CQ HAND + UPPER LIMB
SPECIALIST ORTHOPAEDIC SURGEON

EVIDENCE SUMMARY

Pectoralis Major Repair

Anatomy & Pathophysiology

BONY ANATOMY

- The proximal humerus comprises four main parts: the humeral head, greater tuberosity, lesser tuberosity, and humeral shaft [3].
- The articular head of the humerus is spherical with a diameter of 37 to 57 mm [3].
- The most superior portion of the articular surface of the humeral head averages 8 mm above the greater tuberosity [3].
- Humeral version averages 29.8 degrees, with a range of 10 to 55 degrees [3].
- The humeral head is inclined approximately 130 degrees with respect to the humeral shaft [3].
- The neck-shaft angle measures an average of 135 degrees [4].
- The humeral head is retroverted an average of 30 degrees [4].
- The humeral head averages 19° of retroversion and 41° of inclination (neck-shaft angle) [6].
- The bicipital groove lies between the greater and lesser tuberosities and serves as a pathway for the long head of the biceps [3].
- The distal aspect of the bicipital groove is internally rotated with respect to the proximal portion [3].
- The anatomic neck of the proximal humerus is located at the junction of the articular surface and the tuberosities [3].
- The surgical neck represents an indistinct region below the tuberosities but above the humeral shaft [3].
- The greater tuberosity is located in a posterior-superior location with respect to the humeral shaft [3].
- The lesser tuberosity is located on the anterior aspect of the proximal humerus [3].
- The glenoid is a convex structure of shallow depth shaped like an inverted pear [3].
- The glenoid cavity is a shallow socket, approximately one third the size of the humeral head [4].
- The subchondral bone of the glenoid is relatively flat, with articular concavity augmented by cartilage and a circumferential labrum [6].
- The glenoid averages 5° of retroversion in relation to the axis of the scapular body [6].

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- The scapula is attached to the axial skeleton by the acromioclavicular and sternoclavicular joints [5].
- The scapula is separated from the chest wall by thin gliding fibro-fatty tissue, allowing smooth excursion over the chest wall [5].
- The basic part of the scapula is the body, which is triangular when viewed anteroposteriorly with its base situated superiorly and its apex inferiorly [5].
- The glenoid is connected with the flat body of the scapula by the scapular neck [5].
- The coracoid process curves forwards from the superior surface of the scapular neck [5].
- The scapular spine ends in a flattened bony process, the acromion, which curves forwards [5].
- The highest concentration of bony mass in the scapula is found in the glenoid, the scapular neck, and the lateral border of the scapular body [5].
- Two bony pillars transmit compressive forces from the glenoid fossa: the lateral pillar and the spinal pillar [5].
- The lateral pillar connects the inferior border of the glenoid with the inferior angle [5].
- The spinal pillar arises from the central part of the glenoid and continues medially to become part of the base of the scapular spine [5].
- The weakest bone in the scapula is located primarily in the central part of the biomechanical body, specifically in the infraspinous fossa [5].
- The weakest area of the circumference of the biomechanical body of the scapula is the spinomedial angle [5].
- The clavicle is the first bone to ossify, occurring in the fifth week of gestation [6].
- The clavicle is the only long bone to ossify by intramembranous ossification [6].
- The medial (sternal) epiphysis of the clavicle is the last ossification center to fuse, at age 20 to 25 years [6].
- Ossification of the scapular body begins at the eighth week of gestation [6].
- The acromion has three ossification centers: the metacromion, mesoacromion, and preacromion [6].
- Failure of fusion of the acromial ossification centers results in os acromiale [6].
- The proximal humerus has three centers of ossification: the humeral head, greater tuberosity, and lesser tuberosity [6].
- The humeral head ossification center appears at 4 to 6 months [6].
- The greater tuberosity ossification center appears at 1 to 3 years [6].
- The lesser tuberosity ossification center appears at 3 to 5 years [6].
- The proximal humeral ossification centers fuse to the shaft at age 17 to 20 years [6].

MUSCULAR ANATOMY & BIOMECHANICS

- The pectoralis major inserts on the humeral shaft and displaces it medially following proximal humerus fracture [3].

