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Scapulothoracic Bursitis and Snapping Scapula Syndrome

A Critical Review of Current Evidence

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Background: Symptomatic scapulothoracic disorders, such as painful scapular crepitus and/or bursitis, are uncommon; however, they can produce significant pain and disability in many patients.

Purpose: To review the current knowledge pertaining to snapping scapula syndrome and to identify areas of further research that may be helpful to improve clinical outcomes and patient satisfaction.

Study Design: Systematic review.

Methods: We performed a preliminary search of the PubMed and Embase databases using the search terms ''snapping scapula,'' ''scapulothoracic bursitis,'' ''partial scapulectomy,'' and ''superomedial angle resection'' in September 2013. All nonreview articles related to the topic of snapping scapula syndrome were included.

Results: The search identified a total of 167 unique articles, 81 of which were relevant to the topic of snapping scapula syndrome. There were 36 case series of fewer than 10 patients, 16 technique papers, 11 imaging studies, 9 anatomic studies, and 9 level IV outcomes studies. The level of evidence obtained from this literature search was inadequate to perform a formal systematic review or meta-analysis. Therefore, a critical review of current evidence is presented.

Conclusion: Snapping scapula syndrome, a likely underdiagnosed condition, can produce significant shoulder dysfunction in many patients. Because the precise origin is typically unknown, specific treatments that are effective for some patients may not be effective for others. Nevertheless, bursectomy with or without partial scapulectomy is currently the most effective primary method of treatment in patients who fail nonoperative therapy. However, many patients experience continued shoulder disability even after surgical intervention. Future studies should focus on identifying the modifiable factors associated with poor outcomes after operative and nonoperative management for snapping scapula syndrome in an effort to improve clinical outcomes and patient satisfaction.

Keywords: snapping scapula; scapulothoracic; bursitis; crepitus; partial scapulectomy; superomedial angle resection

To produce smooth shoulder motion, the scapula must glide freely over the posterior thorax. Incongruence between the concave scapula and the convex thoracic wall, which can occur from anatomic predisposition, space-occupying skeletal lesions, fibrotic bursae, muscle imbalance, or a kyphotic posture, can produce painful crepitus and/or bursitis within the scapulothoracic articulation. While some patients are mildly symptomatic, others may complain of severe pain and poor shoulder function even with simple tasks.

The constellation of symptoms surrounding scapulothoracic crepitus or bursitis, commonly known as snapping scapula syndrome, can be classified according to the suspected cause. Excessive anterior angulation of the superomedial scapular angle or abnormal space-occupying lesions within the scapulothoracic space, such as elastofibromas, fibrotic bursae, or other osseous lesions, commonly result in mechanical crepitus. On the other hand, patients with scapular pain without mechanical symptoms are more likely to have symptomatic bursitis as a result of chronic

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overuse. However, this clear distinction is not commonly seen in clinical practice because mechanical crepitus can lead to symptomatic bursitis, and conversely, symptomatic bursitis can lead to mechanical crepitus. As a result, most patients have symptoms that may resemble both mechanical and nonmechanical origins.

Regardless of the etiology, current data support initial nonoperative management in patients with symptoms characteristic of scapulothoracic crepitus or bursitis.[14,24,36,60,62,74] Surgical management is typically indicated after a trial of nonoperative treatment fails to result in symptomatic improvement. However, the threshold for early surgical intervention is lowered when an anatomic lesion capable of producing scapular snapping is identified on imaging studies because these patients are more likely to fail nonoperative treatment.

Scapulothoracic bursectomy with or without partial scapulectomy using an open, mini-open, or all-arthroscopic approach can result in considerable improvements in pain and function. However, several outcomes studies have shown that despite these improvements, many patients still suffer from continued pain and disability as evidenced by suboptimal clinical outcomes scores and marginal patient satisfaction ratings.[5,49,61] Therefore, the purpose of this article is to review the current knowledge pertaining to snapping scapula syndrome and to identify areas of further research that may be helpful to improve clinical outcomes and patient satisfaction.

