Anatomy of the Upper Limb: Shoulder Joint and Subacromial Joint Space

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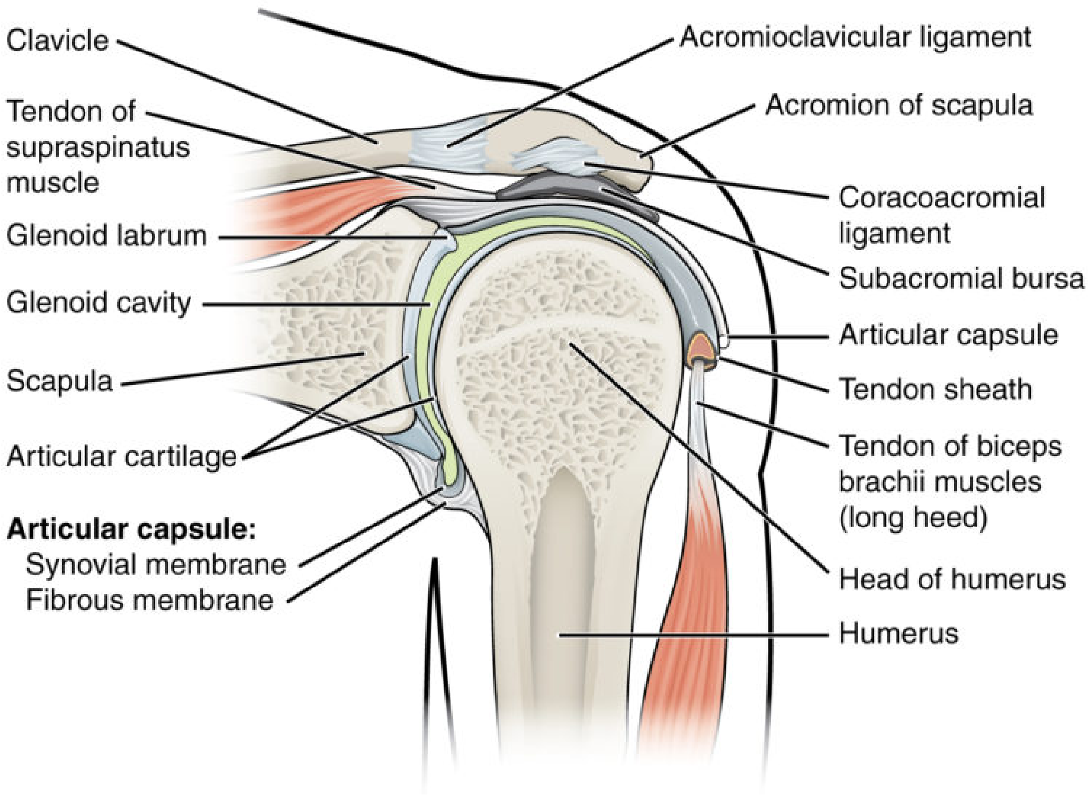
The shoulder joint is one of the most mobile joints in the human body and is extremely susceptible to injury, among other reasons, due to its high mobility. Physicians, not only surgeons or orthopedists, should, therefore, be familiar with its anatomy and functional anatomy. This article provides an overview of the osseous and articular structures of the shoulder joint and the subacromial joint space.



Surface Anatomy of the Shoulder Joint

The **articulatio humeroscapularis** (shoulder joint) is one of the ball joints. The proximal joint partner is the **scapula** which has a concave articulation surface due to its **glenoid cavity**. On the other hand, the **humeral head** of the humerus (distal joint partner) is convex. With regard to the respective joint surface size, there is a clear mismatch of 3:1 to up to 4:1 between the humeral head and the glenoid. As a result of a lack of bone structure, the stability of the joint is significantly reduced.

The lack of stability is compensated by a large complex system of muscles and ligaments, which functionally turn the shoulder joint into a so-called force-locking joint. The shoulder joint is able to perform movements through all axes: flexion/extension, abduction/adduction, and internal/external rotation.

