

Shoulder Arthroscopy: Basic Principles of Positioning, Anesthesia, and Portal Anatomy

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Abstract

Advances in modern arthroscopy have contributed significantly to greater flexibility and efficacy in addressing shoulder pathology. Advantages of arthroscopy include less invasive approaches, improved visualization, decreased risk of many postoperative complications, and faster recovery. As a result, arthroscopy is often preferred by both orthopaedic surgeons and patients. Common shoulder conditions that can be managed arthroscopically include rotator cuff tears, shoulder instability, and labral pathology. A thorough understanding of anatomic principles in conjunction with proper patient positioning and portal selection and placement are essential for successful arthroscopic shoulder surgery.

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With improvements in technology and instrumentation, arthroscopy has become the primary treatment modality for many shoulder disorders. Compared with open techniques, arthroscopy allows for smaller incisions and is associated with decreased risk of deltoid muscle damage,¹ improved intra-articular visualization,¹ less pain immediately postoperatively,² and potentially faster postoperative recovery. As a result, both surgeons and patients have demonstrated a preference for arthroscopy.

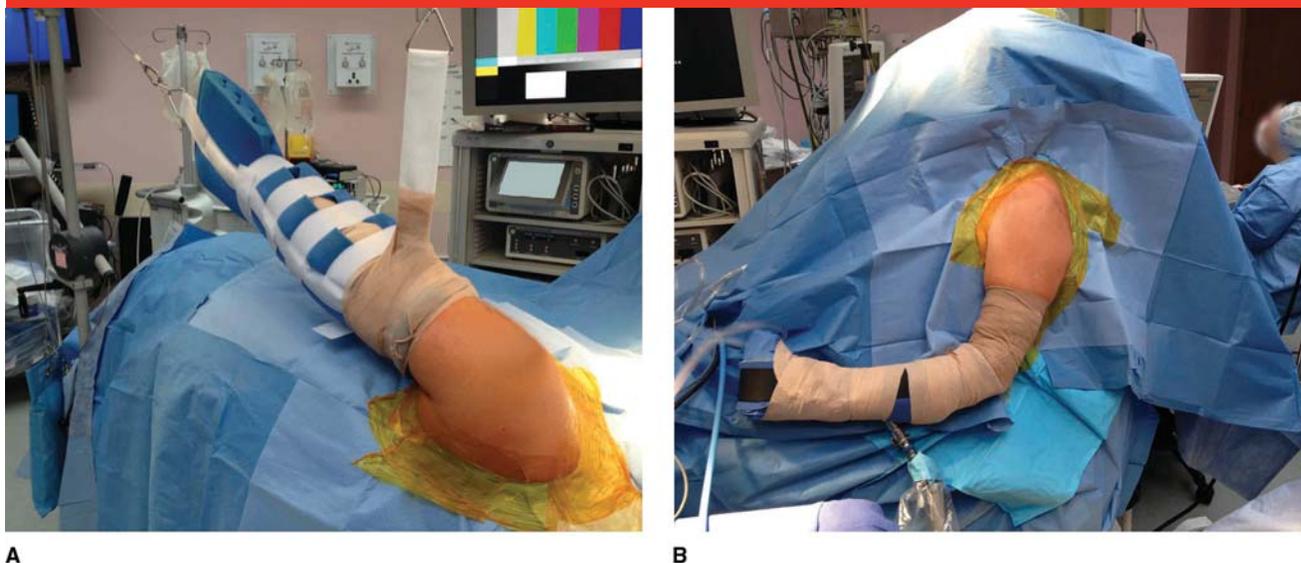
The challenges of shoulder arthroscopy are often underestimated, however. Especially in obese patients, anatomic landmarks are more difficult to palpate in the shoulder than in other joints (eg, the knee). This can add to the difficulty of portal placement and may increase the risk of neurovascular injury. Complication rates of 4.6% to 10.6% have been reported with shoulder arthroscopy.³ Neurologic injury is the most com-

mon finding. A thorough understanding of shoulder anatomy is essential to minimize the risk of complications.

Patient Positioning and Anesthesia

Shoulder arthroscopy is performed with the patient in either the lateral decubitus position (LDP)⁴ (Figure 1, A) or the beach-chair position (BCP)⁵ (Figure 1, B). For the LDP, the patient is positioned laterally on a padded table with a beanbag type support placed on the lower torso and pelvis, keeping the nonsurgical arm in 90° of flexion, the knees bent, and the head in neutral alignment. Bony prominences must be adequately padded, and an axillary roll is placed under the nonsurgical arm to protect the neurovascular structures. The surgical arm is then placed in a sling, and traction is applied longitudinally with or without an additional sling to provide lateral traction of the up-

Figure 1



Intraoperative photographs demonstrating patient positioning for shoulder arthroscopy. **A**, The lateral decubitus position. **B**, The beach-chair position with use of a sterile arm holder. (Photographs courtesy of Matthew Smith, MD, St. Louis, MO.)

per arm. Gross and Fitzgibbons⁶ modified this position to improve visualization by tilting the table 20° to 30° posteriorly, thereby positioning the glenoid parallel to the floor.