MATERIALS AND METHODS

In September 2013, a preliminary literature search of the PubMed and Embase databases was undertaken using the terms "snapping scapula," "scapulothoracic bursitis," "partial scapulectomy," and "superomedial angle resection." A single reviewer screened the resulting titles and abstracts to determine study eligibility. All nonreview articles related to the topic of snapping scapula and/or scapulothoracic bursitis were included.

A total of 266 records were obtained (including duplicates) after searching both PubMed and Embase for each of the 4 search terms. After the removal of 99 duplicates, 167 unique articles remained. Of these, 86 articles were either irrelevant to the topic or presented a review of the topic and were therefore excluded. This left a total of 81 relevant studies that were examined. Of these, there were 36 case reports or case series involving fewer than 7 patients, 16 technique papers, 11 imaging studies, 9 anatomic studies, and 9 outcomes studies (all of which were level IV evidence). The low levels of evidence obtained from this preliminary search did not allow for a full systematic review or meta-analysis. Therefore, a critical review of the current literature is presented.

ANATOMY

Osseous Anatomy

The scapula is a large, triangular-shaped bone that is concave on its anterior surface and spans from the second to the seventh ribs on the convex posterior chest wall, approximately 5 cm lateral to the posterior spinous processes.[39] It has 3 borders (superior, medial, and lateral) and 4 angles (superomedial, medial, inferomedial, and lateral). Its 3-dimensional resting position on the posterior thorax is typically defined as being anteriorly tilted between 10° to 20° in the sagittal plane with a 30° to 40° medial tilt in the coronal plane.[41] The primary functions of the scapula are to (1) provide a stable fulcrum for humeral rotation and (2) to dynamically position the glenoid fossa in space during glenohumeral motion.[45] To achieve these functions, the concave anterior surface of the scapula must glide smoothly over the convex thoracic cage with adequate periscapular muscle contraction.

The osseous topography of the scapula is highly variable and may predispose some patients to painful bursitis or crepitus as a result of scapulothoracic incongruity. In a large series of 92 dry scapulae, Aggarwal et al[2] found the undulating costal surfaces to range from 10.5 mm to 26.5 mm in depth. The thickness of the superomedial angle ranged from 2 mm to 4 mm, while the thickness of the inferomedial angle ranged from 5 mm to 8 mm. In addition, the superomedial angle showed wide variation, ranging from 124° to 162° in most specimens in which higher angles are thought to predispose patients to painful snapping. Approximately 2% of specimens in their study also had an anterior "horn-like" projection at the lateral border of the scapula. Boyle et al[7] reported the presence of a bare area near the superomedial angle, where there is no underlying subscapularis muscle, which is a finding that may predispose some patients to painful snapping. An anatomic study by Edelson[19] demonstrated the presence of superomedial hooking in 6% of cadaveric scapulae. A similar finding was occasionally present near the inferomedial angle in the same study. Milch[47] also described the "Luschka tubercle" as a bony protuberance at the superomedial scapular angle, which may lead to painful crepitus in some patients.[76] Additionally, Totlis et al[76] recently described an anteriorly angulated teres major tubercle that was present in 3.4% of cadaveric specimens, which may also contribute to snapping scapula syndrome in some patients.

The suprascapular notch also has a variable structure[65,66,68,79] and sits at the medial aspect of the lateral third of the superior border of the scapula, just medial to the confluence of the coracoid process with the scapular body.[49] The transverse scapular ligament, a structure that also has significant anatomic variability,[63,64] generally runs mediolaterally between the crests of the suprascapular notch. Below the ligament and within the notch, the suprascapular nerve is found, whereas the suprascapular artery courses above the ligament and thus outside of the notch.