Osteology of Upper Limb: Humerus, Clavicle, and Scapula

Osseous structures and articular surfaces of the humerus

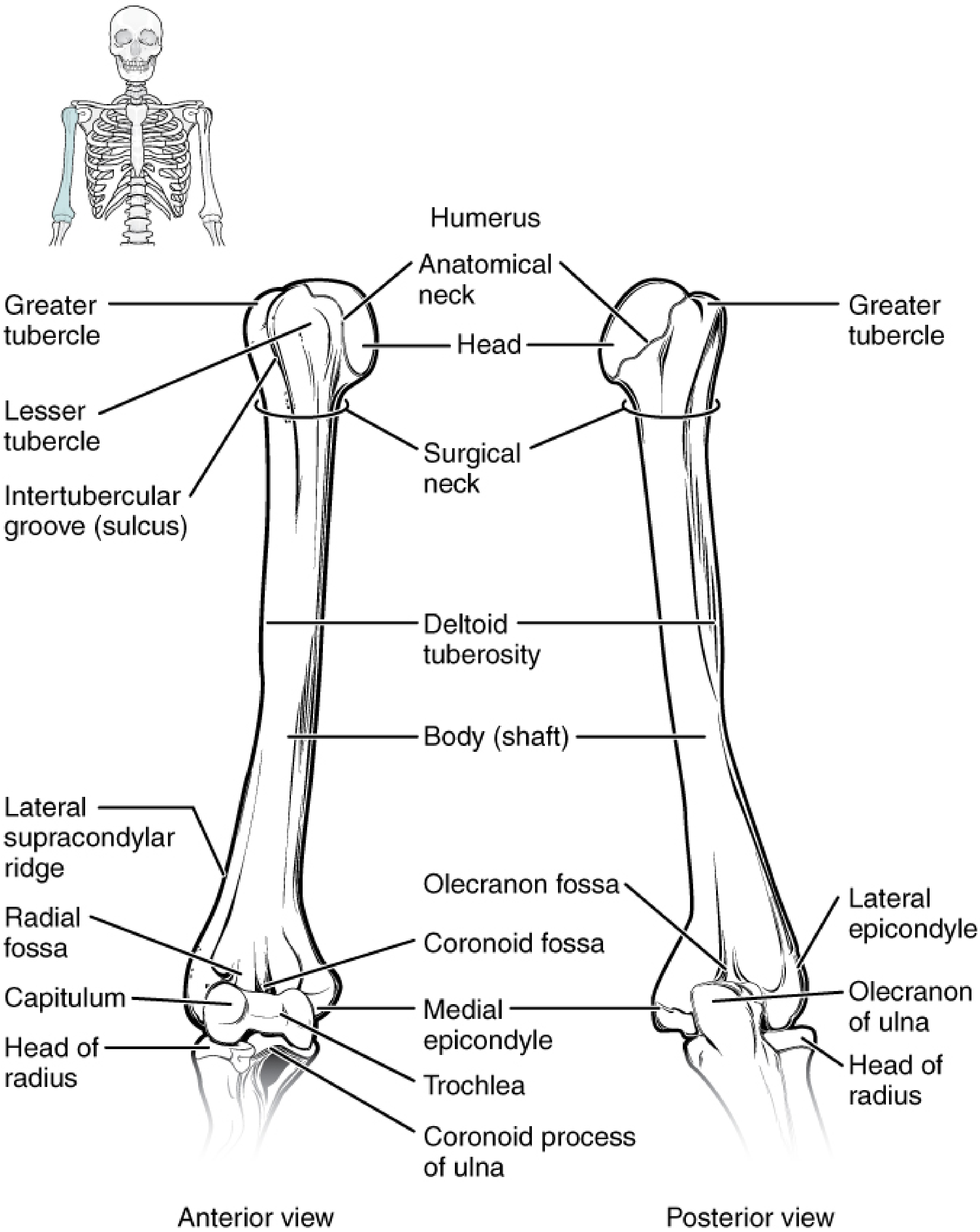


Image: "Humerus and elbow joint" by Phil Schatz. License: CC BY 4.0

The proximal humerus is divided into three sections. These are, from proximal to distal, the **caput**, **collum**, and **corpus humeri**.

Caput humeri

The convex humeral head has a radius of about 2.5 centimeters. The articular surface, which is covered with cartilage, is thickest in the center and becomes thinner towards the exterior.

Anatomical neck

The annular **anatomical neck** separates the head of the humerus from the diaphysis.

Tuberosities

Two osseous protuberances are located laterally of the anatomical neck. In the cranial location is the **tuberculum major** which is aligned from cranial to caudal-dorsal. Ventrally located is the **tuberculum minus**. Both structures are starting points for the muscular system. The tubercles run longitudinally and parallel to the **bicipital groove** in the **crista tuberculi majoris et minoris** which in turn also forms muscle attachments. The bicipital groove separates the two tubercles from each other structurally. The long biceps tendon runs through them.