The position of the arm and the amount of traction applied is important in ensuring adequate visualization while minimizing the risk of neurovascular injury. Klein et al⁷ extensively studied the relationship between arm position and strain on the brachial plexus. In a cadaver study, they found that at any given abduction or flexion angle, increasing flexion or abduction, respectively, reduced strain. They concluded that a combination of two positions, 45° forward flexion/zero degrees abduction and 45° forward flexion/90° abduction, maximized visibility while minimizing strain. Regardless of arm position, traction should be limited to 15 to 20 lb.⁸ It is important to understand the ischemic consequences of traction, particularly with lateral traction, because it can markedly reduce local and distal tissue perfusion.⁹

Advantages of the LDP include increased visualization of the glenohumeral joint and subacromial space without the need of an assistant to apply traction. Lateral distraction of the glenohumeral joint allows easier access to the posterior and inferior glenohumeral joint, thereby easing posterior capsular imbrication procedures and capsulolabral reconstructions. However, the incidence of nerve injury has been estimated to be 10% in the LDP with the arm in traction.¹⁰

The BCP was first described by Skyhar et al⁵ in 1988. It was developed in an effort to avoid the neuropathies seen with the LDP. In contrast to the LDP, neuropathies are rarely reported with the BCP.^{8,11} The patient is positioned supine on a table equipped with a headrest and movable back and foot sections. The table is placed in the Trendelenburg position, with the patient's feet elevated 15°. The knees are flexed to 30°, and a pillow is placed behind them, after which the table is adjusted to bring the trunk upright,

with 60° of hip flexion. The head is kept in neutral alignment in the holder. The nonsurgical arm is placed in an armrest, and the surgical arm is placed either in a sterile holder, which may itself provide traction, or on a sterile padded Mayo stand.

Proposed advantages of the BCP include a lower incidence of neuropathies, decreased risk of neurovascular complications during portal placement, decreased surgical time, easier conversion to an open procedure, and better visualization of the joint.^{8,12,13} The chief complications are maintenance of cerebral perfusion and adequate airway control. In the awake, upright patient, the sympathetic nervous system is stimulated, which increases vascular resistance and mean arterial pressure (MAP) while decreasing cardiac output. This physiologic response is essential to maintain cerebral perfusion. Under general anesthesia, however, the sympathetic nervous system cannot effectively respond to the upright position, which causes a

relative decrease in vascular resistance, a reduction in MAP, and greater reduction in cardiac output. Intraoperative hypotension may occur in patients in the BCP under general anesthesia.¹⁴

Hypotensive anesthesia is a common and safe technique used to aid in visualization in both the LDP and BCP.¹⁰ Potential advantages of intraoperative hypotension include limiting blood loss and maintaining a clear view during arthroscopy. The typical goal is to create a pressure difference of <49 mm Hg between the patient's systolic blood pressure and the pump pressure of the fluid in the surgical space.¹⁵ This can be achieved by either decreasing the systolic blood pressure (ie, inducing hypotension), increasing the pump pressure, or both. However, increasing pump pressure can lead to excessive fluid extravasation into the surrounding soft tissues and thus can shorten the effective surgical time secondary to difficulty in visualizing the surgical area.¹⁵

Although there are known theoretical disadvantages of low blood pressure, it is unclear what effect permissive intraoperative hypotension has on cerebral perfusion.¹⁴ Using near-infrared spectroscopy, Murphy et al¹⁶ compared cerebral oxygenation saturation (rSO_2) in patients undergoing shoulder arthroscopy in either the BCP or the LDP. They found that 80% of patients treated in the BCP under general anesthesia had a desaturation in rSO_2 of $\geq 20\%$, compared with zero percent in the LDP. Patients who experienced a cerebral desaturation event also had a higher incidence of postoperative nausea and vomiting, as well as associated intraoperative systemic desaturations. Using similar monitoring techniques in patients undergoing shoulder arthroscopy in the BCP, Lee et al¹⁷ found that although MAPs decreased at all time points past induction,

rSO_2 decreased only after patients were positioned in the BCP. Of note, Yadeau et al¹⁸ found that although hypotension was common when shoulder arthroscopy was performed with the patient in the BCP, occurring in 75 of 99 patients, rSO_2 desaturation was uncommon when regional anesthesia was used. This suggests that maintenance of cerebral blood flow may be better with regional anesthesia with the patient in the BCP. In a recent poll of members of the American Shoulder and Elbow Surgeons Society, however, the rate of a cerebral vascular event in an estimated 173,370 to 209,628 cases was reportedly <0.01% in both positions.¹⁹ Therefore, the clinical relevance of this observed cerebral desaturation is unclear.

