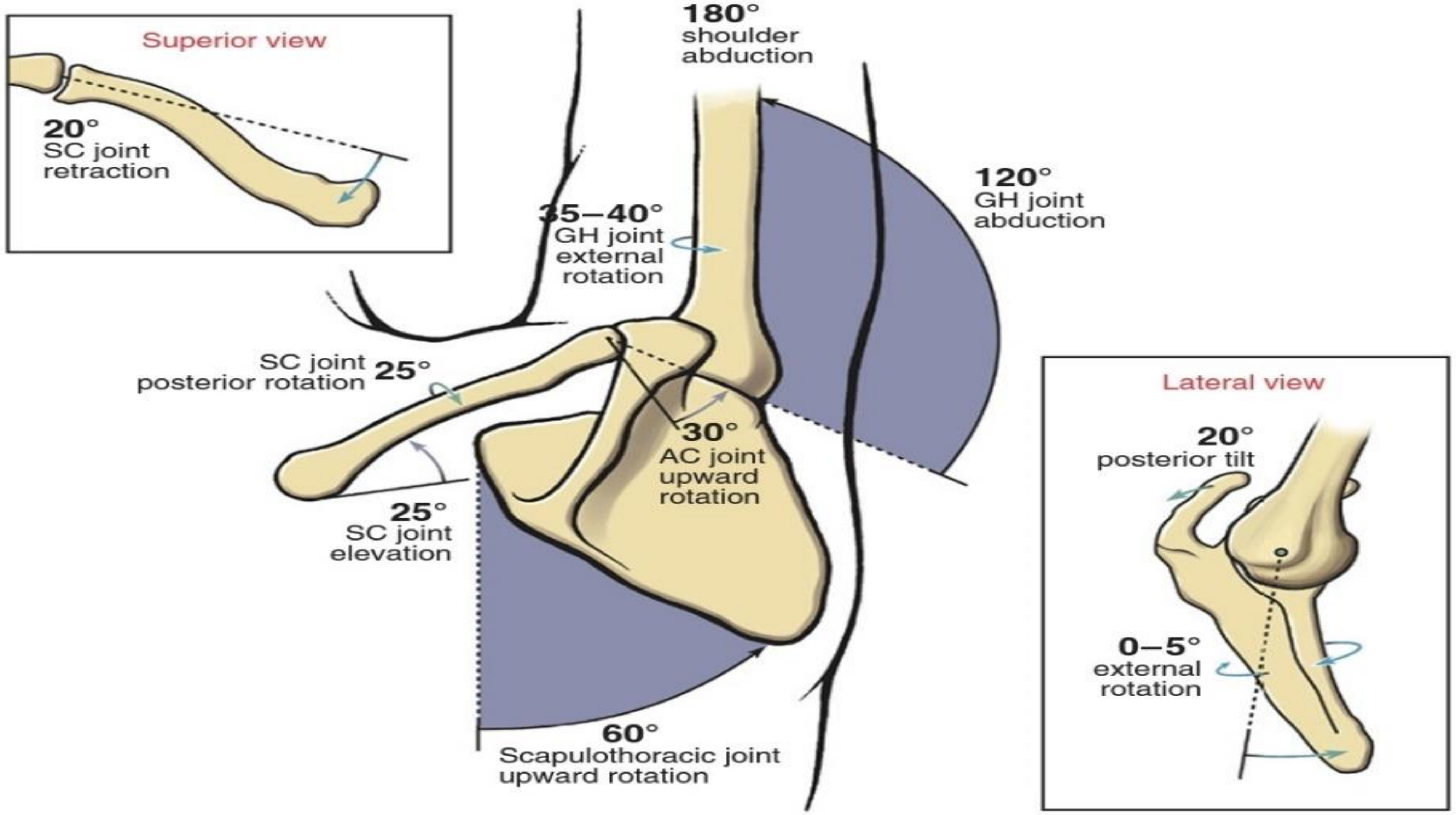


FIG. 5.36 Posterior view of the right shoulder complex after the arm has abducted 180 degrees. The 60 degrees of scapulothoracic joint upward rotation and the 120 degrees of glenohumeral *(GH)* joint abduction are shaded in purple. Additional inserts contained in the boxes depict superior and lateral views of selected kinematics of the clavicle and scapula, respectively. All numeric values are chosen from a wide range of estimates cited across multiple literature sources (see text). Actual kinematic values vary considerably among persons and studies.