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- The subscapularis inserts on the lesser tuberosity and causes medial displacement following proximal humerus fracture [3].
- The supraspinatus and infraspinatus insert on the greater tuberosity and cause superior and posterior displacement following proximal humerus fracture [3].
- The deltoid and rotator cuff counterbalance moderate loads transferred to the shoulder girdle [3].
- The capsulolabral and bone structures counterbalance large loads transferred to the shoulder girdle [3].
- The rotator cuff consists of the subscapularis, supraspinatus, infraspinatus, and teres minor muscles [4].
- The teres major is not a rotator cuff muscle [4].
- The rotator cuff muscles serve as depressors of the humeral head to allow the deltoid to efficiently abduct the humerus [4].
- The infraspinatus and teres minor are external rotators of the humerus [4].
- The subscapularis is an internal rotator of the humerus [4].
- The pectoralis major muscle causes predictable displacement of fractures around the proximal humerus [4].
- Normal shoulder motion is approximately two-thirds glenohumeral and one-third scapulothoracic [6].
- The glenohumeral joint stability depends on the capsule, ligament, and muscle [4].
- A redundant capsule allows for motion in the glenohumeral joint [4].

VASCULAR ANATOMY

- The proximal humerus receives its blood supply from the anterior and posterior humeral circumflex branches from the third division of the axillary artery [3].
- The posterior humeral circumflex artery travels with the axillary nerve and enters the quadrilateral space posteriorly [3].
- The anterior humeral circumflex artery arises from the axillary artery at the inferior border of the subscapularis [3].
- The anterior humeral circumflex artery provides vascular inflow to the humeral head by way of its terminal anterolateral branch, known as the artery of Laing or arcuate artery [3].
- The ascending branch of the anterior humeral circumflex artery courses parallel to the lateral aspect of the long head biceps tendon [3].
- The ascending branch of the anterior humeral circumflex artery enters the humeral head at the interface of the bicipital groove and greater tuberosity [3].
- Injury to the arcuate artery may result in osteonecrosis of the humeral head [3].
- Additional extraosseous collateral branches can permit humeral head perfusion despite complete ligation of the arcuate artery [3].
- The major blood supply to the humeral head is through the ascending branch of the anterior humeral circumflex artery, which penetrates the head at the bicipital groove and becomes the arcuate artery [4].
- The anterolateral ascending branch of the anterior humeral circumflex artery provides the primary blood supply to the humeral head [6].

- The terminal intraosseous portion of the anterior humeral circumflex artery enters at the proximal aspect of the intertubercular groove as the arcuate artery [6].
- Fractures of the anatomic neck have a poor prognosis because of complete disruption of the blood supply to the head [4].
- Surgical neck fractures are common, and with these, the blood supply to the head is preserved [4].
- A fracture involving the anatomic neck is prognostically worse than fractures involving other regions of the proximal humerus with respect to the potential disruption of the vascular supply to the humeral head and subsequent development of avascular necrosis [3].

LIGAMENTS & SOFT TISSUE STRUCTURES

- The acromion, coracoacromial ligament, and coracoid process form the coracoacromial arch [3].
- The coracoacromial arch is a rigid bony-ligamentous structure that imparts stability to the shoulder girdle [3].
- The rotator cuff, subacromial bursa, and subdeltoid bursa pass underneath the coracoacromial arch [3].
- The subscapular bursa lies between the subscapularis tendon and the neck of the scapula [7].
- The subscapular bursa communicates with the joint cavity between the superior and middle glenohumeral ligaments [7].
- The subscapular bursa protects the tendon of the subscapularis at the point where it passes under the base of the coracoid process and over the neck of the scapula [7].
- The subscapular bursa is linked to the coracoid process by a suspensory ligament [7].
- In 28% of specimens dissected by Colas and colleagues, the subscapular bursae merged with the subcoracoid bursae, forming a unique wide bursa [7].
- The subscapular bursa often houses loose bodies in the shoulder [7].
- The subscapular bursa is a region in which synovitis of the shoulder may be most intense [7].
- The rotator interval is defined medially by the base of the coracoid, superiorly by the supraspinatus tendon, and inferiorly by the subscapularis tendon [6].
- The rotator interval contains the coracohumeral ligament, the superior glenohumeral ligament, and the intra-articular portion of the long head of the biceps tendon [6].
- Laxity of the rotator interval results in inferior laxity, known as the sulcus sign [6].
- Contracture of the rotator interval is seen with adhesive capsulitis [6].
- The coracohumeral ligament restricts external rotation in adduction [6].
- The coracohumeral ligament is a static restraint to inferior and posterior translation in adduction and external rotation [6].
- The superior glenohumeral ligament is a primary static restraint against anterior translation with the arm at the side [6].
- The superior glenohumeral ligament, along with the coracohumeral ligament, forms a pulley that provides restraint against medial subluxation of the long head of the biceps tendon [6].

