Shoulder Anatomy

1

Kevin Taniguchi, John G. Lane, and Anshuman Singh

1.1 Shoulder Anatomy

1.1.1 Osseous

The primary articulation of the shoulder is the glenohumeral joint which is "ball-and-socket" shape with the concave glenoid fossa of the scapula articulating with the slightly ovoid head of the humerus. The glenoid is shallow with a large radius of curvature permitting for a wide arc of motion as it articulates with the humerus [1]. In order to maintain this relationship, however, it requires stabilization by surrounding bones, ligaments, and muscles.

The scapula is a flat, triangular shaped structure that serves as a skeletal strut for the shoulder joint as well as an attachment site for the various soft tissue structures that stabilize the shoulder. The glenoid is located at its lateral aspect and articulates with the humeral head. The acromion is a hook-like structure projecting off the posterolateral border of the scapula. Anteriorly, the acromion articulates with the clavicle, a broad S-shaped bone connecting the scapula to the sternum, together forming the acromioclavicular joint, allowing scapular rotation while holding the shoulder out to length [2]. The clavicle articulates with the sternum, or breastbone which is the only connection between the shoulder and the axial skeleton. The coracoid is a bony projection off the anterior-lateral aspect of the scapula and serves as an attachment site of several ligaments: the coracoclavicular ligaments, coracoacromial ligaments, and coracohumeral ligaments. These, along with the acromioclavicular ligaments, form the superior shoulder suspensory complex, a ring of bone and soft tissue that is an important biomechanical structure stabilizing the shoulder joint [3] (Fig. 1.1).

1.1.2 Muscles

The deltoid muscle forms the superior-lateral contour of the shoulder. There are three sets of fibers that form the heads of the deltoid; anterior, intermediate, and posterior. These originate on the anterior aspect of the clavicle, acromion, and scapular spine, respectively [4]. The orientation of these fibers allow for the various functions of the deltoid. The anterior fibers assist in forward flexion of the arm and medial rotation. The intermediate fibers allow for abduction of the arm away from the body in the frontal plane, and the posterior fibers assist in extending the humerus [5]. There are three muscles that originate on the cora-

K. Taniguchi
US Navy-Balboa Medical Center,
San Diego, CA, USA

J. G. Lane · A. Singh (✉)
University of California at San Diego,
San Diego, CA, USA
e-mail: jglane@san.rr.com

J. G. Lane et al. (eds.), *The Art of the Musculoskeletal Physical Exam*,
https://doi.org/10.1007/978-3-031-24404-9_1

Fig. 1.1 The shoulder has four articulations: the scapulothoracic, sternoclavicular, glenohumeral, and acromioclavicular. The latter two are visible on this anteroposterior radiograph. Bozkurt, M., & Acar, H. I. (Eds.). (2017). *Clinical anatomy of the shoulder: An atlas* (1st ed.). Springer International Publishing

coid process of the scapula; the pectoralis minor, coracobrachialis, and short head of the biceps. The pectoralis minor helps to depress and internally rotate the scapula while elevating the ribs aiding with inspiration during breathing; the coracobrachialis and short head of biceps act to flex the arm [6]. The long head of the biceps is a secondary flexor of the arm, its primary function is supination of the forearm. It originates at the supraglenoid tubercle on the scapula and its tendon runs intra-articularly within the glenohumeral joint as it moves distally towards its insertion on the radius of the forearm. The triceps brachii runs opposite the flexors on the posterior aspect of the arm and is an antagonist to the biceps, coracobrachialis, and brachialis muscles, acting to extend the arm at the elbow. It is made up of three heads; the long, medial, and lateral. The long head originates at the infraglenoid tubercle, and since it spans the shoulder joint, contributes to extension and adduction of the shoulder. The medial and lateral heads originate on the posterior humeral shaft, distal to the long head. The three heads converge to a single tendon attaching at the posterior aspect of the olecranon process of the elbow [7].

