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Surgical Anatomy of the Shoulder

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Abstract

The glenohumeral articulation is a versatile joint that requires a complex integration of bony ligamentous, musculotendinous, and neurovascular structures for proper function. Injuries resulting from dysfunction are common and potentially debilitating. Many of these injuries can be managed nonsurgically; however, if surgical treatment is indicated, a thorough knowledge of the anatomy of the shoulder girdle is critical. It is important for the surgeon to be aware of commonly used arthroscopic and surgical approaches to the glenohumeral joint along with anatomic structures at risk with each surgical approach and methods of avoiding injury.

Instr Course Lect 2012;61:87-95.

Surgical Anatomy

Bony Structures

The shoulder complex comprises several bony structures that play an important role in normal shoulder function. The clavicle is the only bony attachment that connects the glenohumeral joint to the axial skeleton. Its articulation with the sternum and acromial process allows the clavicle to function as a strut, suspending the glenohumeral joint from the axial skeleton. The broad, flat acromion is the most lateral part of the scapula and articulates with the clavicle through the diarthrodial acromioclavicular joint and also serves as an attachment site for several muscles and ligaments.

The coracoid process is an excellent landmark for many shoulder procedures. It lies medial and anterior to the glenohumeral joint and is the attachment site for the conjoined tendon of the coracobrachialis muscle and short head of the biceps muscles. The coracoacromial ligament connects the coracoid and anterolateral acromion, thereby forming the coracoacromial arch. The proximal humerus consists of the head, the surgical and anatomic neck, and the greater (lateral) and lesser (anteromedial) tuberosities. The tuberosities form attachment sites for the rotator cuff muscles, and the bicipital groove lies between them.

The glenohumeral articulation is a ball-and-socket joint formed by the shallow glenoid and the large humeral head. This lack of bony containment is unique to the glenohumeral joint and provides a wide range of motion; however, it also makes the joint prone to instability. The surrounding ligaments and muscles substantially contribute to glenohumeral stability.

Soft-Tissue Structures

The labrum surrounds the glenoid and functions to deepen the glenohumeral socket and provides an attachment site for the glenohumeral ligaments. The superior glenohumeral ligament originates at the superior glenoid tubercle and blends with the anterior rotator cuff musculature and coracohumeral ligament to form the bicep pulley near the bicipital groove. The middle glenohumeral ligament runs from the anterior labrum to the lesser tuberosity, and the inferior glenohumeral ligament connects the inferior glenoid to

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the inferior humerus. Each glenohumeral ligament is believed to contribute to glenohumeral stability in various positions of glenohumeral motion.

Shoulder Musculature

Glenohumeral motion and stability are directly linked to the surrounding musculature. The deltoid consists of anterior, lateral, and posterior components separated by fibrous raphes. Its proximal attachment is to the lateral third of the clavicle anteriorly, the lateral acromion, and the scapular spine posteriorly. The deltoid muscle is innervated by branches of the axillary nerve and inserts at the deltoid tuberosity of the lateral humerus. Its primary function is abduction, flexion, and extension of the shoulder.

The coracobrachialis muscle and pectoralis major muscle lie medial to the deltoid. The two heads of the pectoralis major originate from the clavicle and sternum and insert lateral to the bicipital groove of the humerus. The pectoralis major is innervated by the medial and lateral pectoral nerves and functions primarily as a humeral adductor. The coracobrachialis and the short head of the biceps lie deep to the pectoralis major and deltoid. They originate from the coracoid process and are innervated by the musculocutaneous nerve. The coracobrachialis and the short head of the biceps serve as an important landmark for shoulder surgery because the brachial plexus and vascular structures lie just medial and deep to them.

The rotator cuff musculature exists deep to the deltoid muscle and surrounds the glenohumeral joint. It is composed of four muscles that play an important role in glenohumeral motion and dynamic shoulder stability. The subscapularis originates from the undersurface of the scapula and inserts at the lesser tuberosity. It is innervated by the upper and lower subscapular nerves and functions to internally rotate the humerus. In collaboration with the infraspinatus, the subscapularis inferiorly depresses the humerus, thereby preventing acromial impingement when the deltoid is activated. The infraspinatus and teres minor originate from the posterior scapula and insert at the greater tuberosity. They primarily function by providing an external rotation moment at different degrees of glenohumeral abduction and are innervated by the suprascapular and axillary nerve, respectively. The supraspinatus is also innervated by the suprascapular nerve and inserts at the greater humeral tuberosity. It is responsible for initiating glenohumeral abduction, which allows the deltoid to function more efficiently.

Neural Structures

The axillary nerve innervates the deltoid and teres minor muscles. It originates from the posterior cord of the brachial plexus and runs along the anterior aspect of the subscapularis muscle before passing under the inferior border of the subscapularis medial to the coracoid process. The axillary nerve forms two major branches as it passes under the inferior glenohumeral capsule and exits through the quadrangular space. One branch innervates the teres minor and posterior deltoid, and the other branch winds around the proximal humerus to innervate the lateral and anterior deltoid. In this lateral position, the average distance from the acromion to the axillary nerve is approximately 5 to 7 cm.[1-3]

The musculocutaneous nerve originates from the lateral cord of the brachial plexus and enters the muscle belly of the coracobrachialis an average of 4 to 8 cm distal to the tip of the coracoid process. From this location the nerve exits the coracobrachialis and traverses the interval between the biceps and brachialis muscles. Although the musculocutaneous nerve is not frequently encountered during surgical approaches to the glenohumeral joint, it can be injured by indiscriminant retraction of the conjoined tendon.

The suprascapular nerve originates from the upper trunk of the brachial plexus and passes beneath the trapezius muscle before it passes through the suprascapular notch along the superior edge of the scapula. It is likely most vulnerable to injury along the superior margin of the glenoid before entering the infraspinatus fossa.

