ELSEVIER

Operative Techniques in

Sports Medicine

Arthroscopic Posterior Shoulder Burscoscopy and Superior Medial Angle Resection

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Snapping scapula is a condition that can cause severe debilitation in some patients. It has a number of causes including scapulothoracic bursitis, bony or soft tissue masses, muscle abnormality, and trauma. Nonoperative treatment is successful for most patients; however, snapping scapula associated with structural causes is less likely to respond to nonoperative management and most likely would require operative intervention. Scapulothoracic burscoscopy offers a safe and efficacious option for treatment of snapping scapula and scapulothoracic bursitis with similar results to those of open procedures and potentially with less morbidity and faster return to sports and activities of daily living.

KEYWORDS scapulothoracic burscoscopy, snapping scapula, shoulder bursitis, posterior shoulder pain, winging

Introduction

The scapulothoracic articulation plays a crucial role in the motion of the upper extremities. The unique junction between the scapula and the thoracic cage lends itself to potential disorders that can predispose this articulation to a condition known as snapping scapula. Snapping scapula syndrome was first described in 1867 by Boinet[1] to describe periscapular pain. Snapping scapula has a number of causes including scapulothoracic bursitis, bony or soft tissue masses, muscle abnormality, and trauma. Crepitus associated with snapping scapula has been described by a snapping, grinding, thumping, or popping sound with scapulothoracic motion.[2] As further understanding of this condition improves, more cases are being diagnosed and treated. In most cases, conservative management is successful.[3] However, patients for whom conservative management fails may be treated with open or arthroscopic surgery. Historically, open procedures were the mainstay of treatment.[4-10] An all-arthroscopic procedure was initially described by Cuillo and Jones[3] in 1992 and the first series was later published by Harper et al.[11] Combined approaches including both open and arthroscopic procedures have also been described.[6,12] Scapulothoracic burscoscopy has the advantage of being less invasive, more cosmetic, and has the potential to return the patient to normal activities in a more timely fashion.[2,11,13,14-18] It provides a safe alternative to open superomedial angle resection, bursectomy, and excision of masses.[19,20]

Anatomy and Pathoanatomy

Disorders of the scapulothoracic joint requiring surgical treatment are rarely seen. The surgeon should have a good understanding of the anatomy and pathoanatomy of the shoulder and the scapulothoracic joint. The scapula is a triangular-shaped bone that articulates with the humerus and clavicle laterally and thorax ventrally. Its only attachment to the axial skeleton is the acromioclavicular joint. The scapula is integral to motion of the shoulder, maintaining a stable base of support for the humerus and allowing dynamic positioning of the glenoid fossa during glenohumeral elevation.[2]

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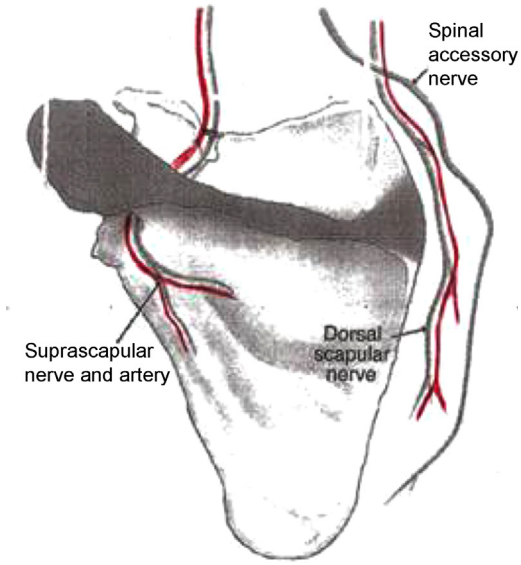

Figure 1 Posterior view of the scapula showing the relationship of the neurovascular structures (suprascapular artery and nerve, spinal accessory nerve, and dorsal scapular artery and nerve). The handwritten "and artery" and "spinal" were meant to be covered by the textboxes which have been inadvertently moved below the handwritten words. The handwritten words should not be visible.