The rotator cuff is a key structure in regard to stability and function of the shoulder joint. It is comprised of four muscles: the supraspinatus, infraspinatus, subscapularis, and teres minor. These muscles function to provide rotatory movement at the shoulder joint and maintain the humeral head centered within the glenoid. The supraspinatus originates on the posterior aspect of the scapula and acts to abduct the shoulder. It has its highest mechanical advantage during the first 15° of motion, with the deltoid contributing more to abduction at greater degrees of abduction. The infraspinatus is a thick triangular shaped muscle that is located on the posterior aspect of the scapula and separated from the supraspinatus by the bony spine of the scapula. The infraspinatus acts to externally rotate the shoulder when the arm is at the side. The teres minor is the major external rotator with the arm abducted. The supraspinatus, infraspinatus, and teres minor all attach on the greater tuberosity, a bony prominence on the posterior lateral aspect of the proximal humerus. The subscapularis runs along the anterior aspect of the shoulder acting as secondary restraint to anterior translation of the humeral head in addition to performing shoulder adduction and internal rotation [8]. It attaches to the lesser tuberosity of the humerus, located anteromedial to the greater tuberosity (Fig. 1.2).

1.1.3 Ligaments

While the rotator cuff musculature provides dynamic stability with movement of the shoulder, the ligamentous structures act as static stabilizers. These glenohumeral ligaments are capsular thickenings of the shoulder joint that are check reins to excessive rotational or translational movement of the humeral head within the glenoid. They are described as discrete bands, the superior glenohumeral ligament (SGHL), middle glenohumeral ligament (MGHL), and inferior glenohumeral ligament (IGHL) complexes. The IGHL has both an anterior band (aIGHL) and posterior band (pIGHL).

Unlike most ligaments in the body which impart force through the entire arc of motion, the

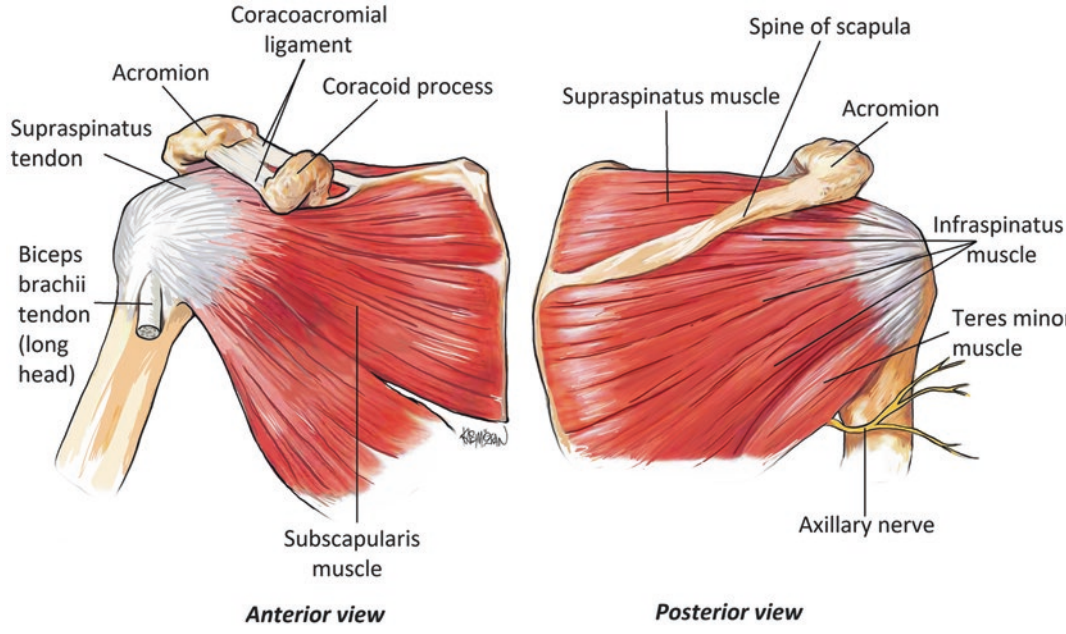

Fig. 1.2 The four rotator cuff muscles are critical to shoulder stability and motion. Yılmaz S., Vayısoğlu T., Çolak M.A. (2020) Shoulder Anatomy. In: Huri G., Familiari F., Moon Y.L., Doral M.N., Marcheggiani Muccioli G.M. (eds) Shoulder Arthroplasty. Springer, Cham. https://doi.org/10.1007/978-3-030-19285-3_1

glenohumeral ligaments act variably depending on the specific position of the arm. The SGHL provides restraint to inferior translation when the arm is at the side, the MGHL resists anterior and posterior translation at the midrange of abduction. The IGHL is the most important contributor to stability overall as it acts during the most common position of dislocation, when the shoulder is abducted 45–90°. The aIGHL is important when the arm is externally rotated, and the pIGHL in internal rotation [9, 10]. The coracohumeral ligament (CHL) supplements the function of the SGHL, running from the base of the coracoid process and attaching to the superior aspect of the shoulder capsule. The CHL, MGHL, and SGHL along with the long head of the biceps tendon travel within the rotator interval, which is bordered by the tendons of the supraspinatus and infraspinatus [11, 12].