Vascular Structures

The blood supply of the shoulder girdle is derived primarily from branches of the subclavian and axillary arteries. The suprascapular artery accompanies the suprascapular nerve and vein over the superior edge of the scapula. In contrast to the suprascapular nerve, the suprascapular artery passes over the transverse scapular ligament and must be protected during suprascapular nerve release. The thoracoacromial branch of the axillary artery follows the course of the coracoacromial ligament and can be injured near this location. If injury occurs, the artery usually can be easily cauterized arthroscopically. The anterior and posterior circumflex humeral arteries encircle the humerus deep to the deltoid. The posterior circumflex artery accompanies the axillary nerve and posterior circumflex vein, whereas the anterior circumflex artery arises deep to the coracobrachialis and runs along the inferior border of the subscapularis. This vessel is frequently encountered with a deltopectoral approach and is ligated before subscapularis mobilization.[4-6]

Surgical Anatomic Layers

Cooper et al[7] described the anatomy of the shoulder as consisting of four layers. Layer 1 consists of the deltoid and pectoralis major muscle bellies. Layer 2 is formed by the clavipectoral fascia, the conjoined tendon, and the coracoacromial ligament anteriorly and is posteriorly continuous with the clavipectoral fascia, with the posterior scapular fascia overlying the infraspinatus and the teres minor muscles. The third layer is composed of the deep layer of the subdeltoid bursa and underlying rotator cuff. Layer 4 is formed by the capsule of the glenohumeral joint.

Open Surgical Approaches to the Shoulder Joint

Deltopectoral Approach

Indications

The indications for a deltopectoral approach to the shoulder joint have decreased considerably over the past two decades because of the evolution of advanced arthroscopic techniques; however, this extensile approach continues to serve as a workhorse approach because it allows access to many areas of the shoulder. Currently, the deltopectoral approach is primarily used for reduction and internal fixation of proximal humerus fractures, to treat bony glenoid injuries, and in shoulder arthroplasty procedures. It can also be used to perform an inferior capsular shift, or in Bankart repair, bicep tenodesis, or rotator cuff repair if the procedure cannot be accomplished arthroscopically.

Technique

The deltopectoral approach is classically performed with the patient in the modified beach chair position. Standard procedures are used to prepare the patient, and the involved extremity is prepped free. A skin incision is made beginning just inferior to the clavicle and passes along the lateral border of the coracoid process. The incision is extended distally along the deltopectoral interval approximately 10 to 12 cm. The subcutaneous tissue is divided, and the cephalic vein should be identified.

The cephalic vein marks the internervous plane between the deltoid and pectoralis major muscles, which are innervated by the axillary and pectoral nerves, respectively.[8] The cephalic vein should be carefully mobilized and may be retracted either medially or laterally. More branches requiring ligation are encountered if the cephalic vein is mobilized from the deltoid and retracted medially; however, the vein is likely easier to protect in this location. The pectoralis major is retracted medially, and the deltoid is retracted laterally to expose the clavipectoral fascia investing the strap muscles and subscapularis. After developing the subdeltoid and subpectoral spaces, a self-retaining retractor can be placed.

The clavipectoral fascia is incised from the inferior margin of the coracoacromial ligament inferiorly along the lateral border of the conjoined tendons of the coracoid process. A subcoracoid plane is then developed bluntly to identify the axillary nerve medially as it passes inferior to the subscapularis muscle. Care should be taken while retracting the conjoined tendon to prevent neurapraxia of the musculocutaneous nerve that enters the coracobrachialis muscle 5 to 8 cm distal to the coracoid process.

The arm is externally rotated, thereby tensioning the subscapularis muscle and increasing the distance between its lesser tuberosity attachment and the axillary nerve along its inferomedial border. The inferior margin of the subscapularis is marked by a triad of small vessels that must be ligated before reflecting the subscapularis insertion. The rotator interval can be incised along the inferior border of the supraspinatus tendon to provide access to the glenohumeral joint. The lesser tuberosity is identified, and the subscapularis insertion is removed sharply, leaving a 1-cm stump for reattachment, or, alternatively, the lesser tuberosity may be removed with a small fleck of bone. Removal of the bone provides bone-to-bone healing that can be radiographically monitored. Regardless of the technique, it is usually possible to separate the capsule from the overlying subscapularis tendon if desired. A capsulotomy is then preformed, and access to the anterior glenohumeral joint is established (**Figure 1**).

Structures at Risk

Several neurovascular structures may be at risk with a deltopectoral approach. The cephalic vein lies within the deltopectoral interval and is an excellent landmark for its identification. It can be mobilized either medially or laterally as the interval is opened. Lateral retraction is often easier to accomplish because fewer tributaries requiring ligation are encountered entering the pectoralis compared with the deltoid. However, the vessel is more frequently injured intraoperatively with lateral mobilization because of the placement of the deltoid retractor. Although efforts are made to preserve this vessel if possible, it can be ligated if it is injured.

The musculocutaneous and axillary nerves are also occasionally injured during the deltopectoral approach. The musculocutaneous nerve is infrequently directly encountered during the surgical approach as it enters the coracobrachialis 5 to 8 cm distal to the coracoid and medial to the typical surgical exposure. Nevertheless, a traction injury can occur with exuberant traction of the conjoined tendon. Adequate subcoracoid mobilization and moderated retraction are usually successful in preventing a traction neurapraxia. The axillary nerve is also at risk during this approach. It should

