Chapter 2

Shoulder Complex

2 Shoulder Complex

2.1 Introduction

2.1.1 Significance and Function of the Shoulder Region

This chapter will consider the function and pathology of the shoulder region, or shoulder complex.

The shoulder complex is one of the largest movement complexes in the musculoskeletal system. It includes the following:

- The glenohumeral or GH joint.
- The bony parts and joints in the shoulder girdle (acromioclavicular and sternoclavicular joints).
- The sliding scapulothoracic articulation.
- The cervicothoracic transition to the cranial rib joints.
- Costal joints 1 to 6.

The **most important principle of function** of the shoulder complex is the optimization of arm movements with the greatest radius possible and to provide a mobile and stable base for the arm movements. End-range arm elevation is one of the most complex movements of our body.

The intricate interplay between the individual components of the shoulder complex can lead to a variety of dysfunctions. A cause of restricted shoulder elevation, for example, can be found in every single mobile articulation in the cervicobrachial region.

There are a comparatively large **number of causes** for shoulder/arm pain. Pain may be referred or projected from the cervical spine and the thoracic outlet, or may be due to several other possible causes ranging from arthritis, ligamentous laxity and instability to soft-tissue lesions such as internal or external impingement or labral lesions and ruptures of the rotator cuff muscles.

When presented with a "shoulder patient," the therapist is often compelled to thoroughly assess all components of the shoulder complex and frequently finds it quite difficult to interpret results.

2.1.2 Common Applications for Treatment in this Region

Techniques used in this region that require knowledge of palpation include the following:

- Joint play tests and manual therapy techniques (e.g., glenohumeral, acromioclavicular, and sternoclavicular).
- Laxity and instability tests of shoulder joints.
- Local cross-frictions according to Cyriax, for example, on tendons and at insertion sites of the rotator cuff muscles.
- Local application of electrotherapy and thermotherapy on the muscles and articular structures.

2.1.3 Required Basic Anatomical and Biomechanical Knowledge

Therapists should be familiar with the location and form of the articular structures in all shoulder joints, as well as the location, course, and attachments of clinically important muscles, for example, the subscapularis. A good spatial sense is of advantage as the clinically important structures are found close to each other, especially in the GH joint. Knowledge of the shape of the spine of the scapula and the acromion, of the proximal humerus, the dimensions of the clavicle, and the position of the joint spaces is especially important (▶ Fig. 2.1, ▶ Fig. 2.2, ▶ Fig. 2.3).

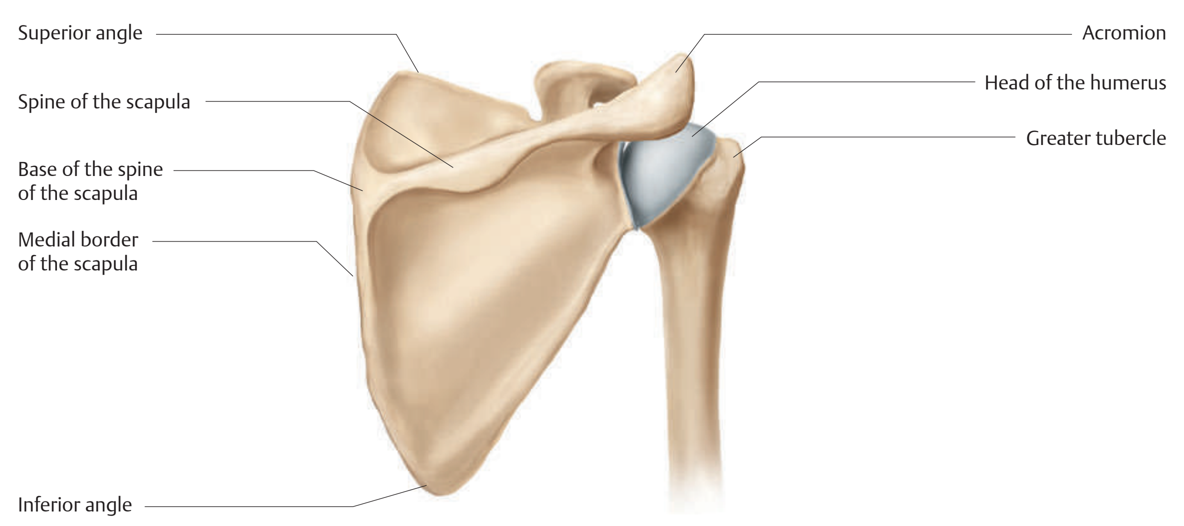

Fig. 2.1 Overview of the topography on the posterior aspect.