- The scapula contributes to elevation of the arm not only by upwardly rotating on the thorax but also through other ST motions.
- As the arm is elevated into flexion, scapular plane abduction, or frontal plane abduction, the **scapula posteriorly tilts** on the thorax.
- As the arm moves from the side to 150° of elevation, the magnitude of this motion is about 20° to 30°
- This posterior tilting allows the inferior angle of the scapula to move anteriorly and stay in contact with the thorax as it rotates upward and around the rib cage.

- Posterior tilting of the scapula also has the effect of bringing the **anterior acromion up and back.**
- This may serve to minimize reduction in the subacromial space as the humerus elevates.
- During elevation, the scapula is more variable in its internal/external rotation both within and between subjects.
- In general, at the **end ranges of elevation** the **scapula is ER** on the thorax.

- However, **early in the ROM for flexion**, **<u>slight IR of the scapula</u>** on thorax occurs.
- In flexion, the **<u>scapula initially protracts and internally rotates</u>** to orient the glenoid fossa anteriorly (in the sagittal plane).

SC AND AC CONTRIBUTIONS

- Elevation of the arm in any plane involves motion of the SC and AC joints to produce ST motion.
- The initiation of ST upward rotation as the arm is flexed or abducted appears to couple with **clavicular posterior rotation** and **elevation at the SC joint**.
- This scapular upward rotation occurs around an oblique A-P axis, passing through the costoclavicular ligament (SC joint motion) and projecting backward through the root of the scapular spine (ST motion).