It has also been suggested that cerebral desaturation events in the BCP are more common with use of an antihypertensive agent on the day of surgery; however, the use of angiotensin-converting-enzyme inhibitors and angiotensin receptor blockers might be acceptable.²⁰ With this in mind, counseling the patient on holding antihypertensives before surgery may be advisable. The use of sequential compression devices also may decrease the risk of cerebral hypotension in patients who are positioned in the BCP; as a result, these devices are recommended for this procedure.²¹

The risk of intraoperative hypotensive events underscores the need for effective communication with the anesthesia team. Regional anesthesia appears to be advantageous and provides reliable postoperative pain control. Newer techniques in peripheral nerve blockade, including ultrasonographic localization, have led to fewer reported postoperative complications. In a series of 1,169 patients, Liu et al²² reported 99.8% successful pain relief when ultrasound-guided interscalene and supraclavicular

blocks were used in ambulatory shoulder surgery. Postoperative hoarseness was more common with interscalene block than with supraclavicular block. No significant difference was found in postoperative dyspnea between the two groups (7%, supraclavicular; 10%, interscalene). Postoperative nerve symptoms were found in only 0.4% of patients, and no patient had permanent nerve injury. The authors imply that ultrasound-guided localization for peripheral nerve blockade may be more accurate than use of a nerve stimulator, which has a reported incidence of postoperative nerve symptoms of 11% to 14%.

More severe complications from interscalene blocks (eg, pneumothorax or central nervous system toxicity) are much rarer.²³ The reported rate of phrenic nerve blockade with an interscalene block is 100%, with subsequent hemiparalysis of the diaphragm and an almost 30% reduction in forced vital capacity and forced expiratory volume.²⁴ These blocks may not be appropriate in patients with underlying pulmonary issues.

Even with the aforementioned risks, both patient positions are widely regarded to be safe. Therefore, the optimal position for shoulder arthroscopy is left to the discretion of the surgeon based on training and clinical experience (Table 1).

Pertinent Shoulder Anatomy in Arthroscopy

Following sterile draping, the bony landmarks are palpated and marked (Figure 2). The borders of the acromion, clavicle, scapular spine, coracoid, coracoacromial ligament, and acromioclavicular joint are marked, with the posterolateral edge of the acromion being easiest to palpate. Typically, the triangle made between

Table 1**The Beach-chair and Lateral Decubitus Positions for Arthroscopic Shoulder Surgery: Advantages and Disadvantages**

	Lateral Decubitus	Beach Chair
Advantages	<ol style="list-style-type: none"> 1. Traction increases space in joint and subacromial space 2. Traction accentuates labral tears 3. Operating room table/patient's head not in the way of posterior and superior shoulder 4. Cautery bubbles move laterally out of view 5. No increased risk of hypotension/bradycardia; better cerebral perfusion 	<ol style="list-style-type: none"> 1. Upright, anatomic position 2. Ease of examination under anesthesia 3. Arm not hanging in the way of anterior portal 4. No need to reposition or redrape to convert to open procedure 5. Can use regional anesthesia 6. Mobility of operative arm
Disadvantages	<ol style="list-style-type: none"> 1. Nonanatomic orientation 2. Must reach around arm for anterior portal 3. Must reposition and redrape to convert to open procedure 4. Patients do not tolerate regional anesthesia 5. Traction can cause neurovascular and soft tissue injury 6. Increased risk of injury to axillary and musculocutaneous nerves when placing anteroinferior portal 	<ol style="list-style-type: none"> 1. Potential mechanical blocks to use of scope in posterior or superior portals 2. Increased risk of hypotension/bradycardia causing cardiovascular complications 3. Cautery bubbles obscure view in subacromial space 4. Fluid can fog camera 5. Theoretically increased risk of air embolus 6. Expensive equipment if using beach chair attachment with or without mechanical arm holder

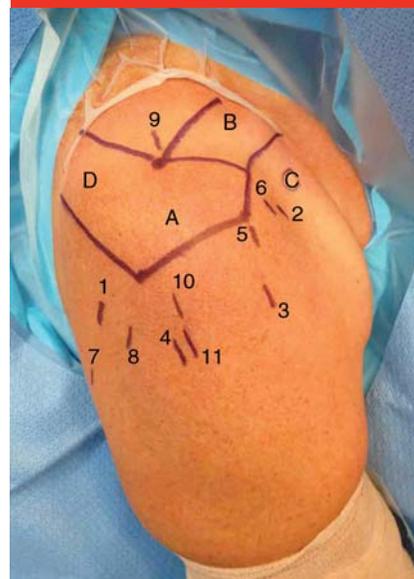
Reproduced with permission from Peruto CM, Ciccotti MG, Cohen SB: Shoulder arthroscopy positioning: Lateral decubitus versus beach chair. *Arthroscopy* 2009;25(8):891-896.

the posterolateral corner of the acromion, the anterolateral corner of the acromion, and the superior soft spot between the acromion and clavicle is equilateral. The tip of the coracoid generally lies in the center of a curve that is made by the anterior edge of the acromion and the concave curve of the anterior clavicle. The literature often reports the distance of neurovascular structures from these landmarks; thus, identifying the borders of these structures is important to safe and accurate portal placement.

The axillary nerve, cephalic vein, and suprascapular artery and nerve are the structures most at risk during shoulder arthroscopy.²⁵ Knowledge of their locations and courses is important to avoid traumatic injury during portal placement. The axillary nerve travels posterior to the

coracoid and inferior to the lateral border of the subscapularis medial to the musculotendinous junction (Figure 3). The nerve can be as close as 3.1 cm from the leading edge of the acromion with arm abduction at this point.²⁶ Typically, the axillary nerve then gives off two branches that supply the inferior capsule. In a cadaver study, Uno et al²⁷ found that the axillary nerve is connected to the capsule with loose tissue between the 5 and 7 o'clock positions and lies close to the glenoid in the neutral position, extension, and internal rotation. Abduction, external rotation, and traction cause the capsule to distend and, thus, move the nerve away from the joint, possibly making this position safer during arthroscopic surgery in the anteroinferior joint.