Muscular Anatomy

Because there is no direct bony articulation that dictates scapulothoracic motion, appropriate dynamic scapular positioning requires the coordinated effort of the surrounding periscapular musculature (Table 1). As such, dysfunction of any of these muscles may result in scapular malposition and/or dyskinesis, which can predispose

TABLE 1
Anatomic Characteristics of the Periscapular Musculature

Muscle	Origin	Insertion	Nerve Supply	Vascular Supply	Function
Supraspinatus	Supraspinous fossa	Superior facet of greater tuberosity	Suprascapular nerve	Suprascapular artery	Abduction of the humerus
Infraspinatus	Infraspinous fossa	Posterior facet of greater tuberosity	Suprascapular nerve	Suprascapular artery	External rotation of the humerus
Teres minor	Inferolateral aspect of posterior scapular body	Inferior facet of greater tuberosity	Axillary nerve	Posterior circumflex humeral artery, circumflex scapular artery	External rotation of the humerus in abduction
Subscapularis	Subscapular fossa	Lesser tuberosity	Upper and lower subscapular nerves	Transverse cervical artery, subscapular artery	Internal rotation of the humerus
Trapezius	Spinous processes of C7-T12	Superior aspect of scapular spine	Spinal accessory nerve	Superficial branch of transverse cervical artery	Scapular rotation and elevation
Serratus anterior	Upper 9 ribs	Anterior aspect of medial scapular border	Long thoracic nerve	Thoracodorsal artery, lateral thoracic artery	Scapular protraction and upward rotation
Levator scapulae	Transverse processes of C1-C4	Medial border of scapula superior to the medial base of the scapular spine	Dorsal scapular nerve	Dorsal scapular artery	Scapular elevation
Rhomboid minor	Spinous processes of C7-T1	Medial border of scapula at the level of the medial base of the scapular spine	Dorsal scapular nerve	Dorsal scapular artery	Scapular retraction and rotation
Rhomboid major	Spinous processes of T2-T5	Medial border of scapula inferior to the medial base of the scapular spine	Dorsal scapular nerve	Dorsal scapular artery	Scapular retraction and rotation

a patient to painful scapular bursitis with or without mechanical crepitus.

Bursal Anatomy

Bursae are fluid-filled sacs lined with synovium that facilitate the gliding of opposing surfaces relative to one another. Periscapular bursae have been described as being either anatomic or adventitial.[14] Anatomic bursae are thought to represent a normal physiological state that allows the normal gliding of surfaces in and around the scapulothoracic articulation. The most consistently recognized anatomic bursae are the infraserratus and supraserratus bursae, which are divided by the serratus anterior muscle. Specifically, the infraserratus bursa allows gliding between the serratus anterior and the posterior thoracic cage, while the supraserratus bursa allows gliding between the subscapularis and the serratus anterior.[14,37] Adventitial bursae, most commonly located at the superomedial and inferomedial angles, are thought to represent a pathological state.[15,62] Symptoms that occur at the inferomedial angle are most likely caused by pathological infraserratus bursal tissue,[48,74] whereas symptoms that occur at the superomedial angle could be caused by pathological infraserratus or supraserratus bursal tissue.[16,36] Occasionally, pain near the medial confluence of the scapular spine may be caused by a pathological scapulotrapezial bursa, which is located deep to the trapezius and superficial to the medial confluence of the scapular spine (Figure 1).

Neurovascular Anatomy

Knowledge of pertinent neurovascular anatomy is critical to minimize the risk for iatrogenic injuries. The spinal accessory nerve travels with the superficial branch of the transverse cervical artery along or through the central portion of the levator scapulae muscle deep to the trapezius muscle[21]; its branches are at risk with portal placement superior to the level of the scapular spine.[71] The deep branch of the transverse cervical artery becomes the dorsal scapular artery, which travels with the dorsal scapular nerve beneath the rhomboid minor and major muscles approximately 1 to 2 cm medial to the medial scapular border.[71] Portal placement should therefore be located approximately 3 cm to the medial scapular border to prevent iatrogenic injury to these structures (Figure 2). The long thoracic nerve innervates the serratus anterior muscle, runs along its anterior surface, and is infrequently endangered unless dissection is carried laterally. The suprascapular nerve branches from the superior trunk of the brachial