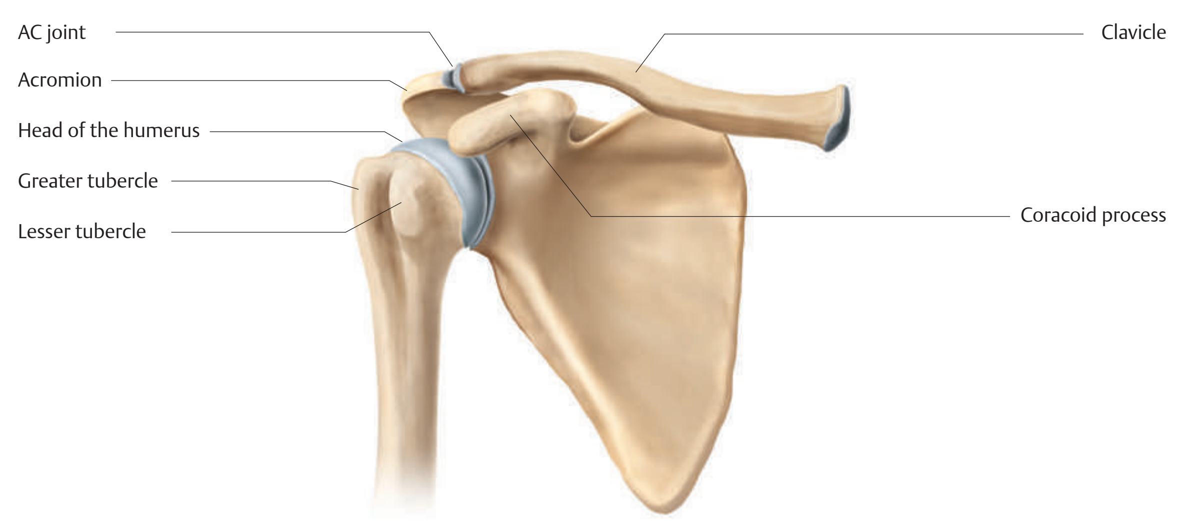

Fig. 2.2 Overview of the topography on the anterior aspect.

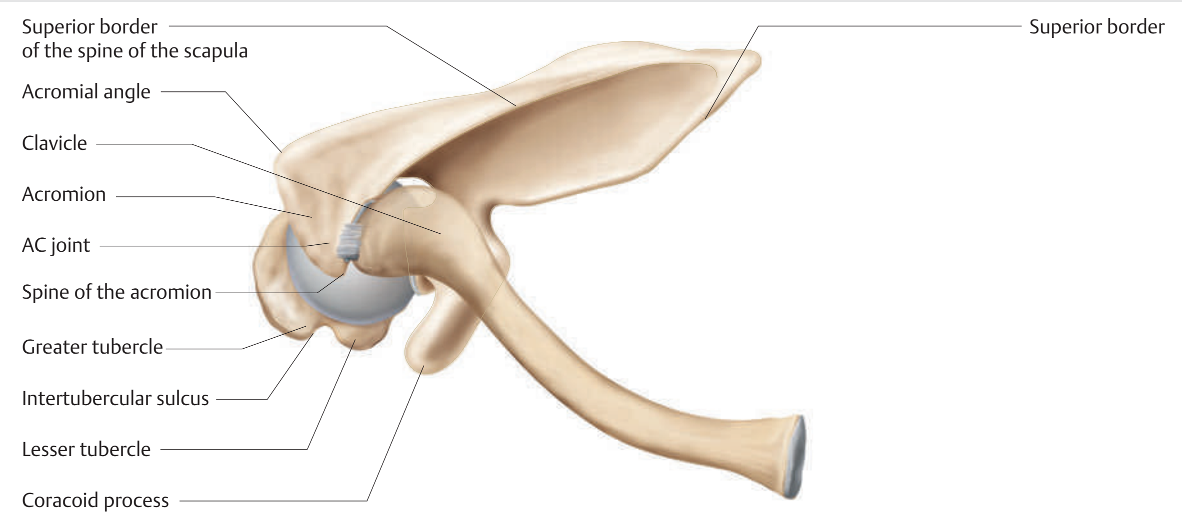

Fig. 2.3 Overview of the topography on the superior aspect.