After passing the capsule, the axil-

Figure 2

Intraoperative photograph of a prepped and draped shoulder arthroscopy patient with important bony landmarks and portal locations marked on the surgical shoulder. The 5 o'clock, 7 o'clock, and anteroinferior portals are safely created using an inside-out technique. A, acromion; B, clavicle; C, coracoid process; D, scapular spine; 1, posterior portal; 2, anterior central portal; 3, anterolateral portal; 4, posterolateral portal; 5, superolateral portal; 6, anterosuperior portal; 7, 7 o'clock portal; 8, axillary pouch portal; 9, Neviaser portal; 10, portal of Wilmington; 11, transrotator cuff portal. (Courtesy of Matthew Smith, MD, St. Louis, MO, and Kathleen McKeon, MD, St. Louis, MO.)

lary nerve travels posteriorly through the quadrilateral space and gives off a posterior and an anterior trunk. The posterior trunk has three terminations: the superolateral cutaneous branch, the posterior branch to the deltoid muscle, and the nerve to the teres minor.²⁸ The anterior trunk travels around the humerus and supplies the three heads of the deltoid muscle²⁶ (Figure 4). Traditionally, this anterior branch of the axillary nerve was thought to be an average of 5 to 7 cm distal to the lateral tip

Figure 3

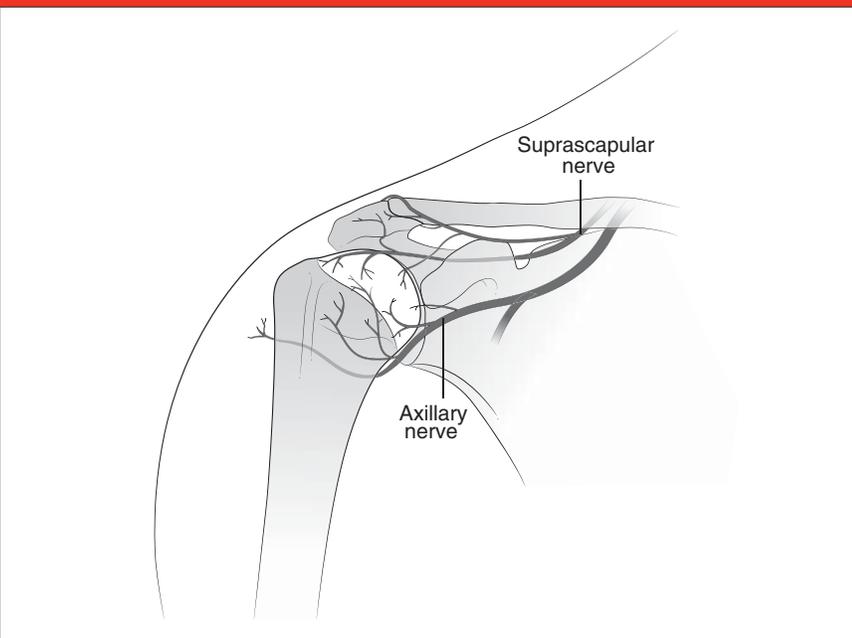


Illustration of the shoulder demonstrating the anterior course of the axillary and suprascapular nerves.

Figure 4

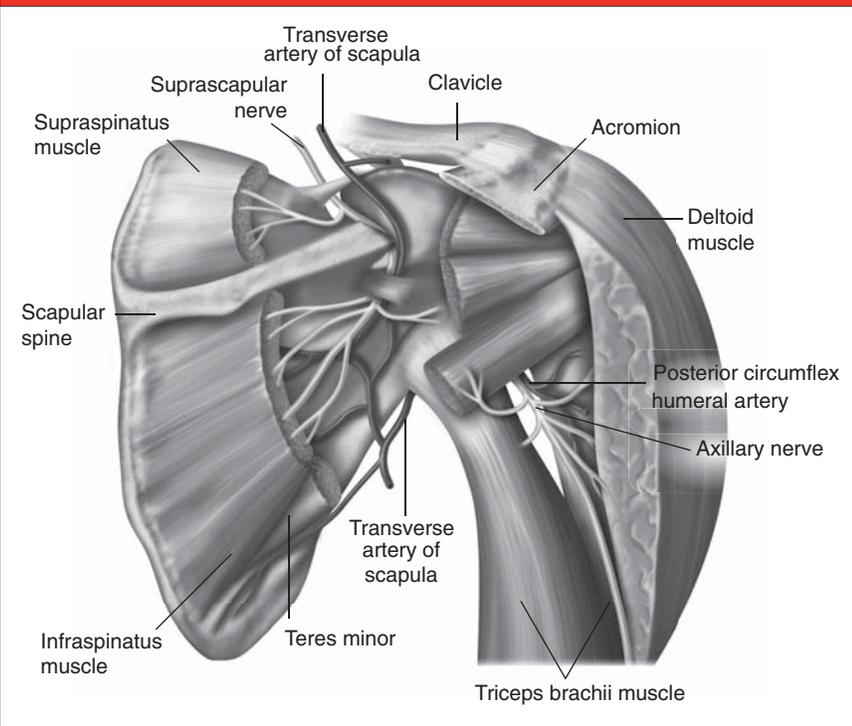


Illustration of the posterior view of a shoulder demonstrating the course of the axillary nerve and its branches through the quadrilateral space and the course of the suprascapular nerve and artery after reaching the suprascapular notch.