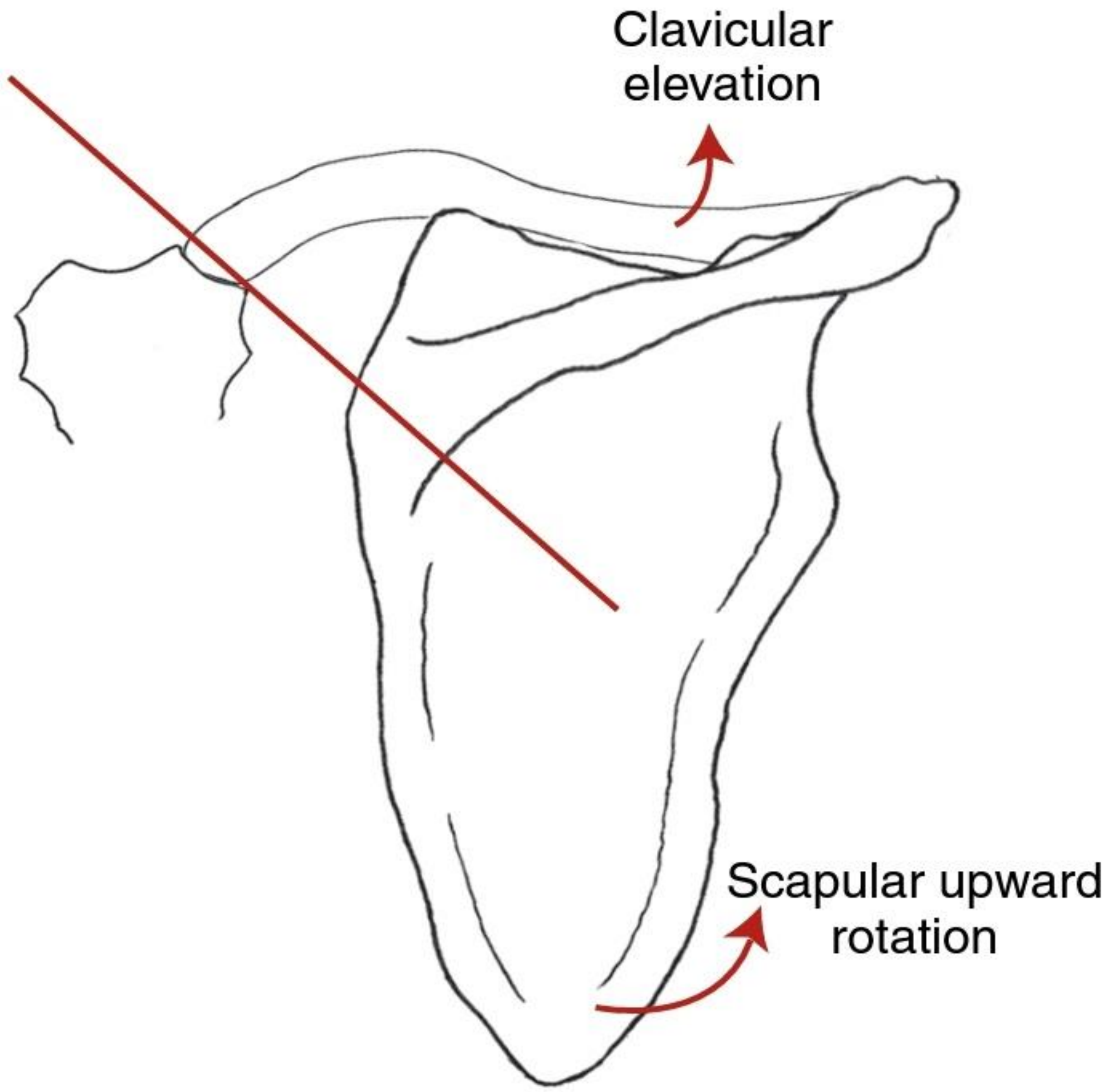


Figure 7–42 With elevation of the arm, the scapulothoracic upward rotation contribution begins as posterior rotation and elevation at the sternoclavicular joint around an axis that appears to pass posteriorly from the costoclavicular ligament to the root of the spine of the scapula.

- As elevation of the arm progresses, the ST axis of rotation gradually shifts laterally, reaching the AC joint in the final range of scapular upward rotation.
- This major shift in the axis of rotation happens because the ST motion can occur only through a combination of motions at the SC and AC joints.
- When the axis of scapular upward rotation is near the root of the scapular spine, ST motion is primarily a function of SC joint motion.

- When the axis of scapular upward rotation is at the AC joint, AC joint motions predominate; and when the axis of scapular upward rotation is in an intermediate position, both the SC and AC joints are contributing to ST motion.

MUSCLES OF ELEVATION

- Elevation and depression have been described as the 2 primary patterns of shoulder complex function.
- Elevation activities are those that require muscles to overcome or control the weight of the limb and its load.
- **The completion of normal elevation depends on not only the freedom of movement and integrity of the SC, AC, and GH joints, but also the appropriate strength and function of the muscles producing and controlling movement**.

DELTOID MUSCLE FUNCTION

- The deltoid is at resting length (optimal length-tension) when the arm is at the side.
- When at resting length, the deltoid's angle of pull results in a predominance of superior translatory pull on the humerus with an active contraction.
- With an appropriate synergistic inferior pull from the infraspinatus, teres minor, and subscapularis muscles, the rotary component of the deltoid muscle is an effective primary mover for elevation.

- While the anterior deltoid is the prime mover for flexion, it can assist with abduction after 15° of GH motion.
- During abduction in the plane of the scapula, the anterior and middle deltoid segments are optimally aligned to produce elevation of the humerus.
- The line of action of the **posterior deltoid has too small a moment arm** (and too small a rotary component) to contribute effectively to frontal plane abduction; it **serves primarily as a joint compressor and in functions such as horizontal abduction and extension.**

- Maintenance of an appropriate length-tension relationship of the deltoid is strongly dependent on simultaneous scapular movement or scapular stabilization.
- When the scapula is restricted and cannot upwardly rotate, the loss of tension in the deltoid with increased shortening has been reported to result in reduced glenohumeral abduction.

SUPRASPINATUS MUSCLE FUNCTION

- The supraspinatus muscle is considered an **abductor of the humerus**.
- Like the deltoid muscle, **it functions in all planes of elevation of the humerus.**
- The pattern of activity of the supraspinatus is essentially the same as that found in the deltoid.
- **The moment arm of the supraspinatus is fairly constant throughout the ROM and is larger than that of the deltoid for the first 60° of shoulder abduction.**

- When the deltoid is paralyzed, the supraspinatus alone can bring the arm through most, if not all, of the GH range, but the motion will be weaker.
- With a suprascapular nerve block paralyzing the supraspinatus and the infraspinatus, the strength of elevation in the plane of the scapula is reduced by 35% at 0° and by 60% to 80% at 150°.
- The secondary functions of the supraspinatus are **to compress the glenohumeral joint, to act as a "steerer" for the humeral head,** and to **assist in maintaining the stability of the dependent arm.**

- With isolated and complete paralysis of the supraspinatus muscle, or an isolated supraspinatus tear, **some loss of abduction force is evident, but most of its functions can be performed by remaining musculature.**
- Most commonly, tears of the rotator cuff muscles do not remain isolated to the supraspinatus but extend to the infraspinatus or subscapularis, producing a more extensive deficit than is seen with paralysis of the supraspinatus alone.