Glenohumeral Joint

The glenoid cavity or glenoid fossa is the socket of the humeral head. Its concavity is directed laterally, forward, and somewhat upward as an extension of the scapular spine. Since the scapula adapts itself to the shape of the thorax as a relatively flat bone, the socket tips in an anterior direction in the sagittal plane so that the anteroposterior surface of the cavity is not transverse. The head of the humerus is almost spherical; in the transverse plane it exhibits a retrotorsion of approximately 30° to the line connecting the epicondyles of the humerus. This retrotorsion determines the range of motion in outward and inward rotation. A slight retrotorsion leads to a smaller outward rotation. In the frontal plane, the humeral head is angled at 45° to the shaft of the humerus. Since the insertion of the capsule lies at the anatomical neck, directly adjacent to the head of the humerus, the superior portions of the capsule are stretched when the arm is allowed to hang. For equal tension on the superior and inferior portions of the capsule, the arm must be abducted by about 45°. This is the resting position.

On the basis of the anatomy seen in radiographs, it was claimed that the shoulder joint was incongruent and that the radii of curvature of the two members of the joint provided a poor fit. According to this finding, the socket would hardly be able to contribute to the stability of the shoulder joint. However, studies of anatomical preparations and modern imaging techniques (CT and MRI) show a high degree of congruence between head and socket.

The decisive factor is the shape of the cartilaginous lining of the socket and the glenoid labrum. The drawing in ▶ Fig. 2.4 summarizes what is known today about the interrelations of shapes in the glenohumeral joint. The cartilage is thicker at the edges than in the center of the socket. The depth of the socket and the resulting congruence play a decisive role in the stability of the glenohumeral joint. The glenoid labrum is a fibrocartilaginous structure that increases the contact surface and functions like a suction cup. Furthermore, it is the origin of the long biceps tendon and the capsule of the labrum.

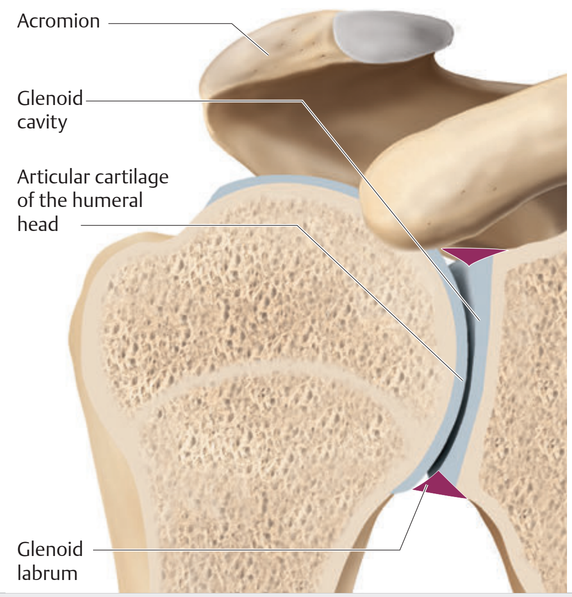

Fig. 2.4 Congruence of the glenohumeral articular surfaces (after Omer Matthijs).

Overall, the high degree of congruence creates such a strong adhesion between the joint surfaces that it is hardly possible to separate the head from the socket in the direction of traction. In 2003, Gokeler et al. were able to demonstrate in a study that it is not possible to separate head and socket with 14 kg of tractive force.

▶ Fig. 2.5 shows a view of the glenoid cavity with the fibrocartilaginous ring (glenoid labrum) and the interior of the capsule with the reinforcing structures as well as the position of the rotator cuff tendons. The capsular fibers are somewhat twisted in their arrangement, in a clockwise direction in the right shoulder, so that the capsule tenses more rapidly in extension than in flexion. Approximately half of the capsular surface is the area of insertion for the rotator cuff muscles, which greatly strengthens the capsule. The subscapularis (SSC) has the broadest tendon; this muscle supports the capsule anteriorly. In the superior part of the capsule there is a gap in the muscle insertion. At this point, the long head of the biceps brachii leaves the capsule and continues in the intertubercular sulcus. The so-called rotator interval is reinforced and overlapped by two bands of the coracohumeral ligament (Werner et al., 2000).