of the acromion.²⁹ The nerve has also been described as lying 3.5 cm distal to the superior prominence of the greater tuberosity,³⁰ although a cadaver study revealed that this section of the axillary nerve can be much closer, especially in short females.²⁶ Overall, the nerve has been reported to be from 3 to 7 cm from the lateral acromion depending on patient size and arm length.^{26,31} Abducting the arm brings the axillary nerve branch even closer to the acromion; at 90°, this distance is decreased by 30%.²⁶

In the upper arm, the cephalic vein travels in the superficial fascia of the deltopectoral interval and extends downward through the coracoclavicular fascia to the axillary vein beneath the clavicle. It is at this deltopectoral interval that the vein is most at risk for injury during portal placement, typically resulting in a superficial hematoma. An anatomic cadaver study showed the cephalic vein to be located <1 cm from anterior portals in 25% of specimens.²⁵

The suprascapular nerve (SSN) arises from the upper trunk of the brachial plexus, traveling through the posterior triangle of the neck. The suprascapular artery runs with the nerve until it reaches the suprascapular notch. The nerve lies 3 cm (range, 2.5 to 3.9 cm) medial to the supraglenoid tubercle at the suprascapular notch.³² At this point, it travels underneath the transverse scapular ligament, with the artery continuing above the transverse scapular ligament outside the notch. Within 1 cm of exiting the notch, the nerve gives its motor branch to the supraspinatus. The nerve then follows an oblique course laterally toward the base of the scapular spine. The nerve lies an average of 1.8 cm (range, 1.4 to 2.5 cm) from the midline of the posterior glenoid at the base of the scapular spine. The nerve then curves medially to innervate the infraspinatus³² (Figures 4 and 5).

Common Portals

Typical portals used in arthroscopic shoulder procedures are summarized in Table 2.

Posterior

The posterior portal is the first portal established in shoulder arthroscopy. It enters the so-called soft spot between the humeral head and the glenoid, 2 to 3 cm inferior and 1 to 2 cm medial to the posterolateral acromion.⁴ These dimensions vary, however, particularly by patient size. A small stab incision is made vertically and a trocar is introduced, aiming toward the coracoid process as described by Andrews et al.⁴ Usually, the underlying humeral head and glenoid can be felt through the capsule, allowing for correct placement of a blunt trocar into the glenohumeral joint. The arthroscope is inserted, and a diagnostic examination is performed.

The posterior portal is the safest portal that provides adequate visualization of the entire joint. Nevertheless, proper placement is essential to avoid injury to the axillary nerve and SSN. The posterior soft spot portal is located an average of 49 mm from the axillary nerve and 29 mm from the SSN, although the axillary nerve can be found as close as 30 mm.²⁵ Placing the portal too medial can place the SSN at risk of injury. Nevertheless, portal placement can be adjusted depending on the pathology being addressed. For example, placing the portal slightly higher is preferred for arthroscopic rotator cuff repair, whereas locating it slightly lower and more lateral is better for labral repairs.

Anterior Central

After creating a posterior portal, an anterior portal is created using either an outside-in or an inside-out tech-

Figure 5

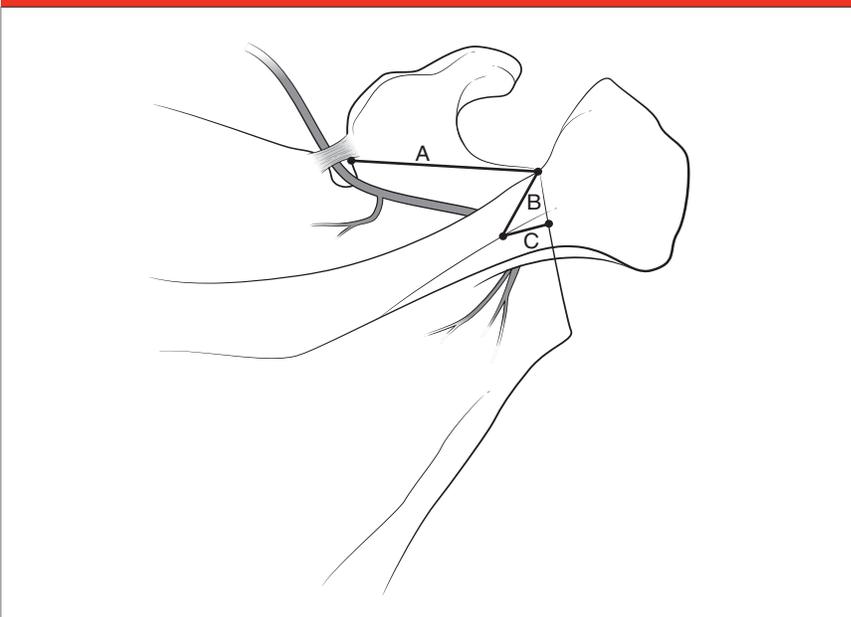


Illustration of the course of the suprascapular nerve along the posterior scapula. In a cadaver study by Bigliani et al,³² line A, the distance from the supraglenoid tubercle to the suprascapular notch, averaged 3.0 cm (range, 2.5 to 3.9 cm); line B, the distance from the supraglenoid tubercle to the base of the scapular spine, averaged 2.5 cm (range, 1.9 to 3.2 cm); and line C, the distance from the midline posterior glenoid rim to the base of the scapular spine, averaged 1.8 cm (range, 1.4 to 2.5 cm).