INFRASPINATUS, TERES MINOR, AND SUBSCAPULARIS MUSCLE FUNCTION

- The combined actions of the infraspinatus, teres minor, and subscapularis muscles, EMG activity indicated a nearly linear rise in action potentials from 0° to 115° elevation.
- Activity dropped slightly between 115° and 180°.
- Total activity in flexion was slightly greater than that in abduction.
- In abduction, an early peak in the activity of these muscles appeared at 70° of elevation.

UPPER AND LOWER TRAPEZIUS AND SERRATUS ANTERIOR MUSCLE FUNCTION

- The upper trapezius, along with the levator scapula muscle, **supports the shoulder girdle against the downward pull of gravity.**
- **The trapezius and lower serratus anterior muscles work synergistically to produce upward rotation of the scapula on the thorax**.
- The **middle trapezius** muscle is also **active during elevation** (especially abduction) and may **contribute to upward rotation of the scapula early in the ROM**.

- In active abduction of the arm, the force of the trapezius seems more critical to ST motion than in active flexion.
- **When the trapezius is intact and the serratus anterior muscle is paralyzed, full active abduction of the arm can occur, although it is weakened, where as flexion is more difficult.**
- With EMG analysis, the trapezius has been found to be more active in abduction than in flexion.

- **Without the trapezius (with or without the serratus anterior muscle), the scapula rests in a downwardly rotated position as a result of the unopposed effect of gravity on the scapula.**