Corpus humeri

Distal from the tuberosity is the **corpus humeri**. The **surgical neck** makes up the proximal portion which is located distal to the tuberosity. The surgical neck gets its name from the fact that humerus fractures often occur at this position, and surgeons then use the line to differ between the **humeral neck fracture (proximal)** and the **humeral shaft fracture (distal)**.

Important information about the humerus: Angle of inclination and retroversion

The collum axis passes through the center of the anatomical neck and the head of the humerus. In relation to the shaft axis, this results in an inclination angle of about **45 degrees** towards caudal.

The retroversion (**retro torsion**) describes the rotation of the proximal towards the distal end of the humerus, which can be seen in the diaphyseal area. In this case, the collum axis represents the proximal axis, whereas the distal axis runs through both **epicondyles**. In the transverse plane, both make up an angle of between 20 and 30 degrees. Neonatally, this angle is at 60 degrees. The goal of this torsion is to optimize the forearm’s position in order to ensure optimal functions of the hand.

Osseous structures and articular surfaces of the scapula

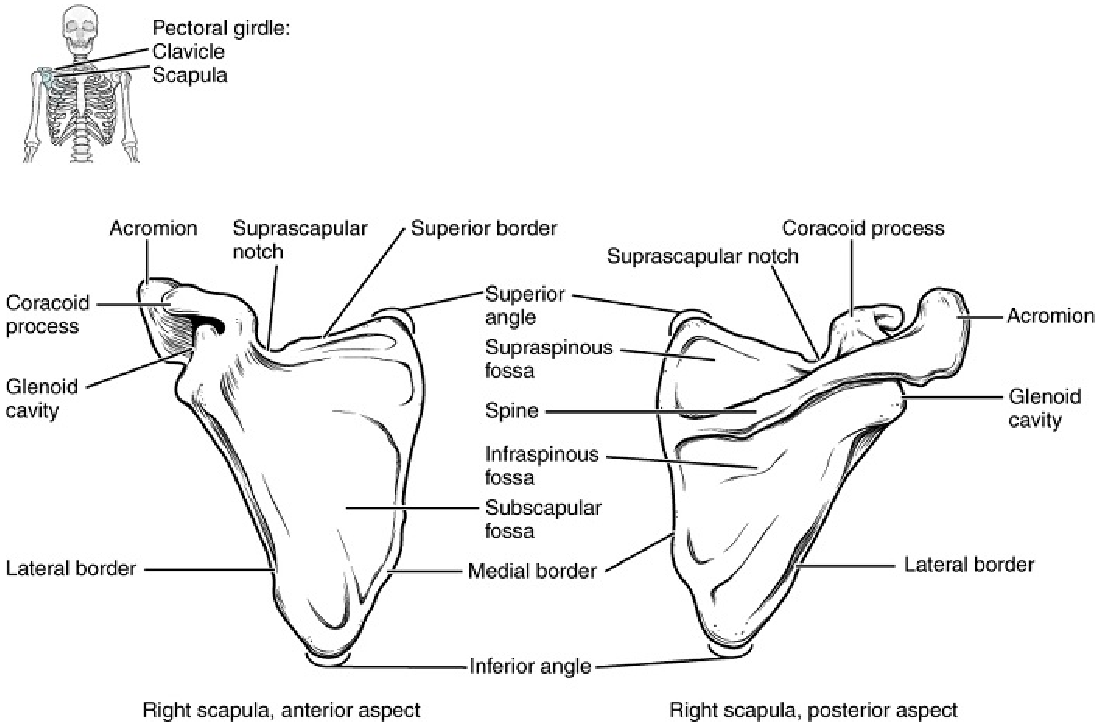


Image: “Scapula” by Phil Schatz. License: CC BY 4.0

The scapula forms the proximal osseous portion of the shoulder joint and has a direct connection to the chest and ribs. This is important to know, because dysfunction of the shoulder joint could consequently result from a problem of the ribs, for example.

Glenoid cavity

The proximal articular surface is very flat and is located on the **lateral angle of the scapula**. It is smaller in the cranial than in the caudal direction, and the vertical alignment is longer than the horizontal. Thus, the joint surface resembles a pear. The surface covered with cartilage is thin in the center and becomes thicker towards the outside – exactly the opposite of the joint surface of the humerus.