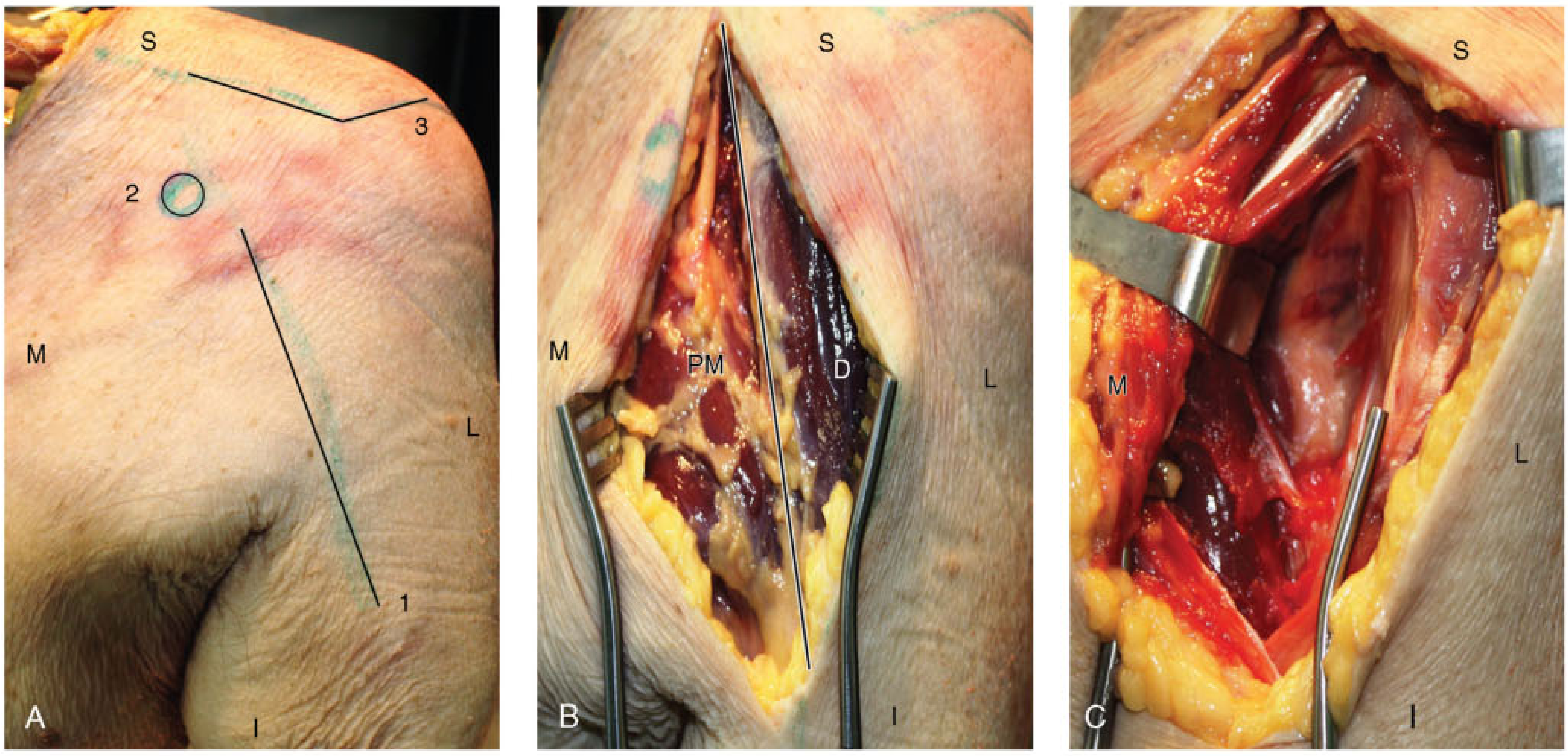

Figure 1 The deltopectoral approach to the shoulder joint demonstrated on a left cadaver shoulder. M = medial, L = lateral, S = superior, I = inferior. **A,** Markings show the skin incision (1), the coracoid process (2), and the anterior and lateral rim of the acromion (3). **B,** Markings show the pectoralis major (PM) muscle medially and the deltoid (D) muscle laterally. **C,** After performing a capsulotomy, the anterior glenohumeral joint is exposed by retracting the joint capsule and the surrounding musculature.

always be identified inferior and medial to the coracoid process after the clavipectoral fascia is incised. It can typically be palpated running inferior to the subscapularis in this location. Injury can also occur along the inferior glenoid. Several cadaver studies have reported that the nerve is within 10 to 15 mm of the inferior glenoid and can be within 2 to 3 mm of the inferior capsular pouch. Care should be taken in performing an inferior capsular release for shoulder arthroplasty or when taking tucks of capsular tissue during a capsular shift procedure. Damage to this nerve can cause dramatic functional limitations if the deltoid is completely denervated.[4-6]

Lateral Deltoid-Splitting Approach

Indications

The lateral deltoid-splitting approach provides exposure of the lateral aspect of the humeral head and rotator cuff. It is not a traditional extensile approach because of the proximity to the axillary nerve inferiorly. The lateral deltoid-splitting approach is primarily limited to rotator cuff repair and surgical fixation of greater tuberosity fractures or simple, two-part proximal humerus fractures. More recently, it is occasionally used for reverse shoulder arthroplasty if the superior rotator cuff is absent.

Technique

The patient is typically placed in the modified beach chair position and the involved extremity is prepped free. A 5-cm skin incision is made from the anterolateral tip of the acromion and extended inferiorly along the lateral aspect of the deltoid. Subcutaneous tissue is divided, and the deltoid is identified. The deltoid is split in line with its fibers from the acromion distally but should not be extended more than 5 cm from the acromion to avoid injury to the axillary nerve. The deltoid may be split between any of its fibers, but the raphe dividing the anterior and the lateral deltoid provides a relatively avascular plane to expose underlying structures. Retraction of the deltoid musculature reveals the subdeltoid portion of the subacromial bursa. Removal of this bursa provides access to the underlying rotator cuff musculature, greater tuberosity, and subacromial space (**Figure 2**).