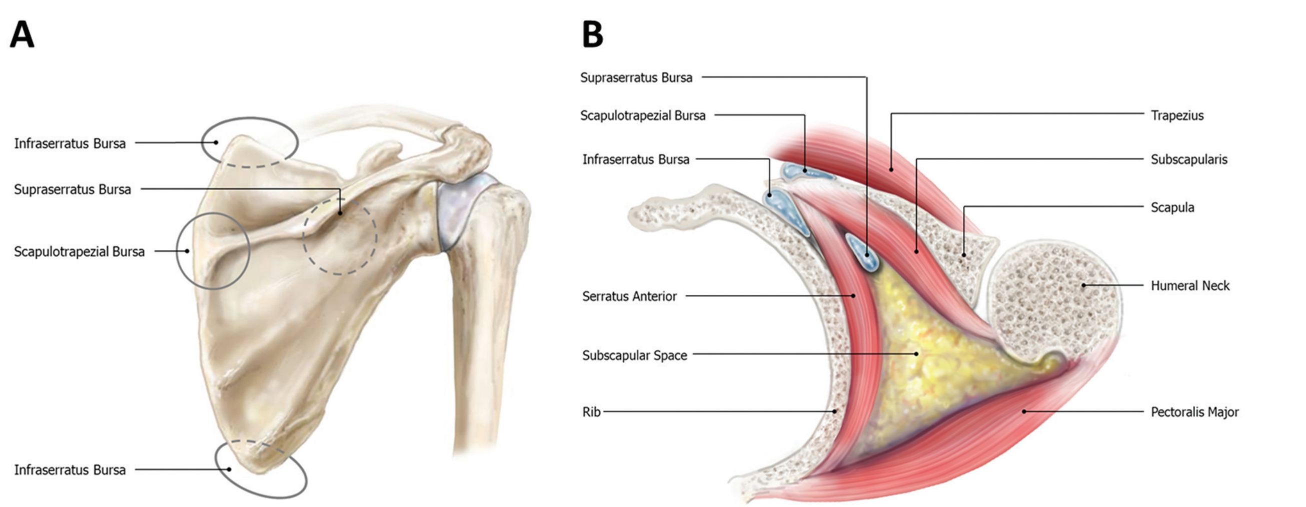

Figure 1. (A) Illustration of a posterior right scapula demonstrating the approximate locations of anatomic and adventitial bursae. (B) Illustration of an axial slice at approximately the level of the scapular spine. Note the orientation of bursal tissue relative to the scapula, posterior thorax, and periscapular musculature.

plexus and travels posterosuperiorly toward the suprascapular notch with the suprascapular artery. The suprascapular nerve passes underneath the transverse scapular ligament, and the suprascapular artery courses above the ligament before supplying the supraspinatus and infraspinatus muscles. These structures are at risk when resection of the superomedial angle is performed with portal placement superior to the scapular spine.[49,50] Some authors have recommended the maintenance of a 2- to 3-cm distance from the suprascapular notch to prevent iatrogenic injuries of the suprascapular nerve and artery.[2,4]

PATHOPHYSIOLOGY

The scapulothoracic articulation is unique in that it does not rely upon hyaline cartilage or synovium to achieve smooth motion; rather, the scapula glides over muscle layers with the aid of interposed bursal tissue. Inflammation of this bursal tissue can occur as a result of an acute traumatic event[3,46] or in the setting of chronic overuse especially in those who are anatomically predisposed to bursal irritation.[46,74] In the majority of cases, bursitis and/or snapping is generally thought to result from abnormal motions between the scapula and posterior chest wall derived from abnormal scapular kinematics with or without anomalous anatomy.[36,62] Continued abnormal scapular motion can lead to chronic inflammation, bursal fibrosis, and recalcitrant bursitis, which are often difficult to manage therapeutically.

There are several potential soft tissue causes of scapular snapping. Adventitial bursal irritation and subsequent fibrosis inhibit normal bursal function, which thus prevents the smooth gliding of the anterior scapula over the posterior thoracic cage. Problems with the interposed muscle can also cause snapping, such as posttraumatic fibrosis