The glenoid labrum is a fibrocartilaginous structure that serves as an anchor for the glenohumeral ligaments in addition to deepening the socket of the glenoid to enhance stability of the joint. It also serves as an anchor point for the long head of the biceps tendon at its most superior position. Injuries to the labrum are common and may manifest as shoulder pain, instability, or both depending on their location and severity [13] (Fig. 1.3).

1.1.4 Nerves

The brachial plexus is made up of a series of nerves that convey sensory and motor function to the upper extremity. They are organized as nerve roots branching off the spinal cord at the C5-T1 levels. These nerve roots initially begin at the neck and are subdivided into trunks, divisions, cords, and branches as they move distally down the arm. The dorsal scapular nerve arises proximally from the C5 nerve root to provide motor function to the rhomboid muscles and levator scapulae, which medialize and elevate the scapula, respectively. The suprascapular nerve arises from the upper trunk formed by the C5 and C6 nerve roots and innervates two muscles of the rotator cuff; the supraspinatus and infraspinatus,

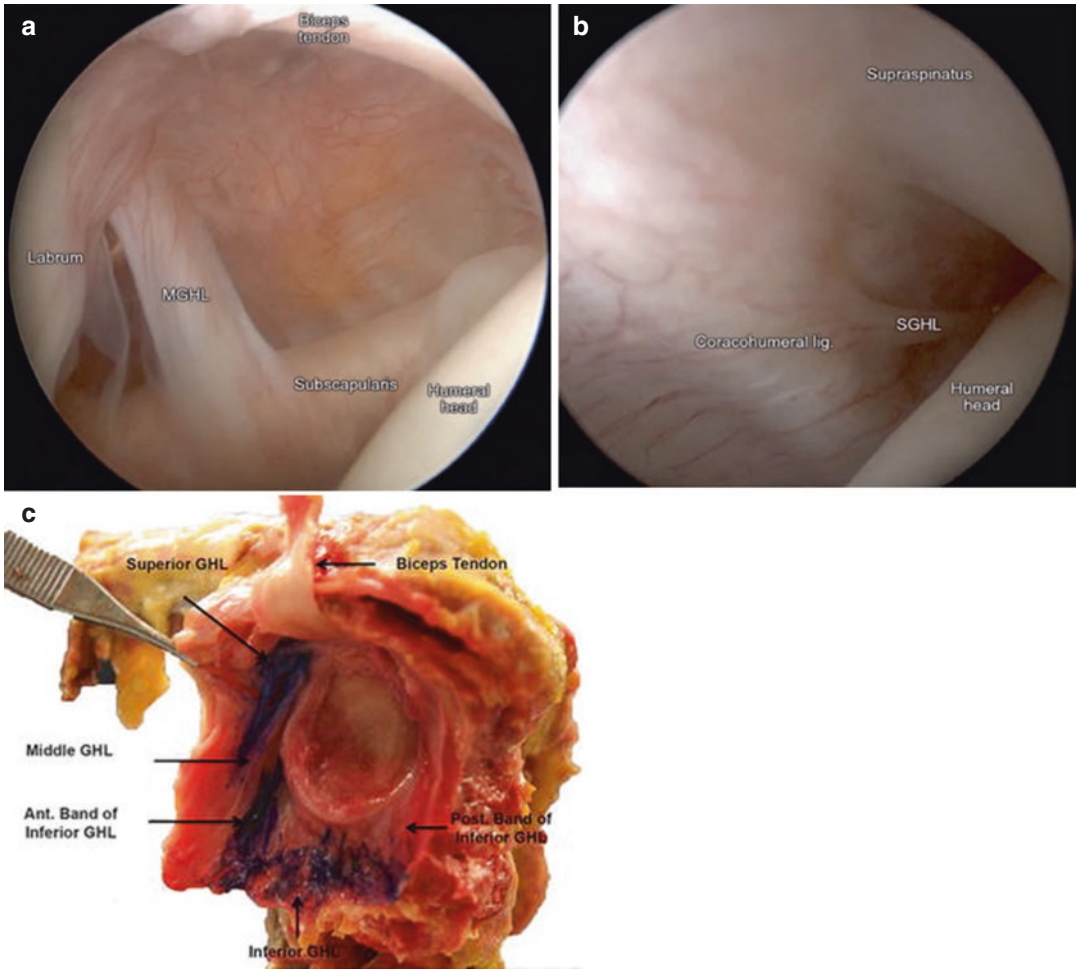

Fig. 1.3 The glenohumeral ligaments are thickenings of the shoulder capsule that serve to as static stabilizers of the shoulder at the end range of motion. (**a** and **b**) Arthroscopic images. (**c**) Anatomic dissection. Apostolakos J. et al. (2015) Glenoid Labrum. In: Bain G., Itoi E., Di Giacomo G., Sugaya H. (eds) Normal and Pathological Anatomy of the Shoulder. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-45719-1_9

as well as providing sensory innervation to the glenohumeral joint capsule. Cysts, or abnormal fluid pockets can form at either the suprascapular notch or spinoglenoid notch; fossae about the scapular neck, which can compress the suprascapular nerve causing both supraspinatus and infraspinatus dysfunction if found at the former, or isolated infraspinatus dysfunction if at the latter [14, 15]. The upper and lower subscapular nerves branch off of the posterior cord of the brachial plexus and innervate the subscapularis muscle; the lower subscapular nerve additionally supplies motor function to the teres major muscle. The axillary nerve is a large terminal branch of the posterior cord that innervates the deltoid and the teres minor. Its course has been well described as it wraps from posterior to anterior approximately 5 cm distal to the lateral edge of the acromion. It travels through the quadrangular space along with the posterior humeral circumflex artery, this anatomic space is bordered by the humerus laterally, the long head of the triceps medially, teres minor superiorly, and the teres major inferiorly [16]. It gives off a posterior branch to innervate the teres minor and shoulder joint capsule and an anterior branch to innervate the deltoid muscle. The poste-