- The middle glenohumeral ligament is a primary static restraint against anterior translation with the arm in external rotation and 45° of abduction [6].
- The anterior band of the inferior glenohumeral ligament is a primary static restraint against anterior-inferior dislocation of the glenohumeral joint in 90° of abduction and external rotation [6].
- The posterior band of the inferior glenohumeral ligament is a primary static restraint against posterior-inferior translation in internal rotation and adduction [6].
- The superior transverse scapular ligament arises from the medial base of the coracoid overlying the suprascapular notch [6].
- The suprascapular artery runs superior to the superior transverse scapular ligament, while the nerve runs deep to it [6].
- Entrapment of the suprascapular nerve at the superior transverse scapular ligament causes denervation of both the supraspinatus and the infraspinatus [6].
- The spinoglenoid ligament overlies the suprascapular nerve at the spinoglenoid notch [6].
- Entrapment, traction, or compression of the suprascapular nerve at the spinoglenoid notch causes denervation of the infraspinatus [6].
- The glenohumeral labrum provides concavity and up to 50% of marginal glenoid socket depth [6].
- The superior shoulder suspensory complex provides a stable connection between the scapula and the axial skeleton [6].
- The superior shoulder suspensory complex is composed of the glenoid, coracoid process, coracoclavicular ligaments, distal clavicle, acromioclavicular joint, and acromion [6].
- The superior strut of the superior shoulder suspensory complex comprises the middle clavicle [6].
- The inferior strut of the superior shoulder suspensory complex comprises the lateral scapular border and spine of the scapula [6].
- The sternoclavicular joint is the only true diarthrodial articulation between the upper appendicular and axial skeletons [6].
- The posterior sternoclavicular joint capsule and ligaments are the primary stabilizers to anterior and posterior translation of the medial clavicle [6].
- The acromioclavicular joint is a small diarthrodial joint with an interposed fibrocartilaginous disk [6].
- The superior and posterior acromioclavicular ligaments are the primary stabilizers to anterior and posterior translation of the clavicle [6].
- The coracoclavicular ligaments are the primary stabilizers to superior translation of the distal clavicle [6].
- The conoid ligament is the medial coracoclavicular ligament [6].
- The trapezoid ligament is the lateral coracoclavicular ligament [6].
- The coracobrachialis muscle and the short head of the biceps tendon originate from the coracoid process [6].
- The pectoralis minor muscle inserts onto the medial coracoid process [6].

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- A soft tissue sheath consistently covers the long head of the biceps tendon to the level of the proximal margin of the pectoralis major tendon [7].
- The fibro-osseous bicipital tunnel consists of three distinct anatomic zones [7].
- Zone 1 of the bicipital tunnel represents the traditional bony bicipital groove beginning at the articular margin and ending at the distal margin of the subscapularis tendon [7].
- Zone 2 of the bicipital tunnel extends from the distal margin of the subscapularis tendon to the proximal margin of the pectoralis major tendon [7].
- Zone 3 of the bicipital tunnel is distal to the proximal margin of the pectoralis major tendon and represents the subpectoral region [7].
- The brachial plexus and axillary artery are anterior to the coracoid process of the scapula and humeral head [4].
- Nerves innervating muscles around the shoulder include the axillary, suprascapular, subscapular, and musculocutaneous nerves [4].
- The anterior compartment of the arm contains the biceps brachii, coracobrachialis, and brachialis muscles [4].
- The neurovascular bundle courses along the medial border of the biceps with the brachial artery and vein and the median, musculocutaneous, and ulnar nerves [4].
- The posterior compartment of the arm contains the triceps brachii muscle and the radial nerve [4].
- The humeral shaft extends from the level of the insertion of the pectoralis major muscle proximally to the supracondylar ridge distally [4].
- The upper portion of the humeral shaft is cylindrical and becomes more flattened in an anteroposterior direction as it proceeds distally [4].
- Medial and lateral intermuscular septae divide the arm into anterior and posterior compartments [4].

Investigations

PLAIN RADIOGRAPHY

- The purpose of shoulder imaging is to help establish the diagnosis, determine the severity of the pathoanatomy, assist in surgical planning, and enable the surgeon to illustrate the condition of the shoulder to the patient [2].
- Standardized plain films are almost always sufficient to garner the information needed for shoulder care [2].
- The first key radiographic view is the anteroposterior (AP) view taken in the plane of the scapula such that the x-ray beam passes through the glenohumeral joint [2].
- The AP view in the plane of the scapula shows the superoinferior position of the humeral head relative to the glenoid, the presence of osteophytes on the humeral head and glenoid, narrowing of the joint space, and the degree of medial displacement of the humerus in relation to the lateral acromial line [2].