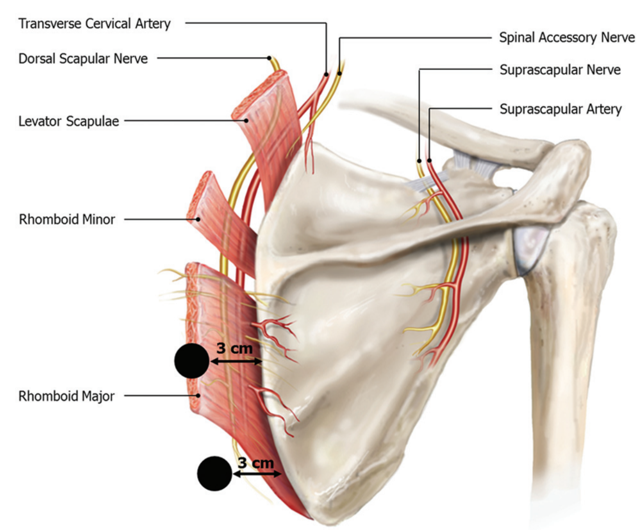

Figure 2. Illustration of pertinent neurovascular anatomy. Note that arthroscopic portals should be placed >3 cm medial to the medial scapular border to prevent iatrogenic injury to the dorsal scapular nerve and artery. Portals placed superior to the level of the scapular spine may increase the risk of injury to the spinal accessory nerve and the suprascapular nerve and artery.

or anomalous musculature. Significant pain can lead to guarding and muscle atrophy, thus allowing the scapula to directly articulate with the rib cage as a result of diminished soft tissue interposition.

In addition to soft tissue causes, bony abnormalities in and around the scapulothoracic articulation can also result in overt scapular snapping. In several cadaveric studies, the superomedial and inferomedial scapular angles have been found to exhibit a hooked or highly angulated architecture,[2,19] leading some to propose a potential familial propensity.[15] Milch[48] described a bony protuberance at the superomedial angle, which has since been referred to as the Luschka tubercle. Malunion or callus resulting from scapular or rib fractures can cause scapulothoracic incongruence and intractable snapping.[48,75] Snapping scapula may also occur in patients who underwent previous first rib resection for thoracic outlet syndrome.[80] In addition, patients with structural spinal abnormalities such as kyphosis or scoliosis can develop scapular snapping as a result of increased spinal angulation relative to the normal curvature of the scapula.[45]

Enlarging scapulothoracic masses can also prevent the smooth gliding of the scapula over the thoracic cage. Osteochondromas are the most common tumors of the rib or scapula reported to be involved in the development of snapping scapula.[1,20,22,38,69,78] Elastofibroma dorsi, a soft tissue growth that is thought to result from repetitive microtrauma, has occasionally been reported and is commonly found near the inferomedial scapular angle, often resulting in elevation of the inferior scapular border (pseudowinging).[1,13,26] Rarely, malignant chondrosarcoma may be encountered in older patients, thus highlighting the need for careful investigation of these patients.

CLINICAL PRESENTATION

Depending on the origin of symptoms, patients with scapulothoracic bursitis and/or snapping may complain of symptoms ranging from mild discomfort to overt, painful, audible snapping that produces notable shoulder dysfunction, especially with overhead activity. It is important to recognize, however, that scapulothoracic crepitus may occur in patients who are asymptomatic.[25] Thus, the potential exists for secondary gain in workers' compensation cases or those in litigation because many patients with symptomatic scapular crepitus have functionally disabled shoulders.[69]

History

Patients with scapulothoracic bursitis or snapping scapula usually complain of pain, scapular noise, and/or crepitant sensations with arm movement, especially with overhead activities.[9,23,74] Each one of these symptoms can vary with presentation: pain at the superomedial angle can be either minimal or excruciating, scapular noise may be distinctly audible or only detected by palpation,[23,48] and crepitant sensations can range from minor to severe in intensity. In addition, patients may or may not report an acute traumatic event leading to their discomfort.[11,43] With these factors in mind, the patient should be questioned regarding the precise location, quality, and intensity of the associated pain or discomfort along with its chronicity, associated symptoms, and aggravating and alleviating factors. The patient's desired type and level of activity should also be documented for appropriate goal setting.

