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

The shoulder joint is one of the most mobile joints in the human body and is, therefore, extremely susceptible to injury. Physicians, in addition to surgeons and orthopedists, should be familiar with its structural 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 \textit{articulatio humeroscapularis} (shoulder joint) is one of the ball and socket joints. \textbf{Scapula} is the proximal joint component with a concave articulation surface due to its \textbf{glenoid cavity}. However, the \textbf{humeral head} (distal joint partner) is convex. A clear mismatch of 3:1 to up to 4:1 exists between the humeral head and the glenoid. The stability of the joint is significantly reduced due to the absence of bone structure.

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 facilitates movements via flexion/extension, abduction/adduction, and internal/external rotation.
Osseous structures and articular surfaces of the humerus

The proximal humerus is divided into three sections along the proximal to the distal axis: caput, collum, and corpus humeri.
The convex humeral head measures 2.5 cm in radius. The articular surface, which is covered with cartilage, is thickest in the center and 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 on the anatomical neck. In the cranium, the tuberculum major is aligned cranially in the caudal-dorsal direction. The tuberculum minus is located ventrally. Both structures represent the origins of the muscular system. The tubercles run longitudinally and parallel to the bicipital groove in the crista tuberculorum majoris et minoris, which in turn also form the muscle attachments. The bicipital groove separates the two tubercles from each other structurally, along with the traversing long head of the biceps tendon.

**Corpus humeri**

The corpus humeri is distal to the tuberosity. The surgical neck constitutes the proximal portion, which is located distal to the tuberosity. The surgical neck derives its name from the location of the humerus fractures at this position, which is used by surgeons to differentiate between the humeral neck fracture (proximal) and the humeral shaft fracture (distal).

**Humerus: Angle of inclination and retroversion**

The collum axis traverses the center of the anatomical neck and the head of the humerus, resulting in an inclination angle of approx. 45° caudally along the shaft axis.

The retroversion (retro torsion) describes the proximal rotation towards the distal end of the humerus, observed 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 constitute an angle ranging between 20° and 30°. Neonatally, this angle is at 60°. The goal of retroversion is to optimize the forearm position in order to ensure the optimal function of the hand.

**Osseous structures and articular surfaces of the scapula**
The scapula forms the proximal osseous portion of the shoulder joint and has a direct connection with the chest and ribs. Any dysfunction of the shoulder joint may be attributed to rib disorders.

**Glenoid cavity**

The proximal articular surface is very flat and is located on the lateral angle of the scapula. It is smaller cranially 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 thicker towards the exterior, which is contrary to that of the joint surface of the humerus.

In fact, only 25–30% of the humeral articular surface is 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 the adhesion caused by the synovial fluid facilitates 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 infraglenoid tubercle is located in the caudal section and represents the origin of the musculus triceps brachii caput longum.

**Glenoid labrum**

The glenoid labrum is a meniscal structure at the edge of the glenoid. It is narrower ventrally and shorter than in other areas and fixated with the tip pointing 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 increases the concave joint surface, thereby supporting the overall stability of the joint by slowing 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 portion of the glenoid cavity is adjusted by 5–10 degrees laterally, in relation to the vertical part. Consequently, the joint surface is minimally oriented cranially but exhibits a major grade resistance, which can result in functionally unstable humeral head.

The sagittal and tangential planes of the cavitas form an angle of approximately 30°. By aligning the joint surface along the dorso-medial to ventrolateral direction, the joint is stabilized dorsally, although clearly unstable ventrally. Consequently, joint lunations are much more frequent ventrally than dorsally. The rotator cuff muscular system is another important dorsally stabilizing factor.

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 the bursae against friction and pressure. It consists of two different layers: 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 approx. 80% 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 the membrana fibrosa.

The joint capsule is developed 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, except in the area of the long head of the biceps. The membrana fibrosa forms a bridge to the bicipital groove. The synovial membrane covers the tendon to the distal end of the sulcus as the vagina tendinis intertubercularis, which is the tendon sheath of the long biceps.

In an upright position with the shoulder joints falling loosely on each side of the body (neutral zero position, NN), the cranial elements 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 via the Weitbrecht’s foramen. It breaks through the capsule wall and the glenohumeral ligament. The bursa cushions the subscapularis muscle against the joint.

The bursa subcoracoid is connected to the caudal bursa subscapularis and protects the tendon from friction with the processus coracoideus.

Ligaments of the shoulder joint

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

Glenohumeral ligament
The glenohumeral ligament is divided into three components: pars superior, medial, and inferior. Generally, it is not very strong, and 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 connected directly to the subscapularis tendon.