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- The AP view in the plane of the scapula also shows the quality of the humeral and glenoid bone, the presence of loose bodies, and whether there is humeral head collapse or deformity [2].
- The second key radiographic view is the axillary view taken with the arm in the functional position of elevation in the plane of the scapula [2].
- The axillary view is oriented so that both the spinoglenoid notch and the scapular neck are visible [2].
- The axillary view demonstrates a different perspective of humeral anatomy, the amount of glenoid bone, the shape of the glenoid, its version in relation to the plane of the scapula, and the relationship of the humeral head to the glenoid fossa [2].
- The axillary view is referred to as the "truth view" because it demonstrates glenohumeral relationships in the functional position of elevation [2].
- CT scans have the disadvantage of being taken with the arm in the adducted position, whereas the axillary truth view is taken with the arm in elevation [2].
- When taken properly, standardized anteroposterior and axillary views indicate the thickness of the cartilage space between the humerus and the glenoid, relative positions of the humeral head and glenoid, presence of osteophytes, degree of osteopenia, and extent of bony deformity and erosion [2].
- Joint space narrowing is most evident on the axillary truth view as opposed to images made with the arm at the side [2].
- The standardized axillary view enables the demonstration of posterior subluxation or "functional decentering" that is not evident in images taken with the arm at the side [2].
- The degree of posterior subluxation can be measured as the position of the center of the humeral head in relation to the plane of the scapula [2].
- The degree of posterior subluxation can be measured as the position of the center of the humeral head in relation to the glenoid face [2].
- The degree of posterior subluxation can be measured as the point of contact of the humeral articular surface on the glenoid articular surface [2].
- The point of contact of the humeral articular surface on the glenoid articular surface reflects the degree of centering of the net humeral joint reaction force on the glenoid [2].
- Malcentering of the joint reaction force leads to posterior instability, posterior glenoid wear, and "rocking horse" loosening of prosthetic glenoid components [2].
- At least two X-ray views should be obtained for shoulder imaging: an anteroposterior in the plane of the glenoid and an axillary projection with the arm in abduction to show the relationship of the humeral head to the glenoid [11].

COMPUTED TOMOGRAPHY

- CT scans may offer a few degrees of increased precision in the measurement of glenoid version [2].
- The precision offered by CT scans for measuring glenoid version does not improve the quality of the surgery or the clinical outcome [2].

- There is information that can be gathered from properly taken plain films that cannot be obtained from CT scans [2].
- Computed tomography (CT) is helpful for planning fracture surgery and shoulder joint replacement [11].
- Three-dimensional reconstructions based on CT scans of the arthritic shoulder are a currently discussed question regarding whether they help surgeons achieve better outcomes compared to imaging consisting only of two standardized plain films [13].

MAGNETIC RESONANCE IMAGING

- Magnetic resonance imaging (MRI) is useful to identify osteonecrosis of the humeral head or a bone tumour [11].
- MRI can identify labral tears and rotator cuff tears [11].
- The accuracy of MRI for identifying labral tears and rotator cuff tears is enhanced by combining the scan with arthrography [11].

ULTRASONOGRAPHY

- Ultrasonography is a simple and accurate test for identifying rotator cuff tears and calcific tendinitis [11].
- Ultrasonography can be useful in guiding injections or barbotage (aspirating calcific deposits in the rotator cuff) [11].
- The most commonly performed joint examination using ultrasonography is the shoulder examination [9].
- The accuracy of rotator cuff ultrasonography depends on the skill of the scanner operator and an awareness of pitfalls that are encountered [9].

GENERAL IMAGING PRINCIPLES

- The diagnosis of a stiff shoulder depends on awareness of the problem, with history and physical examination being paramount and ancillary studies helpful in certain circumstances [1].
- Unless a specific research protocol is in place, the temptation to “overimage” should be resisted, obtaining only the scans or reconstructions that are necessary for the care of the patient [2].
- Proper radiographic technique is as important as proper surgical technique to achieve the desired outcome [2].
- A robust approach to imaging the shoulder needs to recognize that the shoulder is a three-dimensional structure that cannot be represented by a single planar view [13].
- Critical relationships, such as the degree of centering of the humeral head, change with the position of the arm [13].
- Shoulder pathology may be found in a large number of different bones and soft tissues [13].
- Overlying and superimposed structures as well as metallic implants may complicate imaging the structures of interest [13].
- Surgeons need to develop a judicious approach to imaging that yields the information necessary to treat the patient while avoiding the tendency to “over-image” [13].

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