Seventeen muscles originate or insert on the scapula. The subscapularis muscle covers the anterior surface of the scapula and the supraspinatus and infraspinatus muscles cover the posterior surface in the supraspinatus and infraspinatus fossas, respectively. The scapular spine and acromion provide the origin of the deltoid muscle and an insertion for the trapezius muscle. Medial border attachments include the serratus anterior, levator scapulae, and rhomboid major and minor muscles. The triceps, teres major, and teres minor muscles originate from the lateral border. Inferiorly, the latissimus dorsi muscle attaches to the inferior angle of the scapula. Other muscle attachments include the omohyoid, long and short heads of the biceps, coracobrachialis, and pectoralis minor muscles.[13]

Neurovascular structures in proximity to the scapula include the suprascapular nerve and artery, dorsal scapular nerve and artery, transverse cervical artery, spinal accessory nerve, and long thoracic nerve (Fig. 1). The suprascapular nerve travels below the suprascapular ligament through the notch, whereas the suprascapular artery travels above the ligament at the level of the transverse scapular ligament. They both continue laterally around the spine of the scapula through the spinoglenoid notch into the infraspinatus fossa. The dorsal scapular nerve and artery travel parallel to the medial border of the scapula and deep to the rhomboid major and minor muscles. The spinal accessory nerve (cranial nerve IX) crosses the middle section of the levator scapulae muscle deep to the trapezius muscle[14] (Fig. 1).

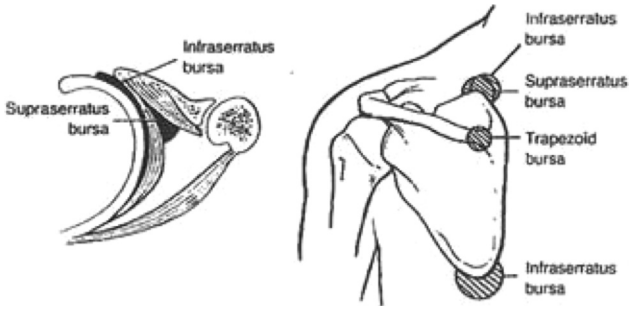

Figure 2 Major (anatomic) and minor (adventitial) bursae of the scapulothoracic joint and the orientation in relation to the chest wall, scapula, serratus anterior muscle, and subscapularis muscle.

The suprascapular nerve and artery are at risk during superomedial scapular resection or from placement of a superomedial portal. The dorsal scapular artery and nerve are at risk of injury with open medial dissection or medial placement of arthroscopic portals. The main branches of the spinal accessory nerve are at risk with open dissection or portal placement superior to the scapular spine. The long thoracic nerve is rarely at risk of injury during arthroscopic or open procedures.[15] Placement of alternative portals located superiorly for improved access to the superior medial angle has shown to be safe with greater than 10-mm distance to the suprascapular nerve.[16,21,22] Understanding these relationships allows for safe placement and minimizes the risk of injury to important neurovascular structures when performing scapulothoracic burscoscopy.

There are 2 major anatomic bursae and 4 minor adventitial bursae of clinical significance (Table 1; Fig. 2). The anatomic bursae include the supraserratus bursa, which is located between the subscapularis and serratus anterior muscles, and the infraserratus bursa, which is located between the serratus anterior muscle and the chest wall.[3,5,14,17,23,24] These bursae are thought to be physiologic and have been consistently located in cadaveric specimens and during arthroscopic procedures.[24]

The 4 adventitial bursae are thought to develop as a result of scapulothoracic dyskinesia and are inconsistently seen and considered pathologic. The supraserratus and infraserratus

Table 1 Major and Minor Bursae of the Scapulothoracic Joint

Anatomic bursae (major)	**Location**
Supraserratus bursa	Between serratus anterior and subscapularis muscles
Infraserratus bursa	Between chest wall and serratus anterior muscle
Adventitial bursae (minor)	
Supraserratus bursa (superomedial angle)	Between serratus anterior and subscapularis muscles
Infraserratus bursa (superomedial angle)	Between chest wall and serratus anterior muscle
Infraserratus bursa (inferior angle of scapula)	Between chest wall and serratus anterior muscle
Trapezoid bursa	Between spine of the scapula and trapezius muscle