nique. Under direct visualization, a spinal needle is inserted 1 to 2 cm inferomedial to the anterolateral acromion.³³ Care must be taken to stay lateral to the coracoid process to avoid the brachial plexus and the axillary vessels that are located inferomedially. Under direct visualization, the needle is placed within the rotator interval, which is bordered by the glenoid medially, the supraspinatus superiorly, the subscapularis inferiorly, and the humeral head laterally. The musculocutaneous nerve lies, on average, 33 ± 6.2 mm inferior to the tip of the coracoid,³⁴ and the cephalic vein is also in the vicinity of this portal. Too-inferior placement puts these structures at risk. The anterior central is an essential working portal in almost all arthroscopic procedures.³³

Anterolateral

The anterolateral portal is typically used to address acromioclavicular joint pathology and subacromial impingement. An incision is made in line with the anterior acromion and 2 to 3 cm distal to the lateral edge.^{25,35} A blunt trocar is inserted, aiming toward the undersurface of the acromion. A spinal needle can also be used under direct visualization to provide a trajectory for the trocar. Care must be taken not to make the portal too inferior in order to avoid the axillary nerve, which may be located as close as 3.1 cm distal to the anterolateral border of the acromion.²⁶ If this portal is placed too superiorly, access to the medial acromion and the acromioclavicular joint can be hindered by the acromion.

Table 2

Portal Use by Procedure in Shoulder Arthroscopy

Procedure	Portal					
	Posterior	Anterior Central	Anterolateral	Posterolateral	5 O'clock	Anteroinferior
Rotator cuff repair	Common	Common	Common	Common	—	—
Subacromial decompression	Common	—	Common	Common	—	—
Anterior labral repair	Common	Common	—	—	Common	Common
IGHL repair	Common	Common	—	—	Common	Common
Multidirectional instability	Common	Common	—	—	Rare	Common
SLAP repair	Common	Common	Rare	Rare	—	—
Biceps tenodesis/tenotomy	Common	Common	—	—	—	—
Distal clavicle excision	—	Common	Common	Common	—	—
SSN release	Common	—	Common	Rare	—	—
Latarjet	Common	Common	Common	—	Common	Common
Irrigation and débridement	Common	Common	—	—	—	—

IGHL = inferior glenohumeral ligament, SLAP = superior labral anterior-posterior, SSN = suprascapular nerve

Posterolateral

The posterolateral portal, also described by Ellman,³⁵ was originally used as the viewing portal for arthroscopic subacromial decompressions and acromioplasty. It is also helpful as a viewing portal during rotator cuff repair and for visualization of labral repairs with patients in the LDP. Establishing two lateral subacromial portals allows the surgeon both a viewing and a working portal when passing cuff repair sutures. Using an outside-in technique, this portal is created 2 to 3 cm below the posterolateral edge of the acromion, aiming medial to the subacromial bursa.^{25,35} Excessive inferior placement of the portal places the axillary nerve at risk of injury.

5 O'clock

The 5 o'clock portal is used for low anchor placement in anterior stabilization procedures when managing Bankart lesions.³⁶ Using an inside-out technique, the camera is driven from the posterior portal to the 5 o'clock position of the glenoid at the

leading edge of the inferior glenohumeral ligament. The arthroscope is removed, and a switching stick is placed in the cannula and pushed through the capsule with the arm maximally adducted. With the aid of a scalpel, the portal exits lateral to the conjoint tendon through the lower aspect of the subscapularis.

Several authors have questioned the safety of this portal because it places the axillary nerve, musculocutaneous nerve, cephalic vein, and humeral cartilage at risk for injury.^{25,37} In a cadaver study, Pearsall et al³⁷ noted that using an inside-out technique for portal placement resulted in significant force on the humeral articular cartilage, resulting in damage to the specimens. Use of an outside-in technique demonstrated that the portal was located within 2 mm of the cephalic vein. Meyer et al²⁵ corroborated these results and concluded that use of the 5 o'clock portal was not advisable because it was located an average of 13 mm from the axillary artery, 15 mm from the axillary nerve, and 17 mm from

the cephalic vein. Nevertheless, Lo et al³⁸ felt that this portal was safe when placed using an outside-in technique. Their patients were operated on in the LDP, and the outside-in method allowed lateralization of the portal placement. These risks should be considered when placing a low anterior portal for fixation of Bankart lesions.