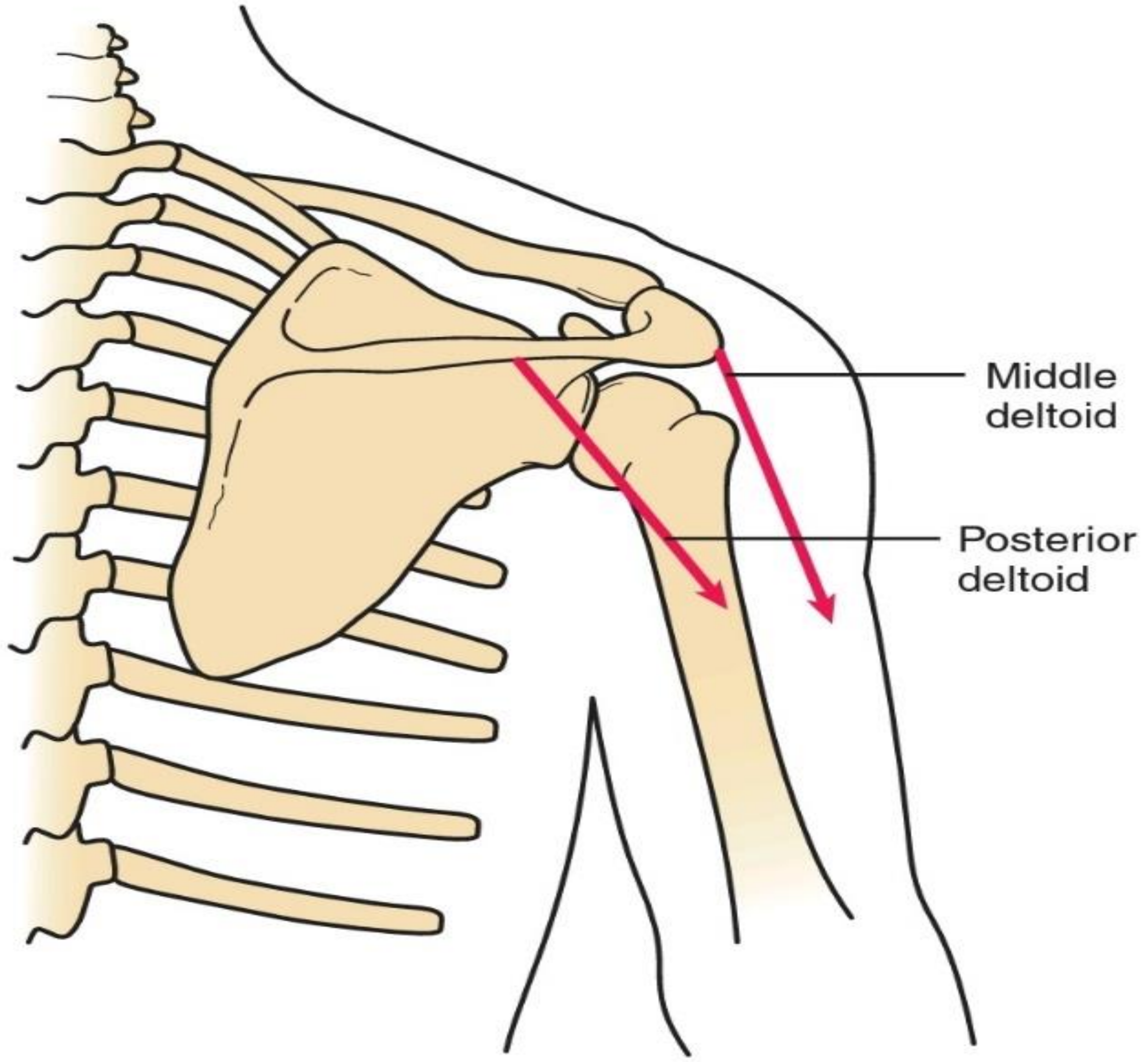


Figure 7–45 Without the trapezius, the scapula rests in a downwardly rotated position as a result of the unopposed effect of gravity on the scapula. When abduction of the arm is attempted, the middle and posterior fibers of the activated deltoid—unopposed by the trapezius—will act on the lighter scapula to increase the downward rotary pull on the scapula.

- If the serratus anterior muscle is intact, trapezius muscle paralysis results in a loss of force of shoulder flexion but a fairly normal range of flexion.
- **If the serratus anterior muscle is paralyzed (even in the presence of a functioning trapezius), flexion will be both diminished in strength and limited in range.**

- **The role of the serratus anterior muscle in normal shoulder function appears to be essential in many aspects.**
- This includes it being the **only muscle capable of producing simultaneous scapular upward rotation, posterior tilting, and external rotation**.
- Thus, the role of the scapular forces of the **trapezius and the serratus anterior muscles** is both **agonistic to scapular movement and synergistic with GH movement**.

RHOMBOID MUSCLE FUNCTION

- The Rhomboid major and minor muscles are active in elevation of the arm, especially in abduction.
- These muscles serve a critical function as stabilizing synergists to the muscles that upwardly rotate the scapula.
- If the rhomboids, downward rotators of the scapula, are active during upward rotation of the scapula, these muscles must be working eccentrically to control the change in position of the scapula produced by the trapezius and the serratus anterior muscles.

MUSCLES OF DEPRESSION

- Depression is the second of the two primary patterns of shoulder complex function.
- Depression involves the forceful downward movement of the arm in relation to the trunk.
- **In depression activities, the scapula tends to rotate downward and adduct during the humeral motion**.

LATISSIMUS DORSI AND PECTORAL MUSCLE FUNCTION

- When UE upper extremity motion is unrestricted, the latissimus dorsi muscle may produce **adduction, extension, or medial rotation of the humerus**.
- Through its attachment to both the scapula and humerus, the latissimus dorsi can also **adduct and depress the scapula and shoulder complex**.
- The latissimus dorsi also contributes to GH joint stability by **compressing the joint when the arm is abducting**.

- When the upper extremity is weight-bearing or restricted, the latissimus dorsi muscle will pull the pelvis upward toward the scapula and humerus.
- When the hands are bearing weight on the handles of a pair of crutches, a contraction of the latissimus dorsi will unweight (lift) the feet as the trunk rises beneath the fixed scapula, allowing the legs to swing forward through the crutches.

- The action of the pectoralis major parallels that of the latissimus dorsi muscle (adduction, extension, or medial rotation of the humerus), with the pectoralis major located anterior to the GH joint rather than posterior.
- **Pectoralis major activity during arm elevation increases GH joint stability by contributing to higher joint reaction forces, but it also increases the magnitude of anterior humeral head translation**.

TERES MAJOR AND RHOMBOID MUSCLE FUNCTION

- The **teres major muscle**, like the latissimus dorsi, **adducts, medially rotates, and extends the humerus**.
- The teres major muscle is **active primarily during resisted activities** but may also be **active during unresisted extension and adduction activities behind the back**.
- The function of the teres major muscle is strongly dependent on the activity of the rhomboid muscles.