The three glenohumeral ligaments, the superior, middle, and inferior glenohumeral ligaments, arise at the edge of the labrum. They reinforce the anterior inferior capsule and limit certain movements of the humerus by increasing tension. The effect of this increasing tension is to center the head in the socket with increasing extent of motion. The axillary recess runs between the two portions of the inferior ligament. The most important centering function is performed by the anterior portion of the inferior glenohumeral ligament. With increasing abduction and outward

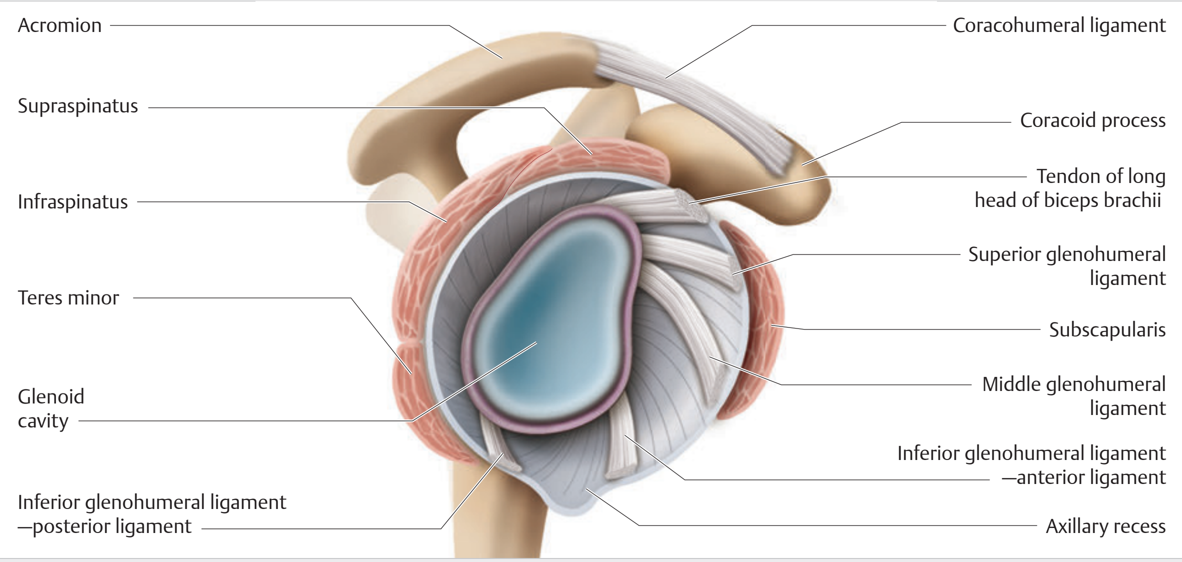

Fig. 2.5 Structure of the glenohumeral capsule (after Omer Matthijs).

rotation (the back-swing phase of the throwing motion) it wraps around the head of the humerus and thus prevents abnormal forward displacement (subluxation) of the head. The subscapular muscle plays a decisive reinforcing role here.

The acromion, the coracoacromial ligament, and the coracoid process form the summit of the shoulder, the fornix humeri. The tendons of the rotator cuff and the subacromial bursa (not illustrated) lie in the subacromial space. In inflammatory processes, the tendons and the bursa can become impinged (clamped) between the tubercula and the fornix humeri. The tendons of the supraspinatus (SSP) and the infraspinatus (ISP) overlap. Only the teres minor (TM) cannot be clamped in this external impingement.

Acromioclavicular Joint

The acromioclavicular (AC) joint has all the characteristics typical of a classical amphiarthrosis:

- It is part of the shoulder girdle motor complex.
- Because it does not have its own muscles it moves only together with the neighboring joints.
- Because of its rather flat joint surface and very tight ligaments it is not very mobile.

However, the joint is very small, with an intra-articular space of only about 1 cm long (▶ Fig. 2.6). Many people have an intra-articular disk. There are numerous variations in the shape of the acromial end of the clavicle in the frontal and transverse planes (De Palma, 1963; Moseley, 1968) and the clavicle is not always convex. Colegate-Stone et al. (2010) describe an even distribution of vertical, oblique, and curved (convex clavicle) shapes in the acromioclavicular joints of the specimens they studied.

One particular shape variation, with sides raised, looks like a volcano and makes precise location of the intra-articular space much harder.