Structures at Risk

The primary structure at risk during the lateral deltoid-splitting approach is the lateral continuation of the axillary nerve along the inferior margin of the incision. On average, this portion of the axillary nerve is located 5 to 7 cm distal to the lateral border of the acromion deep to the deltoid muscle. If the deltoid split is not extended more than 5 cm distal to the acromion, injury to the axillary nerve is unlikely. Injury to the nerve in this location can poten-

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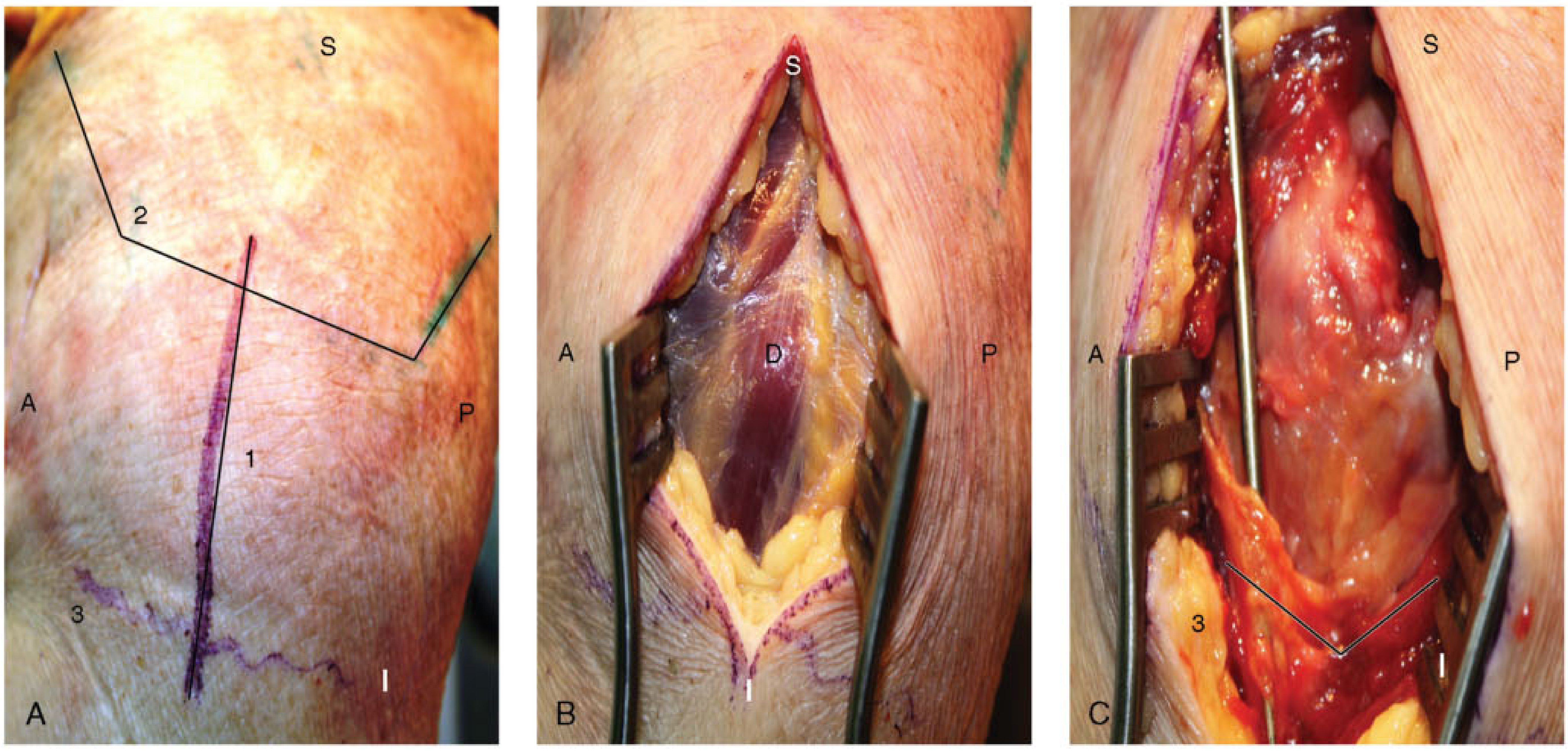

Figure 2 Lateral deltoid-splitting approach demonstrated on a left cadaver shoulder. A = anterior, P = posterior, S = superior, I = inferior. **A,** Markings show the skin incision (1), the lateral aspect of the acromion (2), and the suspected site of axillary nerve (3). **B,** Markings show the deltoid muscle (D) after the skin is incised and the subcutaneous tissue is divided. **C,** Markings show the suspected site of the axillary nerve (3) after splitting and retracting the deltoid muscle.

tially cause denervation of the lateral or anterior deltoid and numbness along the lateral deltoid.[4-6]

Posterior Glenohumeral Approach

Indications

The indications for a posterior approach to the glenohumeral joint have decreased as advanced arthroscopic techniques have emerged. This approach is still frequently used to treat recurrent posterior shoulder dislocations, either by performing a posteroinferior capsular shift or with bony reconstruction of the posterior glenoid deficiency. In certain circumstances, the posterior approach may also be used to perform a glenoid osteotomy or for internal fixation of scapular or glenoid fractures.

Technique

A posterior approach to the glenohumeral joint may be performed with the patient in the modified beach chair or the lateral decubitus positions. The involved extremity is prepped and draped free. A linear incision is made approximately 2 cm medial to the posterolateral border of the acromion. The incision is begun just inferior to the spine of the scapula and extended distally approximately 7 to 8 cm. The subcutaneous tissues are divided, thereby exposing the posterior deltoid and underlying musculature.

The arm is abducted and externally rotated slightly to relax the posterior deltoid. This technique allows the deltoid to be retracted laterally to expose the underlying teres minor and major musculature medially and the long head of the triceps more laterally. An internervous plane exists between the infraspinatus (suprascapular nerve) and teres minor (axillary nerve) muscles. This interval is developed by retracting the infraspinatus superiorly and the teres minor inferiorly to expose the posterior glenohumeral joint capsule. The capsule is tagged and incised and provides access to the posterior glenoid and humerus (**Figure 3**).