Physical Examination

Physical examination begins with a visual inspection of posture because significant kyphoscoliosis is known to reduce scapulothoracic congruity and may induce scapular snapping with or without painful bursitis.[15,36] Evaluation of the cervical spine should be performed in all patients to rule out a referred pain syndrome resulting from nerve compression between the C5 and C8 nerve root levels.[8,44] Inspection of both scapulae is then undertaken, noting any evidence of asymmetry, winging, or audible snapping as the arms are moved through a range of active and passive motion. It is important to note that overhead athletes will often have depression, protraction, and downward rotation of their dominant scapula, which may be independent of their primary complaint.[67]

Scapular winging is a common finding in patients with scapulothoracic bursitis and/or crepitus and may be the result of disordered periscapular muscle kinematics such as weakness or tightness of the serratus anterior, trapezius, levator scapulae, and/or pectoralis minor muscles. Serratus anterior muscle weakness from long thoracic nerve palsy or any other cause can result in lateral scapular winging. Trapezius and levator scapulae tightness may be seen with neck stiffness and can be diagnosed via muscle length testing. Weakness or atrophy of the trapezius muscle (which is innervated by the spinal accessory nerve) can result in scapular depression with subtle medial scapular winging. Pectoralis minor tightness, which can also result in scapular depression and protraction, can be diagnosed by simply visualizing the difference in the height of the shoulders off the examination table while the patient lies supine: the affected shoulder will rise higher off the table than the unaffected shoulder.[6,53] Another method used to assess pectoralis minor tightness is to place one hand on the affected shoulder with the patient supine and apply a moderate anteroposterior force; significant resistance or the inability to flatten the shoulder onto the examination table likely indicates a shortened pectoralis minor muscle-tendon complex.[33] Scapular pseudowinging can also occur in patients who have adapted specific scapular positions that alleviate symptoms or in those with enlarging tumors that push the scapula away from the posterior thorax.[36]

Palpation around the scapulothoracic articulation may reveal areas of localized tenderness, potentially corresponding to adventitial infraserratus or supraserratus bursal inflammation. Placing the arm in the "chicken wing" position (the humerus is internally rotated, and the dorsum of the hand is placed over the lumbosacral junction) may help to tilt the scapula laterally, thereby allowing deeper palpation beneath the medial scapular border.[50,55] On occasion, a patient may be capable of demonstrating provocative movements that reliably produce scapulothoracic crepitus. In these cases, it is often helpful to palpate the scapula during active motion to help localize the site of inflammation.[23] Applying posterior-to-anterior pressure over the scapular body during range of motion testing may also precipitate crepitation between the scapula and the posterior thorax and may help to reproduce the patient's symptoms.[49]

Individual periscapular muscle strength testing should also be undertaken to identify any points of weakness that may result in scapular dyskinesia and subsequent bursitis or snapping. Trapezius muscle strength can be evaluated by simply having the patient shrug the shoulders while the clinician applies resistance. The strength of the levator scapulae and rhomboid musculature is tested by having the patient place the hands on the ipsilateral iliac crests and retracting the scapula by moving the elbows posteriorly. Resistance of this motion can also be performed to assess corresponding muscle strength. The serratus anterior muscle is tested by having the patient perform a wall push-up while the examiner simultaneously visualizes and palpates the medial border of the scapula. Serratus anterior weakness would most likely result in medial scapular winging during this test. The latissimus dorsi muscle is tested by having the patient press posteriorly against resistance with the arms at the side while also palpating the inferomedial angle of the scapula.

The presence of SICK (scapular malposition, inferomedial border prominence, anterior coracoid pain, and scapular dyskinesis) scapula in overhead athletes should alert the clinician to the potential presence of other associated disorders such as a glenohumeral internal rotation deficit, posterosuperior glenoid impingement, and/or superior labral anterior to posterior (SLAP) tears because there is evidence to suggest that scapular malposition and dyskinesis may be causative.[9]

Diagnostic Studies

Plain Radiographs. Standard radiographs obtained when diagnoses of snapping scapula or scapulothoracic bursitis are suspected include true anteroposterior, tangential Y, and axillary views. This combination of views improves the probability of identifying skeletal abnormalities that may contribute to the underlying diagnosis. Unfortunately, however, these lesions are not always apparent on radiographs, especially when lesions are primarily soft tissue based or are not sufficiently calcified. While some researchers have suggested performing fluoroscopy to dynamically identify osseous lesions, this modality is largely unnecessary for diagnosis and poses an increased risk for excessive radiation exposure.[59]