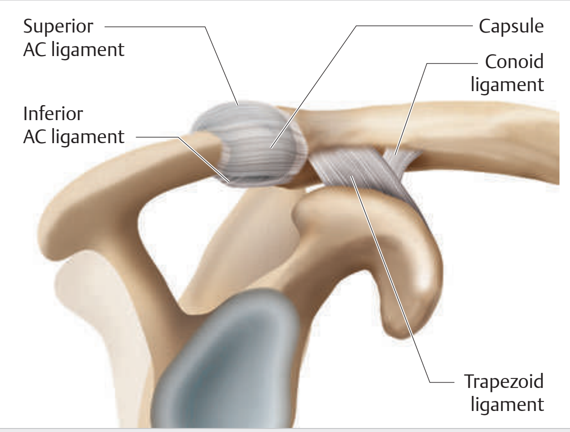

Fig. 2.6 Structure of the AC joint (after Omer Matthijs).

The reinforcing ligaments of the AC joint (Saccomanno et al., 2014) are divided into the following:

- *Intrinsic ligaments:* Superior and inferior acromioclavicular ligaments. The superior ligament is very strong and primarily limits all transverse movements, for instance the translatory tests of manual therapy (see ▶ Fig. 2.36).
- *Extrinsic ligaments:* The coracoclavicular ligaments (conoid and trapezoid ligaments). Except in passive elevation of the shoulder, they are never completely relaxed. They guarantee stability in the face of large, transverse forces (e.g., when the intrinsic ligaments are torn) and limit vertical movements between acromion and clavicle.

Since the AC joint is an amphiarthrosis, it has no motor muscle supply of its own. Nevertheless, fibers in the descending portion of the trapezius muscle and the clavicular portion of the deltoid muscle can extend across the intraarticular space and, at a deep level, make contact with the capsule. For this reason, both muscles are suitable for active stabilization of the joint.

Sternoclavicular Joint

In the sternoclavicular (SC) joint, the movements of the shoulder girdle are facilitated while the forces for the shoulder girdle movements are exerted more on the scapula (▶ Fig. 2.7). During support of the arm and hand, it transfers compression forces on the thorax. Likewise, end-range arm elevations are transmitted via the first rib to the cervicothoracic transition.

It is anatomically classified as a sellar joint. However, the rotation of the clavicle during arm elevation means that it functions as a ball-and-socket joint. The narrow sternal end of the clavicle articulates with the joint surface of the sternal manubrium by means of a disk that subdivides each joint into two compartments. The joint space tilts in the frontal plane by approximately 45° from superomedial to inferolateral.

The joint, which is rather unstable in terms of its bony structure, derives its stability from intrinsic (directly capsule-reinforcing) and extrinsic ligaments (Sewell et al., 2013):

- *Intrinsic ligaments:* Anterior and posterior sternoclavicular ligaments, and interclavicular ligament.
- *Extrinsic ligament:* Costoclavicular ligament.

The costoclavicular ligament is particularly interesting in terms of biomechanics. It is 3 to 10 mm long and is fused directly to the lateral edge of the sternoclavicular (SC) joint (Tubbs et al., 2009). End-range arm elevations are transferred to the first rib via tension of the costoclavicular ligament and further to the cervicothoracic transition. During protraction and retraction, this ligament tenses up and thus becomes a rotational axis. The clavicle therefore behaves consistently with the convex rule during