Structures at Risk

Two structures are primarily at risk using the posterior approach to the glenohumeral joint. The axillary nerve emerges from the quadrilateral space between the teres major and minor muscles as it proceeds along the lateral aspect of the humerus deep to the deltoid. If dissection is inadvertently carried through the teres minor and teres major interval, injury to the axillary nerve or the posterior circumflex humeral artery may occur. It is important to precisely identify the appropriate surgical interval between the infraspinatus and teres minor to avoid iatrogenic injury to these structures. Less commonly, the suprascapular nerve can be injured beneath the infraspinatus medial to the glenoid. Although the suprascapular nerve can be injured if dissection proceeds too medially, it is primarily injured by exuberant retrac-

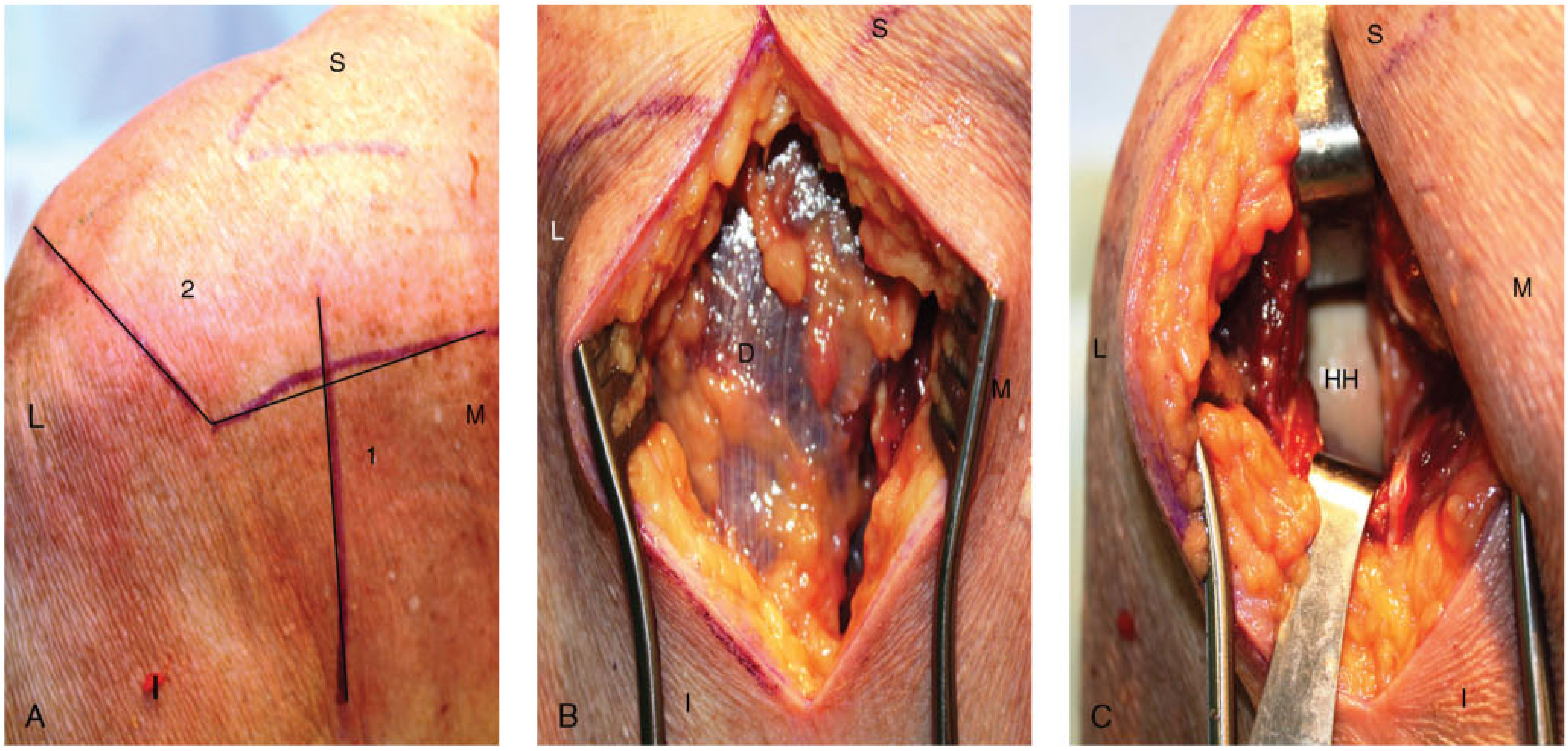

Figure 3 Posterior approach to the glenohumeral joint demonstrated on a left cadaver shoulder. M = medial, L = lateral, S = superior, I = inferior. **A,** Markings show the skin incision (1) and the lateral aspect of the acromion (2). **B,** Markings show the deltoid muscle (D) after the skin is incised and the subcutaneous tissue is divided. **C,** Markings show the posterior aspect of the humeral head (HH) after incision of the posterior joint capsule.

tion of the muscle. Careful mobilization and retraction of the infraspinatus and teres minor will minimize the risk of traction injury to the nerve.[4-6]

Arthroscopic Treatment Considerations

Relevant Anatomy

Arthroscopic shoulder surgery has dramatically improved the diagnosis and treatment of shoulder injuries. Anatomically, the shallow ball-and-socket joint and sizable capsule make the joint ideal for arthroscopic treatment; however, the thick muscular layers and the presence of neurovascular structures require accurate portal placement.