Computed Tomography. Several studies have evaluated the clinical utility of computed tomography (CT) for the diagnosis of scapulothoracic crepitus.[18,52,73] However, although the interrater and intrarater reliability of CT has been found to be excellent, findings on CT scans do not seem to correlate with clinical findings, especially when there is no skeletal lesion present such as an osteochondroma or scapulothoracic incongruity. Routine CT scanning is therefore not suggested in patients with scapulothoracic bursitis/crepitus without documentation of an osseous or cartilaginous lesion that alters the congruency of the scapulothoracic articulation. When an identifiable skeletal lesion appears to occupy an area within the scapulothoracic space on plain radiographs, a CT scan with or without 3-dimensional optimization can be used to further characterize the lesion for the purposes of surgical planning.

Recently, 3-dimensional wing CT scanning has been proposed as a method of quantifying scapular dyskinesis. Park et al[58] evaluated 178 shoulders in 89 athletes with various shoulder disorders and compared the reliability of visual inspection versus 3-dimensional wing CT for the diagnosis of 4 types of scapular dyskinesis as described by others.[34,35,77] Of note, this study only accounts for changes in the resting position of the scapula; however, the authors suggest that their data can be extrapolated to account for changes in dynamic scapular motion. The interrater reliability of visual inspection was found to be 0.780, and the interrater reliability of 3-dimensional wing CT was 0.972. Although this study provides promising results, there are several potential limitations (radiation, cost, supine positioning in the scanner), and future study is recommended to support or refute the use of 3-dimensional wing CT for the diagnosis of scapular dyskinesis.

Magnetic Resonance Imaging. Magnetic resonance imaging (MRI) is most useful to identify soft tissue structures that may contribute to scapulothoracic crepitus or bursitis. Higuchi et al[29] evaluated 9 patients (mean age, 67 years) with painless palpable masses inferior to the scapula that were diagnosed as “soft tissue masses” on clinical examination. Further, MRI found that each of the lesions was actually cystic in nature without any solid components. The cystic lesions spontaneously regressed after several weeks. Ken et al[32] had similar findings in 4 patients with “soft tissue tumors” that were subsequently found to be cystic lesions after MRI. Since then, several studies have evaluated the efficacy of MRI to differentiate between benign and malignant soft tissue lesions.[12,17,27] Harish et al[27] found that increasing size and heterogeneity of soft tissue lesions were associated with malignancy in a series of 40 patients with histologically-diagnosed soft tissue masses. Datir et al[17] subsequently found that soft tissue lesions $>$5 cm in diameter were significantly associated with malignant transformation. In contrast, Pang and Hughes[57] suggested that lesion heterogeneity, including a change in heterogeneity pattern between T1-weighted and T2-weighted images, was more important than the size of the lesion to distinguish between benign and malignant soft tissue lesions. Chen et al[12] used tissue component analysis to demonstrate numerous characteristics of malignant soft tissue lesions that are absent in benign soft tissue lesions. These studies highlight the importance of MRI in the detection and characterization of soft tissue lesions and the prevention of misdiagnoses and unnecessary surgical intervention.

Ultrasound. Although ultrasound has been reported as a potential modality for the initial diagnosis of inflamed bursal tissue,[31] it is most commonly used to guide needle placement for diagnostic and therapeutic injections.[23,72] In general, the temporary resolution of pain after the injection confirms the diagnosis of bursitis while also precisely localizing the pathological bursa.

Electromyograms. An electromyogram may become necessary in patients with unexplained scapular winging and/or periscapular muscle weakness. In particular, lateral scapular winging may be caused by atrophy or weakness of the serratus anterior muscle as a result of a long thoracic nerve injury. Medial scapular winging can be the result of trapezius muscle weakness due to a spinal accessory nerve dysfunction, which may be caused by an aberrant arthroscopic portal placed superior to the level of the scapular spine; however, this is extremely rare and should be considered a diagnosis of exclusion.