- **The rhomboid muscles, as downward rotators of the scapula, offset the undesired upward rotary torque of the teres major muscle.**
- By fixing the scapula as the teres major muscle contracts, the rhomboids allow the teres major muscle to move the heavier humerus.

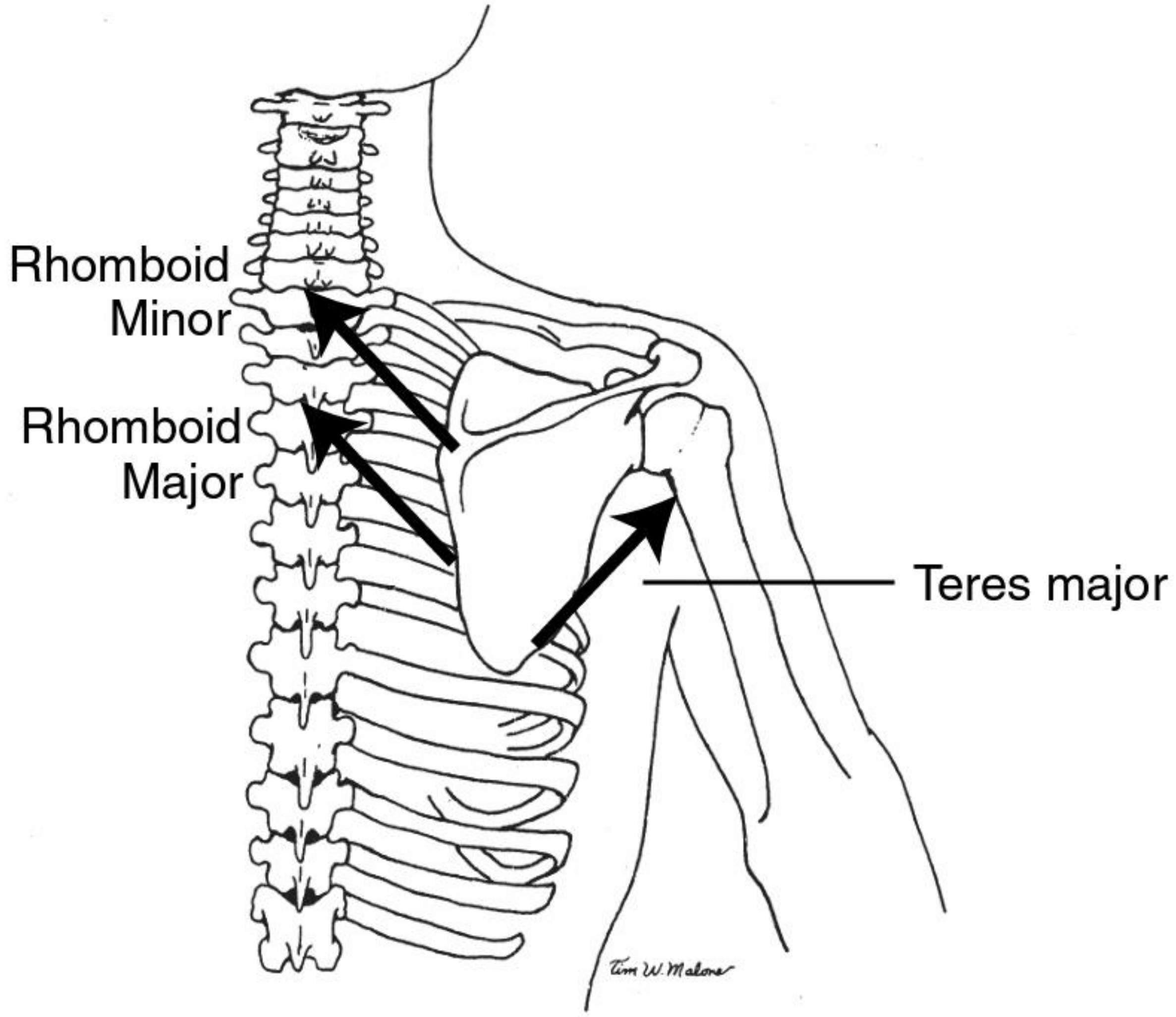


Figure 7–46 In order for the teres major muscle to extend the heavier humerus rather than upwardly rotate the lighter scapula, the synergy of the rhomboid muscles is necessary to stabilize the scapula.