A thorough knowledge of the anatomy of the surrounding neurovascular structures is important to the shoulder arthroscopist. Anteriorly, the neurovascular structures at risk for injury with aberrant portal placement include the axillary and musculocutaneous nerves, the cephalic vein, and the thoracoacromial artery. The axillary and musculocutaneous nerves both lie medial and distal to the coracoid process. If portals are placed superior or lateral to the coracoid, the axillary and musculocutaneous nerves are unlikely to be injured. Lateral portal placement, however, risks injury to the cephalic vein running within the deltopectoral interval. If the anterior portal is placed within the rotator interval, risk to the cephalic vein is minimal. Branches of the thoracoacromial artery also may be injured with superiorly placed portals used to enter the subacromial space near the coracoacromial ligament. If these branches are inadvertently damaged, they are usually easily coagulated arthroscopically.

Posterior portal placement also puts several neurovascular structures at risk. The axillary nerve exits the axillary pouch through the quadrangular space and courses around the proximal humerus deep to the deltoid at 6 to 7 cm (on average) distal to the acromion. Only very inferior posterior portal placement should put the nerve at risk in this location. The suprascapular nerve innervates the supraspinatus and infraspinatus muscles. It runs through the suprascapular notch medial to the coracoclavicular ligaments, enters the supraspinatus fossa deep to its muscle belly, wraps lateral to the scapular spine, and terminates within the infraspinatus fossa. The suprascapular nerve may be at risk with posterior portal placement situated several centimeters medial to its ideal location.

Standard Portal Placement

Indications

As advanced arthroscopic techniques emerge and instrumentation improves, more procedures that have traditionally been performed open can be accomplished arthroscopically. Current indications for arthroscopic treatment include rotator cuff tears, long head of the biceps and superior labral injuries, labral detachment, and arthrofibrosis of the shoulder. More recent arthroscopic applications include suprascapular nerve decompression and transcapular axillary nerve and brachial plexus exploration.

Basic Technique

A basic understanding of the principles of arthroscopic portal placement is important to facilitate safe portal placement. Anatomic landmarks should be used to estimate the appropriate portal location. Because the anatomy of each patient will differ slightly, an 18-gauge spinal needle should be used to confirm (before making the skin incision) that the location of the portal is appropriate to treat the suspected glenohumeral injury. Next, a No. 11 blade scalpel is used to make a 5- to 6-mm incision just through the skin and subcutaneous tissue. Because arthroscopic portals are placed blindly, a blunt trocar should always used. This method provides an added measure of security when placing portals in close proximity to neurovascular structures.

Although outside-in portal placement techniques are most commonly used, familiarity with inside-out techniques may occasionally be useful. After an initial arthroscopic portal is established, a switching stick or other device can be advanced from the interior to the exterior of the joint to localize other arthroscopic portals. This technique is most frequently used to establish anterior portals after a standard posterior portal is established. The disadvantage to this technique is that secondary portal placement is constrained by the placement of the initial portal. Therefore, there is less freedom for portal placement compared with outside-in techniques. When placing portals in sensitive areas close to neurovascular structures, a Seldinger-type technique can be used. A guidewire or switching stick is placed, and cannulated dilators are sequentially passed before placing the working portal cannula.

Specific Portal Techniques

Knowledge of bony landmarks of the shoulder will aid the surgeon in portal placement (**Figure 4**).

Anterior and Posterior Portals

In a manner similar to that used in other shoulder procedures, the patient is placed in the modified beach chair position. Standard methods are used to prepare the patient, and the extremity is draped free. The posterior and anterior portals are commonly used in shoulder surgery and are interchangeable as viewing and working portals. The posterior portal is typically established first for visualization of the glenohumeral joint. This portal is traditionally placed 2 cm inferior to and 1 cm lateral to the posteroinferior border of the acromion; however, portal placement will vary based on the expected intra-articular pathology. Using the coracoid as a guide, the arthroscopic trocar is introduced into the glenohumeral joint. The posterocentral portal differs slightly in that it is placed in line with the glenoid, allowing easier passage of the arthroscope anteriorly if necessary. Although the trocar may pass between the infraspinatus and teres minor, it more frequently travels through the substance of the infraspinatus muscle.[9]

The anterior portal is typically placed half the distance between the coracoid process and anterolateral acromion, although its placement should again be modified based on intra-articular pathology. Typically, a spinal needle is used to localize the portal within the rotator interval before cannula insertion. Although most glenohumeral joint pathology can be treated through these portals (**Figure 5**), several others are frequently used for more specialized tasks.