Table 2 Causes of Symptomatic Scapulothoracic Crepitus

- Interposed tissue
  - Muscle
    - Atrophy
    - Fibrosis
    - Anatomic
  - Bone
    - Rib osteochondroma
    - Scapular osteochondroma
    - Rib exostosis (fracture callous)
    - Scapula fracture
    - Hooked superomedial angle of the scapula
    - Luschka's tubercle
    - Reactive bone spurs from muscle avulsion
  - Other
    - Bursitis
- Abnormalities of scapulothoracic congruence
- Scoliosis
- Thoracic kyphosis

bursae (minor) are located ventral to the superomedial angle of the scapula. A second infraserratus bursa is located anterior to the inferior angle of the scapula. The trapezoid bursa is located dorsal to the spine of the scapula[25] (Fig. 2).

Snapping scapula is caused by a variety of bony and soft tissues disorders (Table 2). Alterations in bony anatomy of the scapula resulting in incongruity of the scapulothoracic joint have been broadly cited in the literature. Osteochondromas, Luschka's tubercle (a bony prominence on the superomedial angle of scapula), hooking of the scapula, elastofibroma (Fig. 3), and malunion or callous formation after scapular or rib fractures have been reported to be a cause of snapping scapula.[3,7,23,26-30] Variable scapular anatomy has also been implicated as the cause of symptomatology in the painful snapping scapula.[31,32] Thoracic scoliosis and kyphosis changes the scapulothoracic articulation and has also been reported as a cause for symptomatic snapping scapula.[19] In addition to soft tissue and bursal inflammation, scar formation after periscapular muscle avulsions may cause incongruity between the scapula and chest wall and result in periscapular crepitus or an audible snapping sound.[33]

The resultant change in anatomy may create sounds that vary from a barely audible friction rub to a loud snapping sound[7,24] (refer to the section History and Physical Examination). There is no consensus on whether anatomical changes or the resulting bursitis are the source of the periscapular pain. It should be noted that symptomatic bursitis does not necessarily have an accompanying audible sound, and conversely, a snapping scapula is not always symptomatic and thus may not be clinically significant.

History and Physical Examination

The patient with a symptomatic snapping scapula often has a history of a traumatic event or a repetitive upper extremity activity.[6,11,34-36] The traumatic event may involve a protraction or retraction movement of the scapula, a direct blow to the scapula, fracture of the scapula, or fracture of the underlying ribcage. Athletes participating in repetitive overhead activities such as professional baseball pitchers have been reported to have snapping scapula.[10] Swimmers, weight lifters, gymnasts, and football players have also been found to have crepitus in the scapulothoracic region.[2]

Regardless of the underlying pathology, most patients report having crepitus, grinding, grating, clicking, or crunching with shoulder motion.[2,7] The audible sound may or may not be painful. Crepitus associated with bursitis is usually less severe than crepitus or snapping caused by bony lesions.[24] Pain is often localized to the superomedial angle or medial border of the scapula. Pain at the inferior angle of the scapula is more typical in overhead athletes.[10] Patients commonly report pain that is worsened with overhead activities, irrespective of the location of the inflamed bursa. Some patients may report a family history of similar symptoms.[34]

In most studies, the period of time from the onset of symptoms to treatment varies widely. Most patients have a prolonged course of pain and limitation of activities with the duration of symptoms averaging greater than 2 years and in some cases even greater than 10 years before treatment.[19,27,37] This delay is often because of a prolonged course of conservative treatment, delayed recognition of the diagnosis, incorrect initial diagnosis, and evaluation by multiple physicians.

Physical examination findings associated with disorders of the scapulothoracic articulation can vary from near normal to severe scapular winging and crepitus. Inspection

Figure 3 Elastofibroma.

Figure 4 Scapular winging and depression of the left shoulder.

of the posterior aspect of the shoulders may reveal subtle asymmetry. The dominant shoulder is frequently slightly depressed in comparison with the contralateral shoulder[38] (Fig. 4). However, this is a normal finding in many active individuals and athletes and is generally not thought to be directly related to snapping scapula.