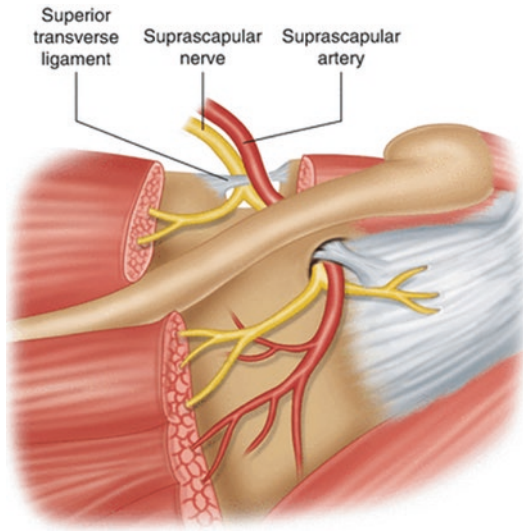

Fig. 1.4 The suprascapular nerve innervates the supraspinatus, infraspinatus and sends branches to the posterior glenohumeral capsule. Martinez, M., Doulatram, G.R. (2018). Suprascapular Nerve Blocks and Neurolysis. In: Manchikanti, L., Kaye, A., Falco, F., Hirsch, J. (eds) Essentials of Interventional Techniques in Managing Chronic Pain. Springer, Cham. https://doi.org/10.1007/978-3-319-60361-2_28

rior branch penetrates the fascia of the deltoid muscle before terminating as the upper lateral cutaneous nerve of the arm which provides sensory innervation to the skin overlying the upper arm [17]. The main terminal branch of the lateral cord is the musculocutaneous nerve which runs in the upper arm, gives off motor innervation to the coracobrachialis prior to piercing its deep surface approximately 6 cm distal to the coracoid process. The musculocutaneous nerve then travels in the anterior arm between the biceps brachii and brachialis, innervating both these muscles. After it exits the interval between these two muscles, it terminates as the lateral antebrachial cutaneous nerve which provides sensation to the lateral forearm [18] (Fig. 1.4).

1.1.5 Vascular

The subclavian artery and its branches provide the blood supply to the shoulder joint. There are several relevant named arterial branches of the axillary artery that are clinically important. The suprascapular artery branches off the proximal aspect of the subclavian artery, it then travels over the superior border of the scapula, in most cases over top of the transverse scapular ligament with the suprascapular nerve running underneath the ligament. The suprascapular artery then supplies the supraspinatus and infraspinatus muscles [19]. After passing the first rib, the subclavian artery changes names to the axillary artery. The axillary artery gives off the anterior and posterior circumflex arteries which supply the deltoid, biceps, coracobrachialis, teres minor, teres major, and triceps muscles. They are however, most important in providing blood supply to the humeral head. The posterior humeral circumflex artery travels with the axillary nerve through the quadrangular space prior to winding around the neck of the humerus to anastomose with the anterior humeral circumflex artery. Based on most recent anatomic studies, the posterior circumflex artery provides the majority of the blood supply to the humeral head [20].