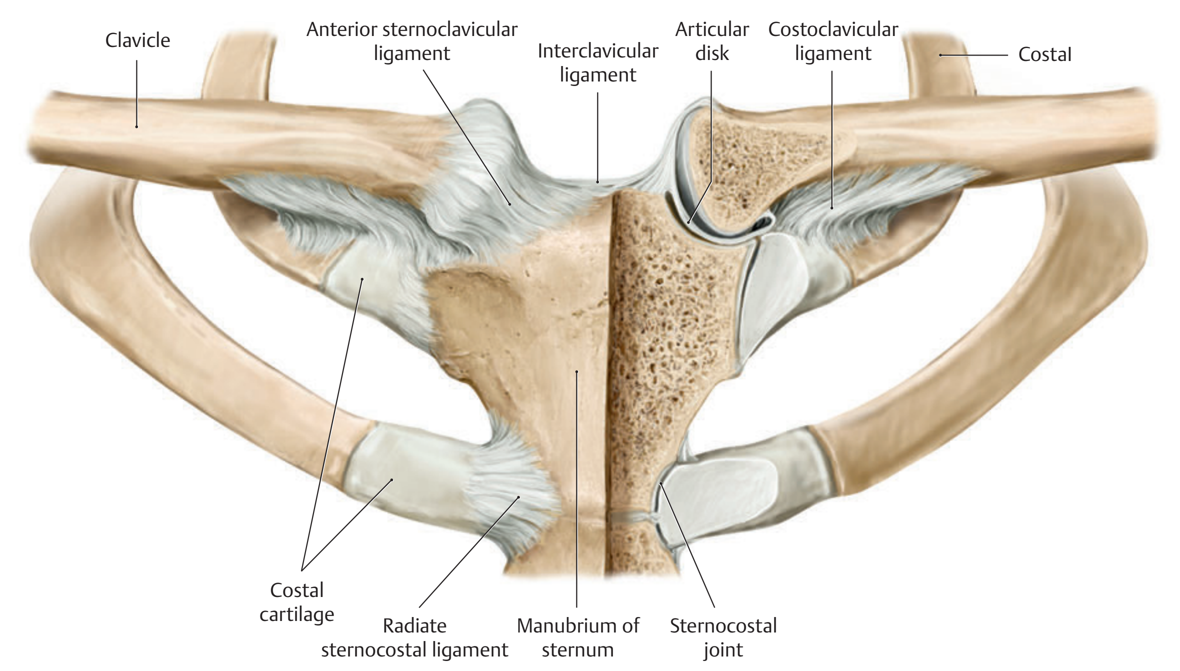

Fig. 2.7 Structure of the SC joint.

movements in both planes. When a patient falls on an arm with a shoulder in protraction, in the worst case the clavicle can become dislocated in a posterior direction.

2.2 General Orientation—Posterior

2.2.1 Summary of the Palpatory Process

Palpation begins dorsally at the scapula, moves toward the acromioclavicular joint and then toward the SC joint, finishing with the anterolateral aspect.

This order has developed from experiences in continuing education courses and is a purely didactic suggestion. Of course, the therapist can begin the palpation at any point.

Starting Position

When the important structures in the shoulder girdle are being located in detail, a practice starting position (SP) is taken: upright-sitting on a stool or a treatment table with the arms hanging loosely by the sides. In this SP, all components of the shoulder complex are usually found in a neutral position and all structures can be reached with ease. Dorsal orientation in this region begins by observing the topographical location of the scapula in relation to the spinal column and the thorax. The position of the most familiar bony landmarks (inferior angle and acromion) is also checked. To do this, the therapist stands behind the patient.

2.2.2 Topographical Position of the Scapula

According to Winkel (2004), Kapandji (2006), and Williams (2009), the superior angle of the scapula is found at the level of the T1 spinous process and the second rib. The inferior angle of the scapula can be clearly palpated and is found at the same level as the T7 spinous process and the seventh rib. The triangular origin of the spine of the scapula can be located at the level of the T3 spinous process (▶ Fig. 2.8).

Tip

The correlations described above are very constant, but only apply when the shoulder is relaxed and a sitting or upright SP is used. They are no longer reliable, however, if the patient changes position, for example, into side-lying, as the position of the scapula has changed (e.g., there is more elevation or abduction).

Medial Border of the Scapula

When the shoulder joint rotates medially, the scapula follows and the medial border of the scapula moves away

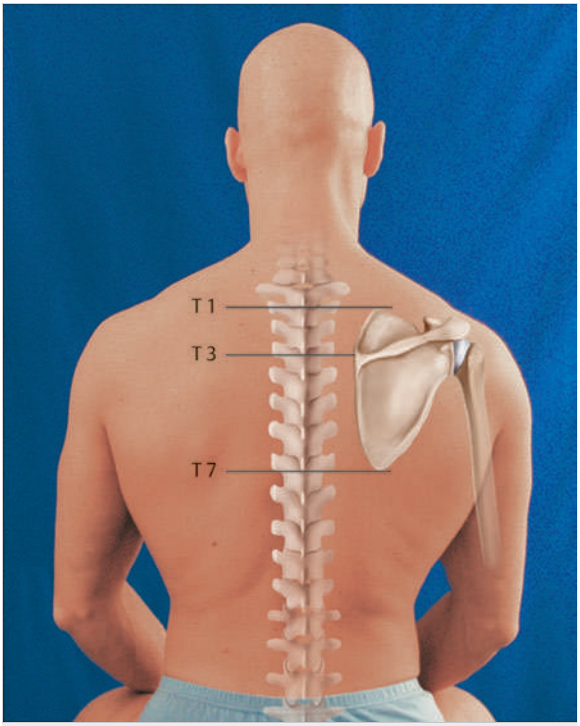

Fig. 2.8 Position of the scapula in relation to the spine.