Many patients have tenderness over an inflamed bursa. The supraserratus and infraserratus bursae, located adjacent to the superomedial angle, are the most common areas affected.[8,23] An audible grinding noise or snap can be reproduced with active shoulder range of motion. These sounds have been described as froissement (gentle friction sound), frottement (a course friction or grating sound), and craquement (loud snapping sound).[39] This distinction is clinically important because froissement almost always responds to nonoperative treatment whereas craquement is usually pathologic and requires operative intervention.[7] When present, the dyskinesia of scapular winging can cause scapulothoracic bursitis. Full range of motion of the shoulder is normally seen.

Diagnostic Imaging

Radiographs should consist of a true anteroposterior (AP) and lateral view of the scapula and an axillary view of the shoulder. Computed tomography (CT) scans may be necessary if no obvious abnormalities are seen on plain radiographs. CT scans have been shown to be useful for further evaluation of the shape of the scapula and narrowing of the scapulothoracic joint. Mozes et al[40] used 3-dimensional CT images to evaluate patients with suspected bony incongruity between the anterior scapula and the chest wall. They found incongruity in 100% of the scapulae they evaluated. These results have not been duplicated by any other author.

Magnetic resonance imaging evaluation may be useful to identify soft tissue abnormalities, such as bursal inflammation or infection; however, they are rarely positive for masses. Additionally, magnetic resonance imaging evaluation of the shoulder and cervical spine may be useful in ruling out associated pathology. Lower cervical spine pathology is a common source of pain in the posterior aspect of the shoulder and should be further evaluated if clinical examination warrants.

In patients with scapular winging, electromyogram and nerve conduction velocity studies should be performed to evaluate for possible neuropathy.[2] Injury to the long thoracic nerve can result in dysfunction of the serratus anterior, causing medial scapular winging and snapping, whereas, injury to the spinal accessory nerve can cause lateral scapular winging.

Treatment

Initial management of most patients should consist of rest, activity modifications, administration of nonsteroidal anti-inflammatory drugs, postural training, and physical therapy. Physical therapy should address muscle imbalances, postural deficits, and muscle dysfunction focusing on periscapular muscle retraining and strengthening, with the inclusion of a program focused on improving core strength.[2] The primary function of the scapular muscles is to provide static stability; therefore, a strengthening program should include low-resistance, high-repetition exercises. Incorporation of the core and lower extremity muscles is also important to promote normal movement patterns and return to activities without recurrence of symptoms. Closed-chain upper extremity exercises are also beneficial to enhance dynamic stability about the shoulder girdle. Most authors agree that nonoperative treatment is successful for most patients; however, snapping scapula associated with structural causes is less likely to respond to nonoperative management and most likely requires operative intervention.[23]

Injections into the inflamed bursa with a corticosteroid and local anesthetic may be both diagnostic and therapeutic. Hodler et al[41] reported symptomatic relief in 18 of 20 patients after fluoroscopy-guided scapulothoracic injection. A patient who has a recurrence of symptoms after successful injection and fails other nonoperative treatments is considered a candidate for operative intervention. Failure to respond to injections is considered a relative contraindication for operative treatment and further diagnostic workup is necessary.[6] In patients who fail to respond to injections, pathology involving the glenohumeral joint, suprascapular nerve, or cervical spine should be investigated. Patients involved in litigation, workers' compensation patients, patients with a history of psychiatric illness, and patients with voluntary snapping should be very critically evaluated before considering operative intervention.[2,33]

Operative Management

Surgical treatment can be extremely beneficial in resolving symptoms and returning the patient to activities