In fact, only 25-30 percent of the humeral articular surface comes in contact with the **glenoid labrum** and the cavity, because, as described above, the size ratio of the two joint surfaces is extremely different. Stabilizing adhesion, caused by the synovial fluid, enables the contact between the two joint partners. The **supraglenoid tubercle**, which is the origin of the **musculus biceps brachii,** is located at the cranial margin of the glenoid. The tubercle infraglenoid is located in the caudal section, forming the origin of the **musculus triceps brachii caput longum**.

Glenoid labrum

The **glenoid labrum** is a meniscus-like structure at the edge of the glenoid. The labrum is narrower ventrally and shorter than in other areas and fixated in a way that the tip points towards the joint cavity. The labrum is especially well-fixed caudally. Dorso-cranially, the labrum is connected to the biceps and forms the so-called **biceps anchor**.

Furthermore, the labrum serves to increase the concave joint surface, thus supporting the overall stability of the joint, because it can slow down any excessive translation. In functional terminology, the positive engagement of the joint through the cavity and the labrum is referred to as **concavity compression**.

Important information about the scapula: Superior tilt and retroversion

The caudal part of the glenoid cavity is adjusted by 5-10 degrees laterally, in relation to the vertical part. Consequently, the joint surface is minimally cranially oriented but a major grade resistance. This grade resistance can result in a functionally unstable humeral head.

The sagittal and tangential planes of the cavitas form an angle of approximately 30 degrees. By aligning the joint surface from dorso-medial to ventrolateral, the joint is more stable dorsally, but clearly unstable ventrally. Consequently, joint lunations are much more frequent ventrally than dorsally. Another important dorsally stabilizing factor is the rotator cuff muscular system.

The joint capsule of the shoulder joint

The joint capsule is limp due to the high range of motion of the shoulder joint and is extended by recessi, as well as protected by bursae against friction and pressure. It consists of two different layers, the membrane of the **membrana synovialis** and the **membrana fibrosa**.

The synovial membrane is very thin and consists of **intima** and **subintima**. The intima consists of 1-4 layers of **synoviocytes** that produce synovial fluid. The subintima, however, is composed of loose connective tissue.

The membrana fibrosa forms the outer covering of the joint capsule and consists of about 80 percent of dense connective tissue with a high density of collagen fibers. The entire rotator cuff and humeral ligaments **coracohumerale et glenohumerale** are in direct contact with it.

The joint capsule is grown together with the labrum within the cavity. While the synovial membrane attaches to the **apex** of the labrum, the attachment of the fibrous membrane is located at the **base**.

With respect to the humerus, it should be noted that the capsule is fixed with two membranes at the collum anatomicum. An exception, however, can be found in the area of the long head of the biceps. The membrana fibrosa forms a bridging to the bicipital groove, and the synovial membrane covers the tendon to the distal end of the sulcus. This refers to the **vagina tendinis intertubercularis** which is the tendon sheath of the long biceps tendon.

If the person stands upright and the shoulder joints fall loosely to each side of the body (**neutral zero position, NN**), the cranial portions of the capsule are tense and the **axillary recess** is wrinkled.

Bursa subtendinea musculus subscapularis and bursa subcoracoidea

The **bursa subtendinea subscapularis** is located ventral to the subscapularis muscle. It is connected to the interior of the joint through the Weitbrecht’s foramen. It breaks through the capsule wall and the glenohumeral ligament. The bursa’s task is to cushion the subscapularis muscle against the joint.

The **bursa subcoracoid** is connected to the caudal bursa subscapularis. This protects the tendon from friction at the nearby **processus coracoideus.**

The ligaments of the shoulder joint

In addition to the muscular insertion, ligaments in both the cranial and in the ventral region reinforce the capsule.

Glenohumeral ligament

The glenohumeral ligament is divided into three parts: the **pars superior**, **medial**, and **inferior**. Generally, it is not very strongly developed. This is important for medical students to know because it can hardly be distinguished from the membrana fibrosa during dissection.

The pars superior originates ventrally to the **tuberositas supraglenoid** and inserts above the **lesser tuberosity of the humerus**, where it connects with the **transverse humeral ligament**. In this section, the tendon of the subscapularis muscle covers the ligaments.

The base of the pars media is located medially to the lesser tuberosity of the humerus and is directly connected to the tendon of the subscapularis.