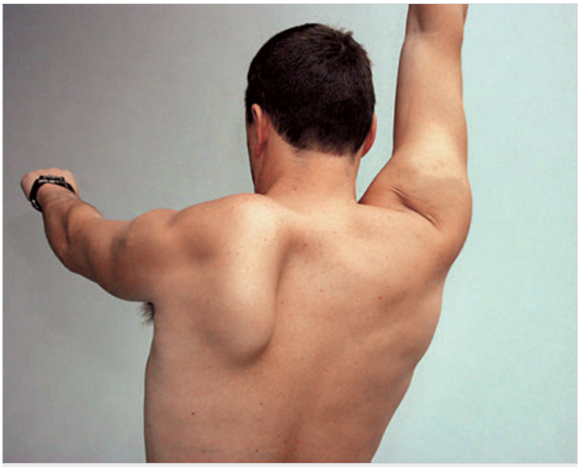

Fig. 2.10 Patient with a lesion of the long thoracic nerve and paresis of the left serratus anterior.

from the thoracic wall (▶ Fig. 2.9). This assists movement of the arm and is normal. It should not be considered pathological. Only the timing and the range of motion allow the therapist to draw conclusions about the ability of the shoulder joint to rotate medially. Extensive outward movement of the scapula indicates a decreased ability of the glenohumeral joint to rotate inward.

The medial border of the scapula is usually only visible when weakness in the rhomboids and serratus anterior results in insufficient thoracic stabilization of the scapula.

Fig. 2.9 Movement of the scapula with medial rotation of the arm.

Considerable weakness or paralysis in these muscles causes winging of the scapula especially when the arm is raised and is also known as scapula alata (▶ Fig. 2.10).

2.3 Local Palpation—Posterior

2.3.1 Overview of the Structures to be Palpated

- Inferior angle of the scapula.
- Medial border of the scapula.
- Superior angle of the scapula.
- Spine of the scapula—inferior edge.
- Acromial angle.
- Acromion.
- Spine of the scapula—superior edge.
- Supraspinatus—muscle belly.
- Infraspinatus—tendon and insertion.

2.3.2 Summary of the Palpatory Process

Following completion of the introductory orientation on the posterior aspect of the shoulder, first several important bony structures will be located. The palpation starts medially, over the spine of the scapula toward the lateral region of the shoulder. The different sections of the acromion are of special interest here and guide the therapist to two structures of great clinical importance: the supraspinatus and infraspinatus.

Starting Position

The patient's SP is identical to that used in the previous section.

2.3.3 Palpation of Individual Structures

Inferior Angle of the Scapula

The inferior angle of the scapula is an important reference point when assessing movement of the scapula. Therapists use this structure for orientation when they are assessing the range of scapular motion during abduction and inward and outward rotation in relation to the spinal column.

Technique

To assess rotation of the scapula, the therapist first palpates the inferior angle of the scapula in its resting position. The patient is then instructed to raise the arm. With regard to scapular movement, it is of no significance whether this is done through flexion or abduction. Once the arm has been raised as far as possible, the therapist palpates the position of the angle again and assesses the range of motion (▶ Fig. 2.11). This is also compared with the other side. It is more difficult to locate the inferior angle when the latissimus dorsi is well developed.

Range of motion is not the only aspect of interest when analyzing movement of the scapula. Asymmetrical or even jerky movements of the inferior angle as it moves to assist elevation of the arm indicate poor coordination and a possible weakness of the serratus anterior. Two types of movement can be distinguished, particularly at the start and the end of arm elevation—scapular winging and scapular tipping. Scapular winging describes the brief swinging outward of the medial border of the scapula in the transverse plane. Scapular tipping describes the brief lifting of the inferior angle in the sagittal plane. A lack of support by the scapula for arm elevation not only limits the overall movement but can also be the cause of various forms of external or internal impingement of the shoulder joint.

Fig. 2.11 Position of the inferior angle of the scapula in maximal arm elevation.

Medial Border of the Scapula

The medial border of the scapula is located using a perpendicular technique and palpating from inferior to superior. This is the first opportunity for students to consciously use this technique and to differentiate between the soft and elastic consistency of the muscles and the hard resistance of the edge of bone.