References

1. Bakhsh W, Nicandri G. Anatomy and physical examination of the shoulder. Sports Med Arthrosc Rev. 2018;26(3):e10–22.
2. Willimon SC, Gaskill TR, Millett PJ. Acromioclavicular joint injuries: anatomy, diagnosis, and treatment. Phys Sportsmed. 2011;39(1):116–22.
3. DeFranco MJ, Patterson BM. The floating shoulder. J Am Acad Orthop Surg. 2006;14(8):499–509.
4. Brown JM, Wickham JB, McAndrew DJ, Huang XF. Muscles within muscles: coordination of 19 muscle segments within three shoulder muscles during isometric motor tasks. J Electromyogr Kinesiol. 2007;17(1):57–73.
5. Gagey O, Hue E. Mechanics of the deltoid muscle. Clin Orthop Relat Res. 2000;375:250–7.
6. Rios CG, Arciero RA, Mazzocca AD. Anatomy of the clavicle and coracoid process for reconstruction of the coracoclavicular ligaments. Am J Sports Med. 2007;35(5):811–7.
7. Casadei K, Kiel J, Freidl M. Triceps tendon injuries. Curr Sports Med Rep. 2020;19(9):367–72.
8. Clark JM, Harryman DT 2nd. Tendons, ligaments, and capsule of the rotator cuff. Gross and microscopic anatomy. J Bone Joint Surg Am. 1992;74(5):713–25.

9. O'Brien SJ, Neves MC, Arnoczky SP, Rozbruck SR, Dicarlo EF, Warren RF, Wickiewicz TL. The anatomy and histology of the inferior glenohumeral ligament complex of the shoulder. Am J Sports Med. 1990;18(5):449–56.
10. O'Connell PW, Nuber GW, Mileski RA, Lautenschlager E. The contribution of the glenohumeral ligaments to anterior stability of the shoulder joint. Am J Sports Med. 1990;18(6):579–84.
11. Jost B, Koch PP, Gerber CH. Anatomy and functional aspects of the rotator interval. J Shoulder Elb Surg. 2000;9:336–41.
12. Hunt SA, Kwon YW, Zuckerman JD. The rotator interval: anatomy, pathology, and strategies for treatment. J Am Acad Orthop Surg. 2007;15(4):218–27.
13. Burkart AC, Debski RE. Anatomy and function of the glenohumeral ligaments in anterior shoulder instability. Clin Orthopaed Related Res. 2002;400:32–9.
14. Leschinger T, Hackl M, Buess E, et al. The risk of suprascapular and axillary nerve injury in reverse total shoulder arthroplasty: an anatomic study. Injury. 2017;48:2042–9.
15. Westerheide KJ, Dopirak RM, Karzel RP, et al. Suprascapular nerve palsy secondary to spinoglenoid cysts: results of arthroscopic treatment. Arthroscopy. 2006;22:721–7.
16. Rea P. Chapter 3: Neck. In: Rea P, editor. Essential clinically applied anatomy of the peripheral nervous system in the head and neck. Academic Press; 2016. p. 131–83.
17. Gurushantappa PK, Kuppasad S. Anatomy of axillary nerve and its clinical importance: a cadaveric study. J Clin Diagn Res. 2015;9(3):AC13–7. https://doi.org/10.7860/JCDR/2015/12349.5680.
18. Flatow EL, Bigliani LU, April EW. An anatomic study of the musculocutaneous nerve and its relationship to the coracoid process. Clin Orthop Relat Res. 1989;244:166–71.
19. Singh R. Variations in the origin and course of the suprascapular artery: case report and literature review. J Vasc Bras. 2018;17(1):61–5. https://doi.org/10.1590/1677-5449.008117.
20. Hettrich CM, Boraiah S, Dyke JP, Neviaser A, Helfet DL, Lorich DG. Quantitative assessment of the vascularity of the proximal part of the humerus. J Bone Joint Surg Am. 2010;92(4):943–8.