The pars inferior is divided into an anterior and posterior portion. Both insert into the caudal portion of the anatomicum collum.

The glenohumeral ligament primarily serves the ventral stabilization of the joint and prevents subluxation of the humeral head in the caudal direction.

Ligamentum coracohumerale

The **ligamentum coracohumerale** (coracohumeral ligament) is fused with the subscapularis capsule and closes the gap between the musculus supraspinatus and the musculus subscapularis. It is divided into short ventral and long dorsal fibers. The long fibers are connected to the transverse ligament of the humerus, whereas the short fibers insert at the tubercular minus.

This ligament has a stabilizing function as well and prevents the caudal descent of the humeral head.

Clinical examples of the shoulder joint

There are a number of different injuries of the shoulder joint. This is a selection of frequent lesions which medical students as well as fully trained doctors in orthopedics and surgery, but also in neurology, are confronted with.

SLAP lesion

If the labrum dissolves from the cranial socket pole with a partial or complete replacement of the long biceps tendon, this constitutes a **SLAP lesion**. This is caused by repeated small traumas to the maximum extended arm or a severe injury due to falling. In traumatology, SLAP lesions are divided into four levels of severity:

- Type I: The labrum is injured directly.
- Type II: The labrum, as well as the long biceps tendon, have completely detached from the glenoid rim.
- Type III: The labrum has suffered a bucket-handle tear, while the long biceps tendon was not damaged.
- Type IV: The labrum has suffered a bucket-handle tear and the biceps anchor is torn off.

Traumatic shoulder luxation

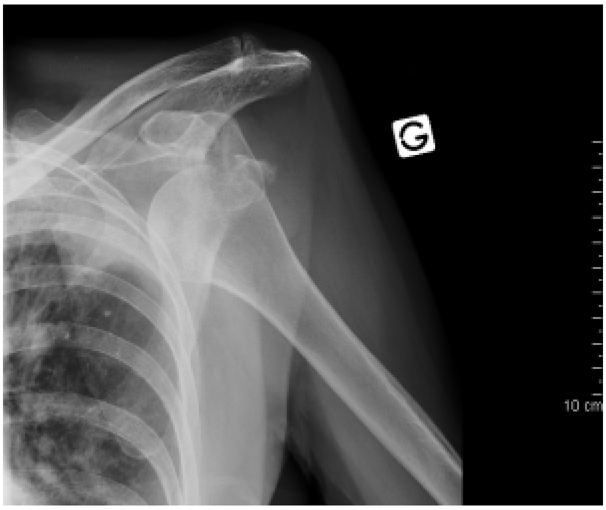


Image: “Luxace ramenního kloubu (skiagram)” by LobStoR.
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Shoulder luxations are caused by direct or indirect trauma, as well as after a stroke by the flaccid paralysis of the shoulder and shoulder girdle muscles. The dislocation is the most common anterior form of luxation.

If in addition to the dislocation of the humeral head in the glenoid fossa, partial shares of the anterior labrum are detached, we refer to it as a **Bankart lesion**. A rupture of the joint capsule often accompanies this.

In very severe trauma, the glenohumeral ligament can rupture, and an osseous impression on the humeral head is produced due to the impact of the humeral head on the articular surface of the scapula. This injury is called a **Hill-Sachs lesion**.

Inflammations

In chronic inflammations, for example, through permanent incorrect positioning and the resulting relieving posture, the recessus axillaris sticks together. The result is a massive deterioration in the mobility of the shoulder joint in all planes. This particularly affects the movement chain flexion/abduction/external rotation.

Therapeutic options include infiltration or oral supplementation of anti-inflammatory drugs, as well as mobilization treatment of the shoulder joint through manual therapy or physiotherapy. In extreme cases, mobilization under anesthesia may be necessary, for example, in cases of **frozen shoulder**.

The Subacromial Joint Space

The subacromial joint space is not a real joint, but the space between the humeral head and the acromion and has a high functional and clinical significance for the shoulder joint.

Osseous structures with respect to the subacromial joint space

The acromion and the processus coracoideus form the osseous portions of the subacromial joint space. Together with the ligamentum coracoacromiale they form the acromion.

Acromion

The **acromion** is a bony extension of the **lateral scapular spine**. Ventro-medially, it represents a connection to the clavicle, the **acromioclavicular joint (ACG)**. Among other purposes, it serves as the origin of the **deltoid muscle**.