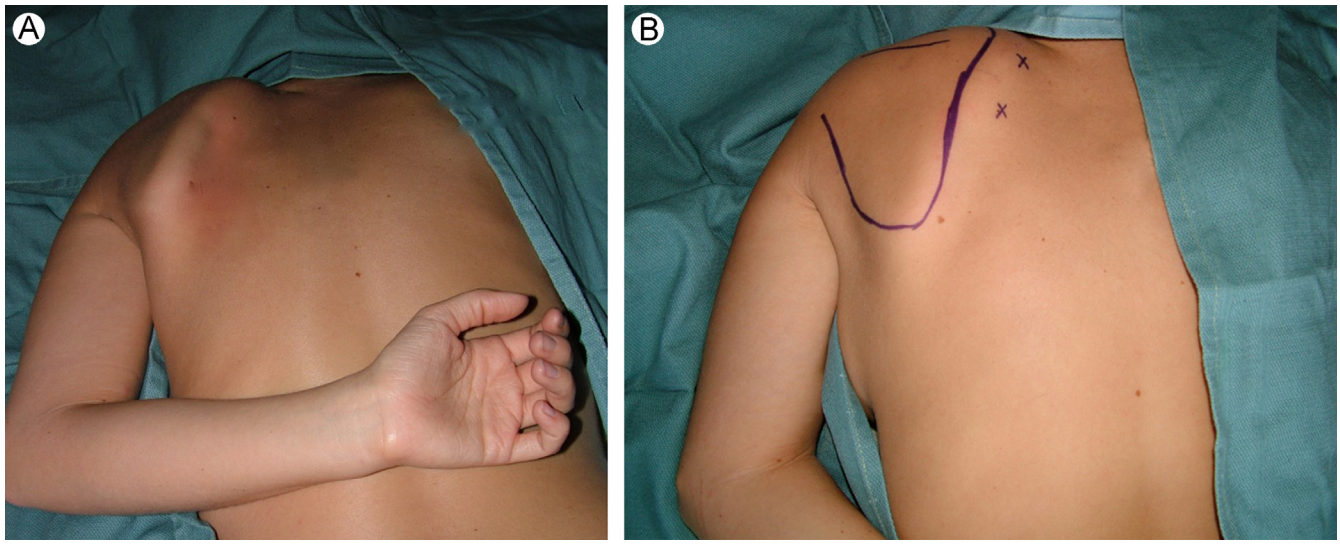

Figure 5 Prone positioning for scapulothoracic burscoscopy with the "chicken-wing" position. Note that the arm is in internal rotation and extension with the hand placed on the lower back.

expediently.[2,6,24,36,42] There are many operative procedures for treating snapping scapula and scapulothoracic bursitis. Initially, open superomedial angle resection was described for treatment of bony abnormalities of the scapulothoracic articulation.[5-9,43,44] Isolated open bursectomy for symptomatic bursitis without bony abnormalities has been advocated by others.[10,37] Comparison of open bursectomy and superomedial angle excision to arthroscopic bursectomy combined with open superomedial angle excision within a single patient population was found to have equivalent results.[6] Good outcomes from all-arthroscopic techniques for bursectomy and superomedial angle excision have been reported[3,11]; however, outcomes have only been described in case reports and small series. We advocate an all-arthroscopic bursectomy for symptomatic bursitis and concomitant superomedial angle resection if scapulothoracic incongruity is present.

Arthroscopic Technique

Arthroscopic burscoscopy can be performed in either the prone or lateral position (Figs. 5 and 6). Prone positioning allows for easier entry into the bursal space owing to increased scapular protraction. The disadvantage of the prone position is that the patient must be repositioned if glenohumeral arthroscopy is required. The lateral position may be more difficult to perform because of medial displacement of the scapula secondary to gravity restricting the scapulothoracic interval. An assistant can be helpful for proper arm orientation in either position but is essential in the lateral position.

The arm is draped free with the thorax. The drapes are placed on the opposite side of the spinous processes and 15 cm below the inferior angle of the ipsilateral scapula. The arm is placed in internal rotation and extension, the so-called