Anteroinferior

The anteroinferior portal described by Wolf³⁹ is used in anterior shoulder capsulorrhaphy, typically combined with an anterosuperior portal. Using an inside-out technique, the arthroscope is inserted into the posterior portal and is slid off the inferolateral edge of the coracoid tip. A switching stick is then pushed through the anterior capsule just superior to the upper border of the subscapularis tendon, and a scalpel is used to expose the portal. The cephalic vein is most at risk in creating this portal, and the axillary nerve can be injured adjacent to the inferior capsule. This portal allows easier access and a better

Table 2 (continued)

Portal Use by Procedure in Shoulder Arthroscopy						
Portal						
Anterosuperior	7 O'clock	Axillary Pouch	Neviaser	Transrotator Cuff (Superior)	Portal of Wilmington	G Portal
Common	—	—	Rare	—	—	—
Common	—	—	—	—	—	—
Common	—	Rare	—	—	—	—
Common	Common	Common	Rare	—	Common	—
Common	Common	Rare	—	—	—	—
Rare	—	—	Common	Common	Common	—
—	—	—	—	—	—	—
—	—	—	—	—	—	—
Common	—	—	—	—	—	Common
—	—	—	—	—	—	—
—	—	—	—	—	—	—

IGHL = inferior glenohumeral ligament, SLAP = superior labral anterior-posterior, SSN = suprascapular nerve

angle to the glenoid neck and inferior glenoid.

Anterosuperior

For procedures involving the anterior capsule, the anterosuperior and anteroinferior portals are best for visualization, and their use permits surgical triangulation in the anterior glenohumeral joint.³⁹ The anterosuperior portal is created using an outside-in technique starting at the mid distance between the coracoid and the acromion. The trocar is directed just anterior to the long head of the biceps tendon into the joint. More lateral placement (ie, superolateral portal) can allow work in the anterior glenohumeral joint as well as in the subacromial space (ie, for SSN release).^{40,41} Although the cephalic vein and axillary nerve are at risk of injury via this portal, such injury is less likely than with the anteroinferior portal. The anterosuperior portal also provides a good angle for anchor placement on the anterosuperior glenoid during superior labral anterior-posterior (SLAP) repair.

Posteroinferior (ie, 7 O'clock) Portal

The posteroinferior (ie, 7 o'clock) portal can be created inside-out or outside-in to address loose body removal and posteroinferior labral fixation.⁴² The inside-out technique involves placing a switching stick through an anterior portal to the 7 o'clock position on the glenoid. This stick is then pushed through the capsule, and a skin incision is made. The outside-in technique involves making a skin incision 2 to 3 cm inferior to the posterior viewing portal and inserting a cannula to the 7 o'clock position under direct visualization. This portal can also be used exclusively as a percutaneous portal to avoid both overcrowding with cannulae and neurovascular injury. The structures at risk are the suprascapular nerve and artery, the axillary nerve, and the posterior circumflex humeral artery. In a cadaver study, the portal was found to be a mean distance of 39 ± 4 mm from the circumflex artery and 29 ± 3 mm from the axillary nerve and SSN.⁴²

Axillary Pouch

The axillary pouch portal was described as a safer alternative to the posteroinferior portal for accessing the inferior glenohumeral recess for removal of loose bodies, synovectomy, anchor placement on the posteroinferior glenoid rim, and anchor placement on the humerus in repairing humeral avulsion of the glenohumeral ligament lesions.⁴³ This portal is developed using an outside-in technique beginning 2 to 3 cm inferior to the posterolateral acromion and 2 cm lateral to the posterior viewing portal. The spinal need is angulated medially and inferior into the joint. The axillary nerve is thought to be farther away from this portal than from the 7 o'clock portal.⁴³

Neviaser

The Neviaser portal is convenient for suture fixation during SLAP repair,⁴⁴ and it provides excellent arthroscopic visualization of the anterior glenoid. The portal is created superiorly in the soft spot between the clavicle, acromion, and scapular

spine. A needle is placed from this location laterally and anteriorly through the capsule. In SLAP repairs, the needle can be placed under the biceps anchor. It can also be useful for securing a supraspinatus tear by passing a penetrating curved suture-passing device through the cuff medially. The suprascapular nerve and artery are only 3 cm from the supraglenoid tubercle³² and are at risk when using the Neviaser portal.

Transrotator Cuff Options

The most notable of the transrotator cuff portals, the portal of Wilmington, was originally described by Morgan et al⁴⁵ for use during SLAP repair. The portal is made 1 cm anterior and 1 cm lateral to the posterolateral edge of the acromion, piercing the rotator cuff medial to the musculotendinous junction and entering the shoulder at a vector aimed toward the coracoid tip, allowing anchors to be placed at a 45° angle to the glenoid surface. Similar transrotator cuff portals have been described with slight variations.⁴⁶ Controversy exists regarding the use of a cannula in the portal of Wilmington. Stephenson et al⁴⁷ published a case series of six patients who had rotator cuff tears following SLAP repair using a transrotator cuff portal. They concluded that care must be taken to make the portal medial to the muscle-tendon junction. As with all lateral portals, inferior placement puts the axillary nerve at risk of injury.