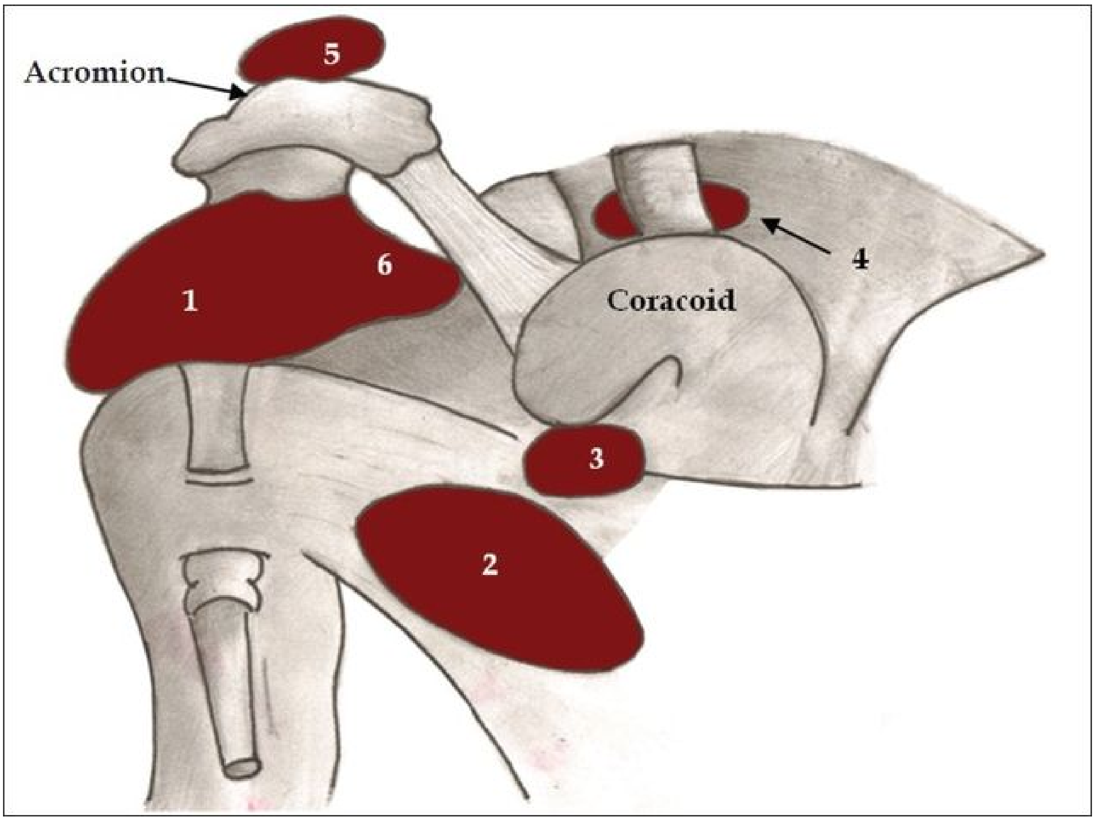

Image: "Diagram of normal bursae surrounding the shoulder joint" by Zameer Hirji. License: CC BY 3.0

Processus coracoideus

The processus originates from the cranial neck of the scapula. It serves as the origin of the **biceps short head**, the **coracobrachialis muscle**, as well as of various ligament structures.

The ligaments of the subacromial joint space

There is only one ligamentous structure in the subacromial joint space that is functionally related to the shoulder joint: the l**igamentum coracoacromiale**.

Ligamentum coracoacromiale

The ligament extends from the coracoid laterally to the anterior acromion and its underside as well as partly to the ACG. Some fibers of the biceps short head insert into the ligament. Through its connection to the ligamentum coracohumeral, it prevents an inferior subluxation. By counteracting the pull of the **pectoralis minor muscle** at the processus, it reduces the bending stress on the bone and thus serves as the tension band of the osseous structure.

Structures in the subacromial joint space

In addition to the tendon of the supraspinatus, the anterior parts of the supraspinatus, and the long biceps tendon, two important bursae are found in the subacromial joint space. These are the **subacromial bursa** and the **subdeltoid bursa**, which are not located directly within the joint space but can be functionally counted as such due to the direct communication with the subacromial bursa.

Subacromial bursa

The bursa is located directly below the acromion and reaches the ACG medially. It is covered by a thin liquid film and ensures a smooth sliding of the tissue layers. The superficial layer adheres to the acromion, while the deep layer is directly connected to the rotator cuff.