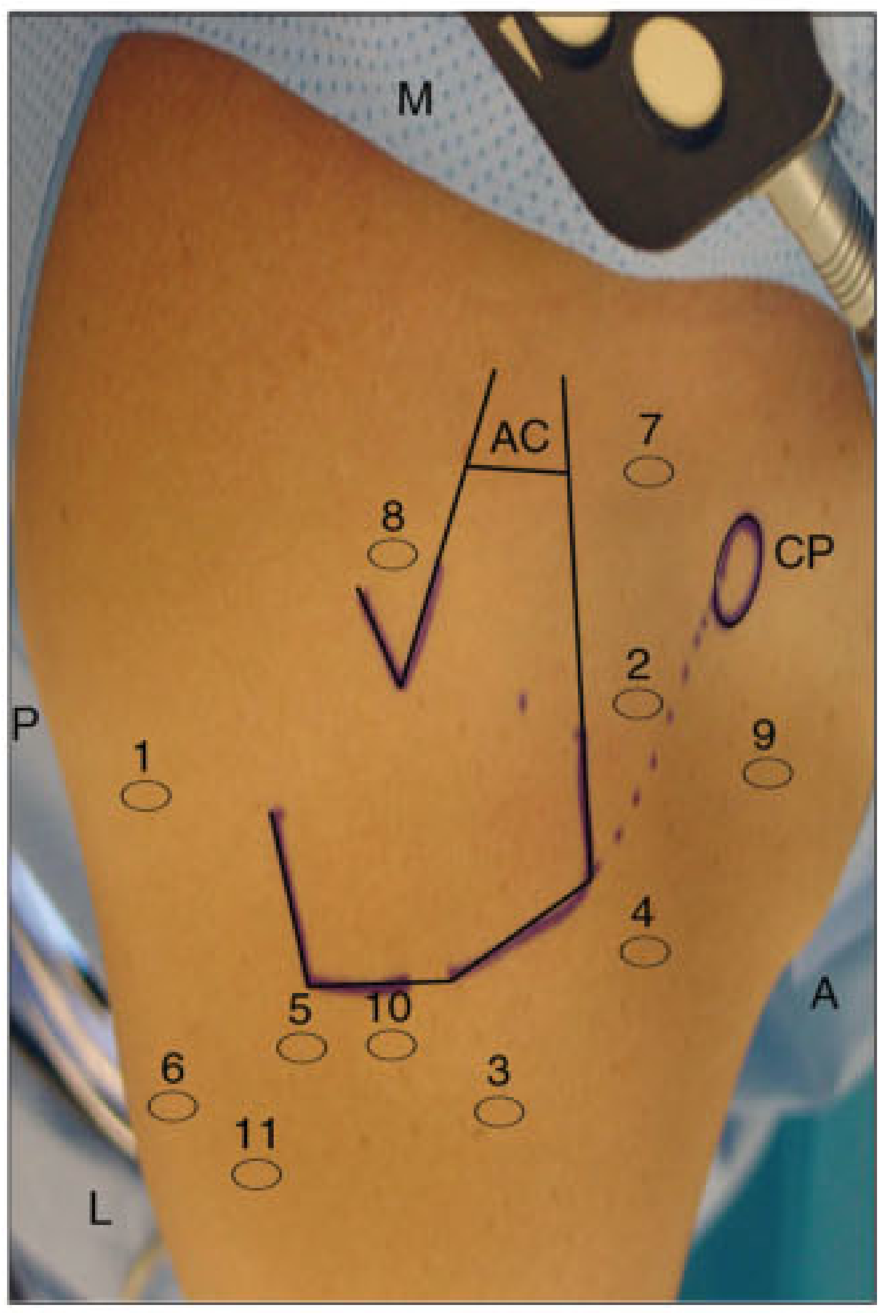

Figure 4 Superior view of a left shoulder with bony landmarks and possible portal placements marked. M = medial, L= lateral, A = anterior, P = posterior, CP = coracoid process, AC = acromioclavicular joint, 1 = standard posterior portal, 2 = standard anterior portal, 3 = standard lateral portal, 4 = anterolateral portal, 5 = posterolateral portal, 6 = posteroinferolateral portal, 7 = subclavian portal, 8 = Neviaser portal, 9 = anteroinferior portal, 10 = portal of Wilmington, 11 = trans-rotator cuff portal.

Lateral Portals

Anterolateral and posterolateral portals are frequently used to provide access to the subacromial space to perform an arthroscopic rotator cuff repair, subacromial decompression, acromioplasty, or suprascapular nerve decompression. These portals are typically located approximately 2 cm distal to the lateral border of the acromion and 1 cm from the respective anterior or posterior corners of the acromion. No structures are jeopardized by these portals if they are not placed extremely distally, where damage can occur to the axillary nerve.