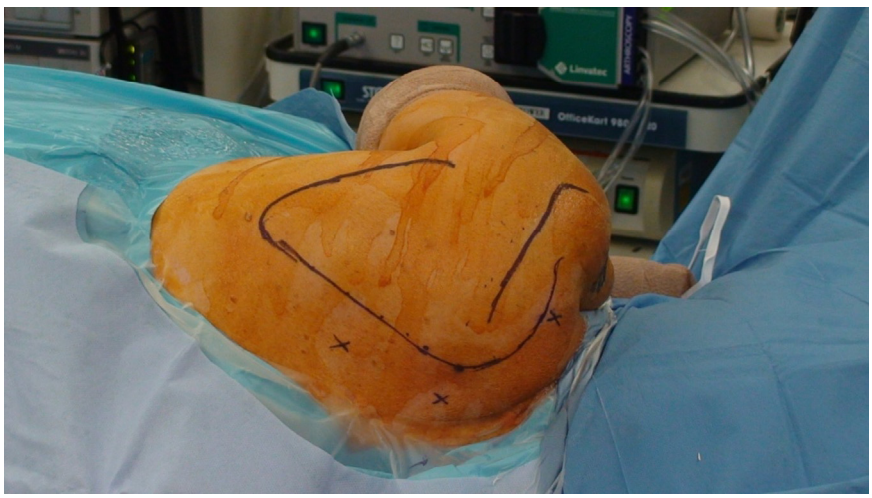

Figure 6 Lateral position for scapulothoracic burscoscopy. The medial and inferior portal sites are marked 2-3 cm medial to the medial scapular border. The superior portal is placed 1-2 cm superior to the superior border of the scapula at the junction of the medial one-third and lateral two-thirds of the scapula.

chicken-wing position. The bony anatomy is then drawn out in detail and the portal sites marked (Figs. 5B and 6). A standard viewing portal and a working portal are created (Figs. 6 and 7A). Typically, the proximal portal is used for viewing and the more inferior portal is used for working. Alternatively, these can be interchanged to improve visualization. If there is difficulty resecting the tissue along the superior medial angle, a superior portal may be helpful. All portals should be marked before beginning the procedure. This reduces the risk of neurovascular injury secondary to improper placement after distortion from tissue edema due to fluid extravasation. Although some authors insufflate the serratus space for distention,[15,42,45] we have found that this does not improve visualization and therefore do not recommend injecting saline before inserting the arthroscope.

The standard initial viewing portal is made 2 cm medial to the medial scapular border at the level of the scapular spine. A blunt trocar is placed into the serratus anterior space, making sure to aim posteriorly away from the chest wall and taking care not to aim too laterally into the subscapularis space. Sweeping the bursa with the trocar creates a space for visualization. A 30°, 4.5-mm arthroscope is then placed into the serratus anterior space and a diagnostic arthroscopy is performed. To limit excessive tissue swelling and fluid extravasation, we recommend maintaining the fluid pressure at 50 mm Hg or less. Occasionally, the fluid pressure may need to be raised for better visualization; however, it should be lowered to less than 50 mm Hg as soon as possible.

A working portal is then established using spinal needle localization on a line that is drawn 2-3 cm medial and parallel to the medial scapular border. This portal is usually 4-6 cm inferior to the initial portal. This can be adjusted inferiorly or superiorly based on the size of the patient and can be made anywhere along the line. A 4.5-mm cannula is used for instrumentation. The bursal tissue is debrided with a full radius resector. After the bursa is resected, the superior medial angle should be localized with a spinal needle (Fig. 7B). The medial attachment of the supraspinatus, superomedial attachment of the serratus anterior, and lateral attachment of the rhomboid minor and levator scapulae muscles should be elevated using an arthroscopic radiofrequency ablation device.

For bony incongruity of the scapulothoracic joint, an arthroscopic burr is used to resect the bony lesion and coplane the superomedial angle of the scapula using a cutting block technique (Fig. 7C). This is completed using the medial portal for viewing and the burr in the inferior portal. We suggest removing sufficient bone to restore a smooth and congruent scapulothoracic articulation. A nasal rasp is inserted via the medial portal and used to complete the superomedial angle resection and smooth any rough edges (Fig. 7D). The coplaned scapula restores a congruent scapulothoracic articulation (Fig. 7E).

If the superior medial angle of the scapula remains prominent and further resection needs to be performed, a superior portal, as described by Chan et al,[21] can be made (Fig. 8). This portal is created using an inside-out technique. The portal is located at the intersection of a line dividing the medial one-third and lateral two-thirds of the scapula and 1-2 cm superior to the superior border of the scapula. This point allows a safe distance from the portal to the suprascapular nerve laterally and the spinal accessory and dorsal scapular nerves and artery medially[16,21,22] (Fig. 8). We place a trocar through the initial working portal, aiming under the superior medial border of the scapula toward the point superior to the scapula and one-third the distance from the medial scapular border to the acromion. The resection is performed in the same fashion as described through the working portal above.