Subdeltoid bursa

The subdeltoid bursa communicates directly with the subacromial bursa and thus has the same frictionless sliding function. It is located between the humeral head, deltoid muscle and the tendons of the musculus infra – et supraspinatus. The deep layer is fused directly to the humerus bone.

The tendon of the musculus supraspinatus

The flat portion of the musculus supraspinatus runs from the ventral acromion portion from caudal to lateral.

The tendon of the musculus subscapularis

Ventrally located in the subacromial joint space are the cranial portions of the subscapularis muscle. They partially run through the greater tuberosity before they find their final attachment at the bicipital groove.

The tendon of the musculus biceps brachii caput longum

The long biceps tendon also runs through the subacromial sliding space. It is well protected against pressure through the vagina tendinis intertubercularis. Problems of the long biceps tendon are rare to find inside the subacromial joint space, but rather in the development or its attachment.

Clinical examples of the subacromial joint space

Due to the anatomical confines of the subacromial joint space and the variety of structures that have to pass through it, secondary signs of impingement and inflammatory mechanisms can develop.

Impingement syndrome

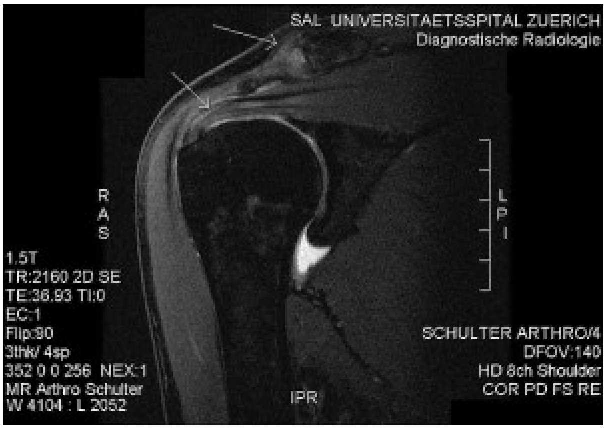

Image: "Diagram of normal bursae surrounding the shoulder joint" by Zameer Hirji. License: CC BY-SA 3.0

During impingement, a spatial bottleneck within the subacromial joint space is apparent. The reasons for this are, for example, an elevation of the humerus or massive morphological changes of the soft tissue in the joint space. If the bursa subacromial is compressed, it reacts with edema. Due to the space-occupying swelling process, the joint space is narrowed further, which increases the pressure on the bursa.

This vicious circle continues until the swelling reaches a level in which nociception is turned on and the mobility of the shoulder joint is reduced. Impingement may also occur when the joint has already changed arthritically and forms osteophytes, particularly in the caudal area. Furthermore, a much rarer coracoidale impingement exists, in which morphological changes of the osseous structures arise after a lesion of the processus coracoideus.

In particularly strong and therapy-resistant forms of these diseases, surgery is the last possible treatment option. In **endoscopic subacromial decompression (ESD)**, the subacromial joint space is mechanically extended through access through the deltoid muscle. This is done by milling the ventral distortion of the acromion and resizing the ligamentum coracoacromiale. In cases of secondary inflammatory processes of the subacromial bursa, it is also removed. The attempt, however, is to go without surgical intervention as much as possible due to the important buffer function of the bursa.

Review Questions

The answers are below the references.

1. What inclination angle does the shoulder joint have?

1. 35 degrees
2. 40 degrees
3. 45 degrees
4. 50 degrees
5. 55 degrees

2. Which of the following statements regarding SLAP lesion types is incorrect?

1. In Type I, the labrum is injured directly.
2. In type II, the labrum and the long biceps tendon have completely detached from the glenoid rim.
3. In type III, the labrum has suffered a bucket-handle tear, while the long biceps tendon adduced no damage.

4. In type IV, the labrum has suffered a bucket-handle tear; the biceps anchor, however, remains intact.
5. In type IV, the labrum has suffered a bucket-handle tear of the biceps anchor and is torn away.

3. Which structure is tried to be maintained surgically when it comes to endoscopic subacromial decompression?

1. Subacromial bursa
2. Subdeltoid bursa
3. Bursa subtendinea musculus subscapularis
4. Subcoracoid bursa
5. Coracoacromial ligament

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Correct answers: 1C, 2D, 3A

Notes