Suprascapular Nerve

The SSN portal (ie, G portal) is a specialized portal used to cut the superior transverse scapular ligament during arthroscopic SSN decompression. Lafosse et al⁴¹ described this portal position between the clavicle and the scapular spine, “approximately 7 cm medial to the lateral border of the acromion. This portal

is approximately 2 cm medial to the Neviaser portal.” The SSN portal is created under direct visualization via an outside-in technique. A spinal needle is placed through the trapezius muscle directly above the medial aspect of the coracoclavicular ligaments, aiming toward the anterior border of the supraspinatus muscle. The structures most at risk with this portal are the SSN within the suprascapular notch and the suprascapular artery above the transverse scapular ligament.

Ensuring Adequate Visualization

Bleeding is a constant challenge in arthroscopic visualization of shoulder pathology, but several methods and tools have been developed to optimize visualization. Controlling blood pressure in combination with intra-articular fluid pressure is a common method to increase visualization. Pump systems are generally preferred to gravity because with a pump system the surgeon can control the intra-articular pressure. Pressures are typically set between 35 and 75 mm Hg depending on the amount of bleeding and duration of the procedure. Increasing pressure usually improves visualization by creating a tamponade effect on bleeding vessels. Pumps that control both pressure and flow rate are favored because they are believed to result in improved visualization, shorter surgical time, and lesser amounts of fluid used.⁴⁸ In addition, the amount of fluid turbulence is important in ensuring adequate visualization. With multiple portals, fluid may escape from an unoccupied portal. As described by Burkhart et al,⁴⁹ this escaping fluid causes a Bernoulli effect that encourages bleeding of injured vessels. Increasing the pump pressure in this situation only worsens visual-

ization by increasing the effect and subsequent rate of bleeding.

Electrocautery is often advantageous in controlling bleeding, but this instrument must be used judiciously with short bursts and lower settings to control fluid temperature. Increased intra-articular fluid temperature has been proposed as a potential cause of chondrolysis;⁵⁰ however, the exact mechanism and incidence of this phenomenon are poorly understood. Fluid temperature is also important in maintaining patient body temperature during arthroscopy. In a randomized controlled trial of 50 patients undergoing shoulder arthroscopy, patients who received room-temperature irrigation fluid had a significant decrease in body temperature compared with patients who had fluid warmed to body temperature.⁵¹ Of patients who had room-temperature fluid, 91.3% experienced hypothermia, compared with 17.4% of patients who received warmed fluid ($P < 0.001$).

The use of epinephrine in the irrigation fluid has been reported to greatly improve visualization. In a randomized, double-blind, placebo-controlled trial, use of 0.33 mg/L of epinephrine significantly improved visualization compared with normal saline alone ($P = 0.0007$).⁵² No adverse cardiac events were identified. However, these results were based on a visual analog scale of clarity completed by the surgeon, and its use is still debated given potential cardiac risks.

In addition to facilitating adequate bleeding control, use of the 70° arthroscope has been advocated to increase visualization⁵³ (Table 3). The 70° scope can be particularly useful for shoulder stabilization, distal clavicle resection, acromioclavicular joint reconstruction, rotator cuff repair (especially subscapularis repair), and subdeltoid arthroscopy.

Table 3**Applications for the 70° Arthroscope in Shoulder Procedures**

Procedure	Advantages of the 70° Arthroscope
Anterior glenohumeral stabilization	Provides superior visualization of a medically displaced anterior labroligamentous periosteal sleeve avulsion lesion from the posterior portal Allows full mobilization of the capsulolabral complex without the instrument crowding that occurs with the camera and working instruments in dual anterior portals
Distal clavicle excision	Provides an excellent view of the entire acromioclavicular joint and distal clavicle from a posterior portal, often obviating the need to shift the camera to an anterolateral or anterior position to confirm adequate resection
Coracoclavicular ligament reconstruction	Allows for visualization of the coracoid process from the posterior portal, allowing for dissection and graft passage around the coracoid by use of working anterolateral and anterior portals without the risk of instrument crowding
Rotator cuff repair	Particularly useful for subscapularis and leading-edge supraspinatus tears. The entire tear pattern can be visualized from the posterior portal, allowing for unencumbered suture passage and management through anterolateral and anterior portals
Subdeltoid shoulder arthroscopy	Has evolved to become a useful tool in this compartment for arthroscopic biceps tenodesis or transfer procedures, proximal humeral fracture fixation, pectoralis tendon repair, and arthroscopic-assisted hardware removal

Adapted with permission from Bedi A, Dines J, Dines DM, et al: Use of the 70° arthroscope for improved visualization with common arthroscopic procedures. *Arthroscopy* 2010;26(12):1684-1696.

Summary

Careful patient selection, proper patient positioning, careful anesthesia, surgeon knowledge of shoulder anatomy, and appropriate portal placement and selection are essential features of successful shoulder arthroscopy. A thorough understanding of these principles is essential to maintain low complication rates and achieve successful outcomes. Advances in arthroscopic technology and technique coupled with more widespread use of shoulder arthroscopy will likely lead to more and better options for minimally invasive management of shoulder pathology.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 21, 23, 51, and 52 are level I studies. References 15, 16, and 22 are level II studies. References 2, 9, 13, 17, 18, 20, 24, 35, 41, 45-48, and 50 are level IV studies. References 1, 3-6, 8, 10, 11, 14, 19, 30, 44, 49, and 53 are level V expert opinion.

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