Once the procedure is completed, a spinal needle is placed into the bursal space to inject a local anesthetic and corticosteroid. Before removing the arthroscope, all fluid is suctioned from the bursal spaces. The portal sites are closed with a subcuticular suture and Steri-Strips. Injection of a local anesthetic and corticosteroid through the spinal needle into the area of the debrided bursa and resected superomedial angle of the scapula provides postoperative pain relief and in our experience, decreases the time to return to pain-free range of motion.

Pearls

1. Proper patient selection is paramount to a predictable outcome. Patients with bony abnormalities of the scapulothoracic joint and those patients who responded to local injections are likely to have greater success.
2. Knowledge and understanding of the scapular anatomy allows for safe portal placement and limits the risk of neurovascular injury and pneumothorax.
3. The patient should be placed in the lateral decubitus position if glenohumeral arthroscopy is planned.
4. To obtain the best view of the pathology and the best angle for a bursectomy and superomedial angle resection, switching the viewing and working portals is often essential.

Pitfalls

1. Care must be taken to avoid anterior trocar placement when making portals. Uncontrolled and improper angle of insertion can result in injury to the chest wall and a subsequent pneumothorax, hydropneumothorax, or hemopneumothorax.
2. Improper fluid management can cause rapid fluid extravasation, thus limiting working space and visibility. Maintain the pump pressure to less than 50 mm Hg.
3. Cooperation with anesthesia to maintain a systolic blood pressure between 90 and 100 mm Hg allows for optimal visualization.

Postoperative Rehabilitation

Postoperatively, the patient is placed in a sling for comfort for 1-2 weeks. A physical therapy program consisting of