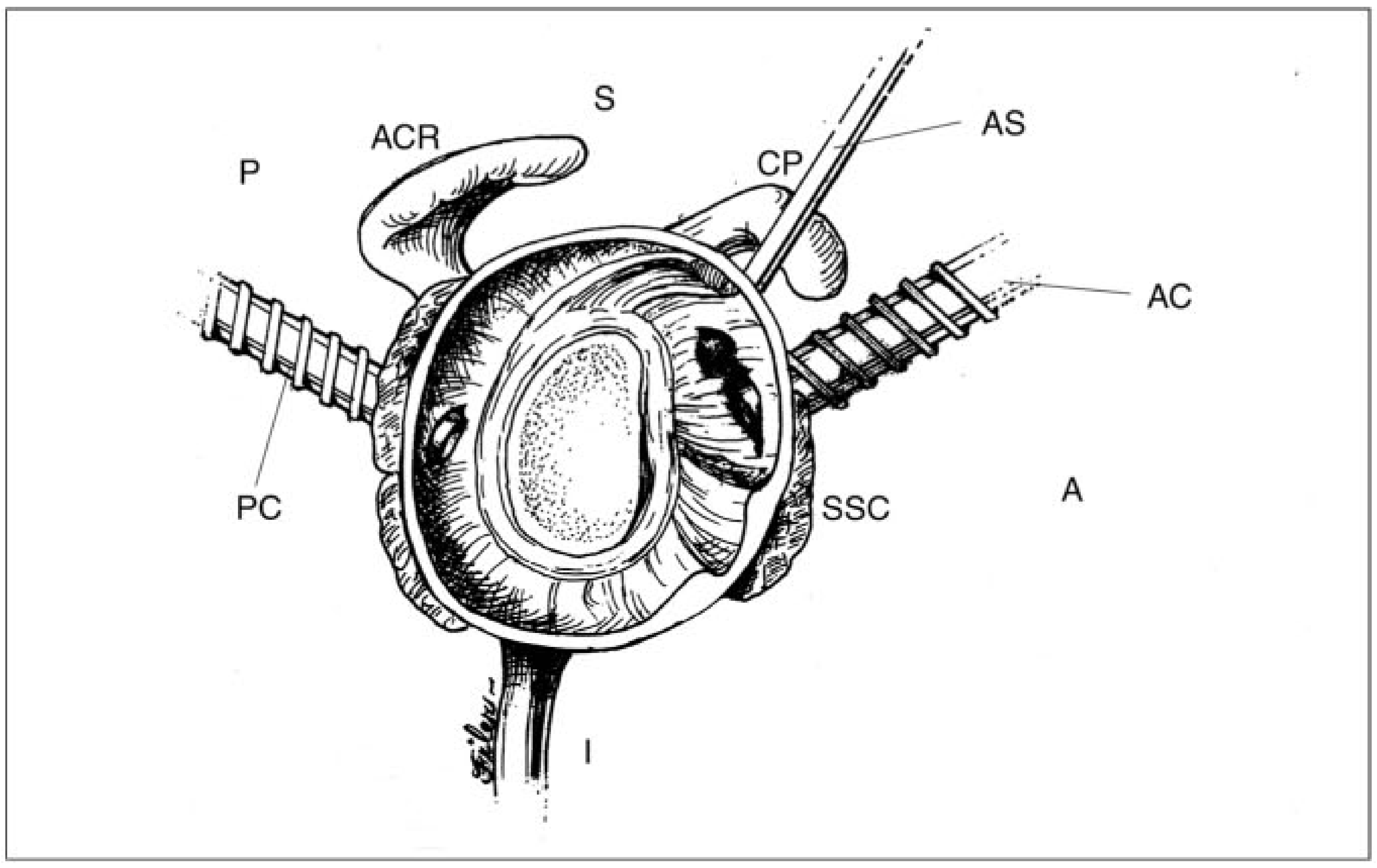

Figure 5 Illustration showing anterior and posterior intra-articular portal placement viewed laterally. The anterior portal is placed in the rotator interval between the supraspinatus and subscapularis muscle. A = anterior, P = posterior, S = superior, I = inferior, AC = anterior canula, PC = posterior canula, AS = arthroscope, ACR = acromion, CP = coracoid process, SSC = subscapularis muscle. (Reproduced from Millet PJ, Clavert P, Hatch GR III, Warner JJ: Recurrent posterior shoulder instability. *J Am Acad Orthop Surg* 2006;14(8): 464-476.)

Posteroinferolateral Portal

A posteroinferolateral portal can be placed approximately 5 to 6 cm distal to and in line with the posterolateral corner of the acromion and provides improved access to the inferior glenohumeral pouch. From this portal, inferior humeral osteophytes can be removed and inferior glenoid anchors can be placed to complete an inferior capsular shift. It can also be used to perform a transcapular axillary nerve decompression for quadrilateral space syndrome. The posteroinferior lateral portal is in close proximity to the axillary nerve as it passes through the axillary space. The axillary nerve travels anteromedially to posterolaterally as it passes beneath the glenohumeral capsule. To prevent iatrogenic injury to the axillary nerve, the portal should enter the glenohumeral joint just anterior to the posterior band of the glenohumeral ligament at the junction of its medial and middle thirds.

Subclavian Portal

The subclavian portal was created to facilitate rotator cuff repairs by allowing more direct access to rotator cuff tissues for passage of penetrating instruments. It is located 1 to 2 cm medial to the acromioclavicular joint (just medial to the coracoid process) and directly under the clavicle. The trocar is then advanced anterior and inferior to the acromioclavicular joint before entering the subacromial bursa. From this portal, rotator cuff penetrating devices can be used to pass stitches through the rotator cuff after anchors have been placed in the humeral head. Medial or inferior placement may endanger the subclavian vascular structures or the brachial plexus.

Neviaser Portal

The Neviaser portal is also known as the supraclavicular fossa portal. Its was initially described as an inflow portal, but it is also useful for arthroscopic repair of superior labrum anterior and posterior lesions.[10] It is created in the soft spot defined by the clavicle anteriorly, the acromion laterally, and the scapular spine posteriorly. The portal is typically created using an outside-in technique, passing the arthroscopic trocar slightly laterally and posteriorly. Although this is a relatively safe position for portal placement, it is typically a mean distance of 24 mm from the suprascapular artery and 26 mm from the suprascapular nerve. Passing the arthroscopic trocar slightly laterally will help avoid injury to these structures because they lie more medially than the portal incision.

Anteroinferior Portal

The anteroinferior or 5-o'clock portal was developed to improve arthroscopic access for Bankart repairs. This portal provides perpendicular access to the anteroinferior glenoid for inferior anchor placement and inferior capsular shift procedures. The 5-o'clock portal was initially described using an inside-out technique with a switching stick from the standard posterior viewing portal. This results in portal placement that exits the skin in an anteroinferior position near neurovascular structures. Cadaver studies have shown the axillary artery is in closest proximity to the 5-o'clock portal and can be within 13 mm of the portal. The axillary nerve and cephalic vein are also at risk at approximately 15 and 17 mm from the trocar.[9] Some physicians recommend establishing this portal using an outside-in technique that allows a more lateral and less inferior starting point, which may provide a larger margin of safety while facilitating anteroinferior glenohumeral joint access.[11]

Port of Wilmington and Trans-Rotator Cuff Portals

A skin incision for the port of Wilmington portal is established 1 cm ante-

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rior and 1 cm lateral to the posterolateral corner of the acromion. An arthroscopic trocar is then advanced in a direction that allows approximately a 45° angle of approach to the posterosuperior glenoid and traverses the rotator cuff. A similar trans-rotator cuff portal was described by O'Brien et al.[12] Typically, this portal is made approximately 2 cm lateral and 1 cm posterior to the posterolateral acromion. This portal also passes through the rotator cuff to the posterosuperior aspect of the labrum. These portals can facilitate anchor placement and suture management of superior labrum anterior and posterior lesion repairs with a large posterior component. These approaches pose little risk to neurovascular structures, but the portals uniformly violate the supraspinatus or infraspinatus tendon—although the clinical significance is unknown.

Summary

The glenohumeral articulation is a versatile and complex joint. Bony, ligamentous, musculotendinous, and neurovascular structures each play a key role in joint function. In patients treated with arthroscopic shoulder procedures, a thorough knowledge of the surgical anatomy and approaches to the glenohumeral joint are mandatory to optimize joint function.

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