The pars inferior is divided into anterior and posterior components, which are inserted into the caudal portion of the anatomicum collum.

The glenohumeral ligament stabilizes the joint ventrally 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 are inserted at the tubercular minus.

This ligament stabilizes as well as prevents the caudal descent of the humeral head.

**Clinical examples of the shoulder joint**

The shoulder joint may be subjected to different injuries. A selection of frequent lesions encountered by medical students as well as skilled orthopedicians and surgeons, and neurologists, is presented here.

**SLAP lesion**

A SLAP lesion is generated by the labrum dissolving from the cranial socket pole with a partial or complete replacement of the long biceps tendon. It is caused by repeated small traumas to the maximum extended arm or a severe injury due to falls. 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 sustains a bucket-handle tear, while the long biceps tendon is not damaged.
- **Type IV**: The labrum shows a bucket-handle tear and the biceps anchor is torn off.

**Traumatic shoulder luxation**
Shoulder luxations are caused by direct or indirect trauma, as well as flaccid paralysis of the shoulder and shoulder girdle muscles after stroke. The dislocation is the most common anterior form of luxation.

If in addition to the dislocation of the humeral head in the glenoid fossa, a Bankart lesion may result in following shoulder joint dislocation (anterior) resulting in damage to the connective tissue ring around the glenoid labrum. Bankart lesion is often accompanied by a rupture of the joint capsule.

In very severe trauma, a Hill-Sachs lesion may result following the rupture of the glenohumeral ligament and osseous impression on the humeral head due to the impact on the articular surface of the scapula.

**Inflammation**

In chronic inflammation, for example, the recessus axillaris may adhere together via permanent incorrect position and massive deterioration in the mobility of the shoulder joint. It particularly affects flexion, abduction, and external rotation.

Therapeutic options include infiltration or oral supplementation of anti-inflammatory drugs, as well as mobilization of the shoulder joint via 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 between the humeral head and the acromion is associated with a high functional and clinical significance for the shoulder joint.

**Osseous structures with respect to 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**. It is connected with the clavicle ventro-mediale via the **acromioclavicular joint (ACG)**. It also serves as the origin of the **deltoid muscle**.

![Diagram of normal bursae surrounding the shoulder joint](Image: 'Diagram of normal bursae surrounding the shoulder joint' by Zameer Hirji. License: CC BY 3.0)

**Processus coracoideus**

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

**Ligaments of the subacromial joint space**

The **ligamentum coracoacromiale** is the single ligamentous structure in the subacromial joint space that is functionally related to the shoulder joint. It extends from the coracoid laterally to the anterior acromion and ventrally as well as partly to the ACG. A few fibers of the biceps short head insert into the ligament. It prevents inferior subluxation via a connection with the coracohumeral ligament. By counteracting the pull of the **pectoralis minor muscle** at the processus, it reduces the bending stress on the bone and thereby serves as the tension band in the osseous structure.

**Structures in the subacromial joint space**

In addition to the supraspinatus tendon, the anterior elements of the supraspinatus and the long biceps tendon, two important bursae are detected in the subacromial joint space. They include 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 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 exhibits 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 travels from the ventral acromion portion in the caudal to lateral direction.

The tendon of the musculus subscapularis

The cranial portions of the subscapularis muscle are located ventrally in the subacromial joint space partially running through the greater tuberosity before finally attaching 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 adequately protected against pressure through the vagina tendinis intertubercularis. The challenges associated with the long biceps tendon related to its development or attachment and rarely occur inside the subacromial joint space.

Clinical examples of subacromial joint space

Due to the anatomical confines and the variety of structures traversing the subacromial joint space, secondary signs of impingement and inflammatory mechanisms can develop.

Impingement syndrome
soft tissue in the joint space. The compression of the subacromial bursa may lead to edema. The space-occupying swelling further narrows the joint space, which increases the pressure on the bursa.

This vicious circle continues until the swelling triggers nociception and reduces the mobility of the shoulder joint. Impingement may also be induced by arthritic changes in the joint and osteophyte formation, particularly in the caudal area. Furthermore, during a significantly rarer coracoidal impingement, morphological changes associated with the osseous structures are induced by lesions of the processus coracoideus.

Surgery is the last treatment option for the management of refractory cases. In endoscopic subacromial decompression (ESD), the subacromial joint space is mechanically extended via access through the deltoid muscle. This extension is accomplished by milling the ventral distortion of the acromion and resizing the ligamentum coracoacromiale. It is also removed in cases of secondary inflammatory processes of the subacromial bursa. However, surgical intervention should be delayed to the extent possible due to the important buffer function of the bursa.

References


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