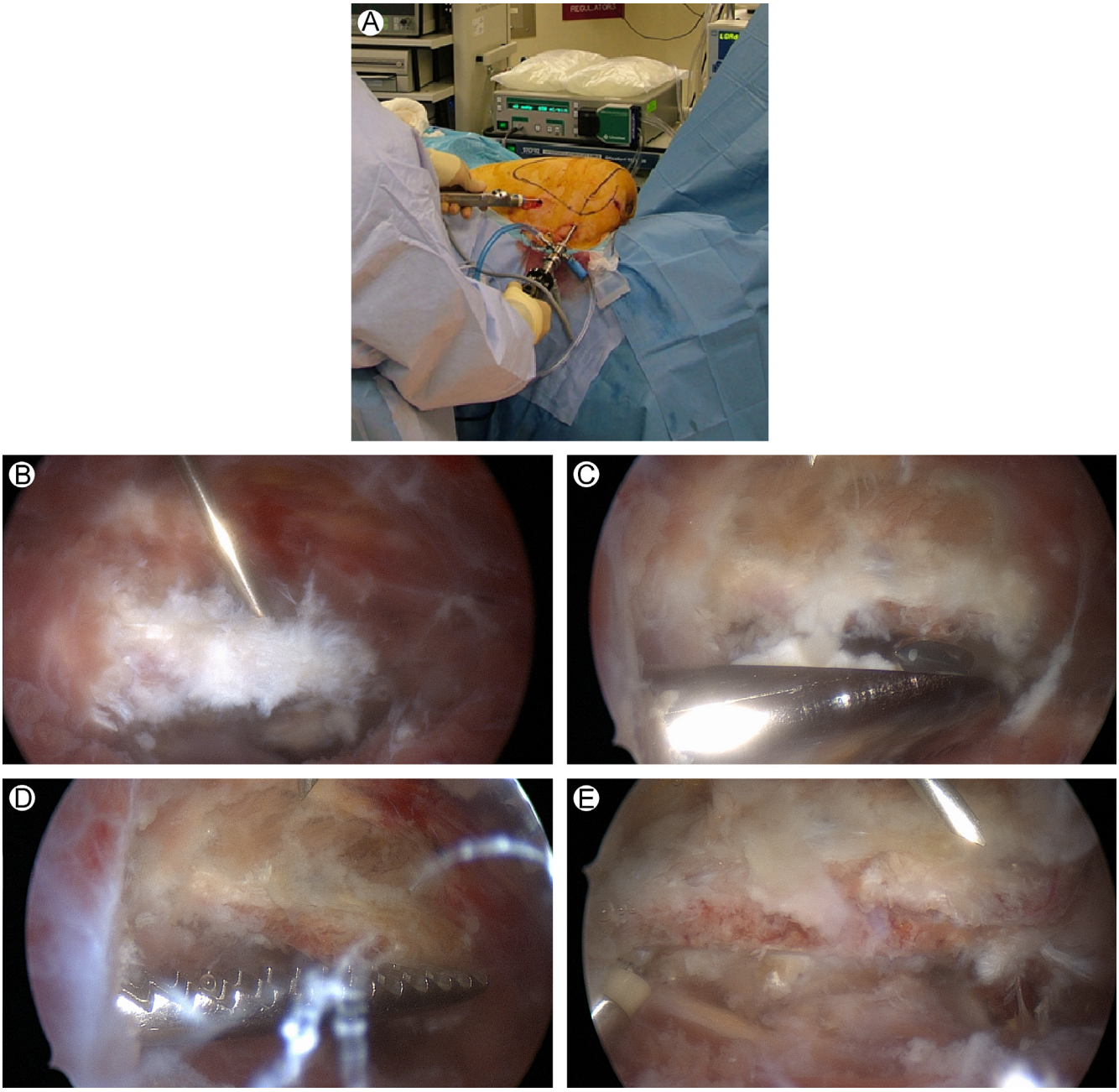

Figure 7 (A) This is the left shoulder with the patient in a lateral decubitus position. Arthroscopic visualization is performed through the medial portal with the working portal placed inferiorly. (B) Needle localization to identify the superomedial angle is completed. (C) The bursa is resected and the superomedial angle of the scapula is coplaned using a motorized burr placed in the inferior portal to remove the bony prominence with a "cutting-block" technique. (D) A nasal rasp can then be used through the medial portal to complete the superomedial angle resection and to smooth any rough edges. (E) The coplaned scapula is shown revealing the establishment of a congruent scapulothoracic articulation.

shoulder range-of-motion, strengthening, and scapular stabilization exercises is started 7 days following the operation if bone has been resected. If an isolated bursectomy is performed, therapy is started 72 hours following the procedure. Postural correction is also considered paramount to improved outcomes and is therefore started preoperatively and continued postoperatively. Patients are allowed to return to overhead work duty and full sports activities at 2-3 months postoperatively. All patients must have regained full strength, range of motion, and proper scapulothoracic mechanics before returning to full activity.

Conclusion

Snapping scapula is a well-described condition that can cause prolonged limitations in activities and persistent scapular pain. Traditionally, open techniques have been employed to treat

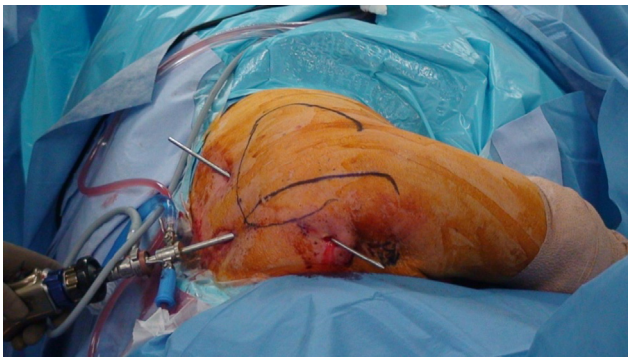

Figure 8 The creation of a superior portal using the inside-out technique (A). The superior portal should be located at the intersection of a line dividing the medial one-third and the lateral two-thirds of the scapula and 1-2 cm superior to the superior border of the scapula. This point allows a safe distance from the portal to the suprascapular nerve laterally and the spinal accessory and dorsal scapular nerves and artery medially.

causes that did not respond to conservative management. Scapulothoracic burscoscopy offers a safe and efficacious option for treatment of snapping scapula and scapulothoracic bursitis with similar results to those of open procedures and potentially with less morbidity and faster return to sports and activities of daily living.

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