Technique

The palpating fingertips come from a medial position and push against the border (▶ Fig. 2.12). It is easy to locate the inferior part of the border as relatively few muscles are found here that impede access. If the border is followed in a cranial direction, precise palpation becomes difficult.

Fig. 2.12 Palpation of the medial border of the scapula.

Tip

If circumstances make it difficult to locate the border, it can help to ease the shoulder into medial rotation so that the medial border of the scapula wings out (see also ▶ Fig. 2.9). However, the aim of this palpatory exercise is to be able to find the edge of bone in any shoulder and with different tissue conditions.

Superior Angle of the Scapula

The superior angle lies at the cranial end of the medial border and approximately at the level of the second rib, thus usually lying higher in a cranial direction than expected.

Technique

The finger is placed as an extension of the medial border at the posterior edge of the descending trapezius muscle belly and palpates from cranial toward the angle.

Tip

It is very difficult to palpate the superior angle of the scapula. The trapezius that runs past it and the inserting levator scapulae are often very tense, making it difficult for the therapist to differentiate between the elevated muscle tension and the superior angle. Moreover, the first costotransverse joint, which is often sensitive, lies directly cranial. The therapist can avoid this problem by passively elevating the shoulder girdle. This can be done in any SP. The therapist elevates the shoulder girdle by pushing along the axis of the hanging arm. The superior angle is then recognized by its pressure from caudal against the palpating finger (▶ Fig. 2.13).

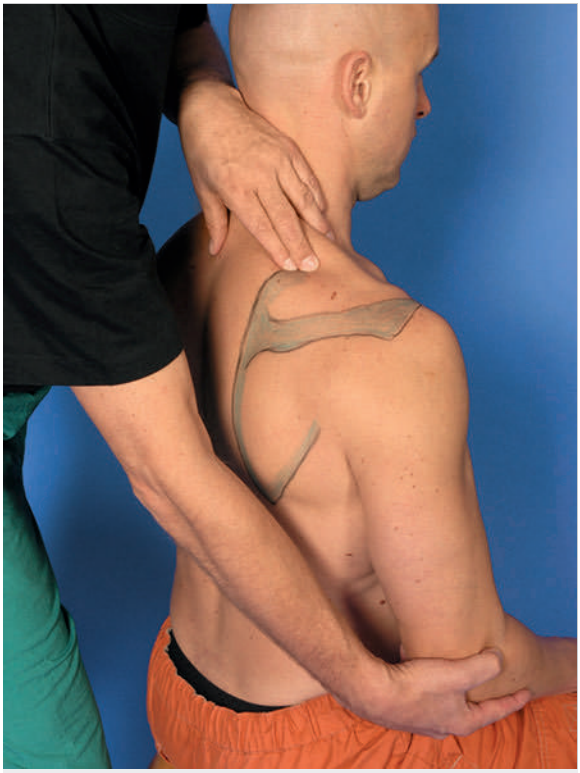

Fig. 2.13 Palpation of the superior angle of the scapula.

Spine of the Scapula—Inferior Edge

The spine of the scapula is another important bony reference point when palpating the posterior aspect. From this point, the therapist has reliable access to the acromion to the side and to the bellies of clinically prominent muscles (supraspinatus and infraspinatus). The spine of the scapula points toward the opening of the socket of the shoulder joint (glenoid cavity) and is the direction for manual therapeutic traction at the GH joint. For this reason, before applying traction to the joint, the manual therapist should determine the direction by palpating the spine of the scapula.

Technique

The inferior and superior edges of the spine of the scapula are palpated using the perpendicular technique we are already familiar with. The supraspinatus and infraspinatus are often quite tense, which makes locating the spine of the scapula more difficult than on the medial border of the scapula.

The inferior edge is palpated from medial to lateral. The spine of the scapula has a rolling, undulating shape that has developed as a result of the pull of muscular attachments, for example, the ascending part of the trapezius.

To locate the inferior edge exactly, the therapist uses the finger pads to push against the elastic resistance of the skin and muscles on the posterior side of the scapula and moves the palpating fingers in a superior direction until the finger pads encounter hard resistance (▶ Fig. 2.14).

The muscle belly of the infraspinatus lies in the space between the lower edge of the spine, the inferior angle, and the lateral border of the scapula.

Acromial Angle

Technique

At the lateral end of the inferior edge there is an angle that is distinctly prominent when the arm is hanging down—the acromial angle (▶ Fig. 2.15). At this point, the