NONOPERATIVE MANAGEMENT

In the absence of an obvious space-occupying mass, malignant lesion, or significant scapulothoracic incongruence, a nonoperative approach to management is typically undertaken and has been shown to be successful on several occasions.[14,24,36,60,62,74] Nonoperative treatment initially consists of nonsteroidal anti-inflammatory medications, activity modification, and therapeutic injections of steroids and/or local anesthetic into inflamed bursae.[23,30,35]

Therapeutic injections are typically administered with the patient in the seated or prone position. The humerus is then internally rotated, and the elbow is flexed such that the dorsum of the hand lies superior to the thoracolumbar junction. This "chicken wing" position elevates the medial scapular border and increases the potential space available between the anterior surface of the scapula and the posterior thorax.[49,50] The needle is directed toward the center of the inflamed bursa (or the point of maximal tenderness[30]) while taking care to maintain a parallel plane between the scapular body and the posterior chest wall to avoid intrathoracic penetration.

Hodler et al[30] reported the potential utility of fluoroscopic guidance to aid the clinician in accurate needle placement for injections. However, the authors also found excellent pain relief when injections were not placed directly within the inflamed bursal tissue (ie, intramuscular injection). Other authors have reported similar satisfactory results even when fluoroscopy was not used.[40,54,61] These studies suggest that although accurate needle placement is desired for therapeutic injections, fluoroscopy is probably not routinely necessary.

INDICATIONS AND OUTCOMES OF OPERATIVE MANAGEMENT

Indications for Surgery

Surgical treatment is typically considered in those patients who have either failed 3 to 6 months of nonoperative therapy or in those with an osseous or soft tissue mass that is causative of their symptoms. Several authors have found surgical outcomes to be more favorable when diagnostic or therapeutic injections result in symptomatic relief.[28,40,54] As with any surgical procedure, careful patient selection is necessary to obtain the most satisfactory outcome possible.

Outcomes of Open Techniques

In 1950, Milch[47] was the first to document the surgical technique and results of partial scapulectomy in 3 patients with snapping scapula syndrome. There have since been numerous studies showing good outcomes after superomedial angle resection, especially in those with a predisposing anatomic variation or distinct skeletal lesions.[3,10,11,40,51,56,59,70] In 1 study, Arntz and Matsen[3] reported excellent results in 12 of 14 shoulders (86%) that underwent open superomedial angle resection for an abnormal bony shape or scapulothoracic incongruity. Of note, the investigators also histologically examined the resected bone and found no abnormalities, corresponding with the findings of other authors.[51,54,56]

Symptomatic patients without radiographic or surgical evidence of an osseous abnormality may be candidates for bursectomy alone without resection of the superomedial angle. McCluskey and Bigliani[46] reported excellent outcomes in 8 of 9 shoulders (89%) after isolated supraserratus bursectomy. In 2002, Nicholson and Duckworth[54] followed 17 patients for a mean of 2.5 years after open bursectomy. Five of the 17 patients (29.4%) received additional superomedial angle resection. The authors noted that superomedial angle resection allowed for a more complete bursectomy while also relieving osseous impingement. Symptom resolution occurred in all patients with significant improvement in American Shoulder and Elbow Surgeons (ASES) scores; however, the authors were unable to compare the outcomes in those who did or did not receive concomitant superomedial angle resection because of low numbers.

Although less common, inflammation of the infraserratus bursa can also occur on occasion. Sisto and Jobe[74] reported on 4 professional baseball pitchers who underwent open bursectomy at the inferomedial angle of their dominant scapulae. Histological examination of the resected bursal tissue revealed signs of chronic inflammation and scarring. After rehabilitation, each patient was able to return to pitching at the professional level without further issues.

Outcomes of Arthroscopic Techniques

Several authors have reported similar clinical outcomes after arthroscopic techniques when compared with open or mini-open approaches. In 1999, Harper et al[28] were among the first investigators to describe a technique for arthroscopic partial scapulectomy. In their series, 7 patients reported excellent improvement in pain and function a mean of 7 months after arthroscopic partial scapulectomy. Later, Pearse et al[61] reported the outcomes after arthroscopic management for scapulothoracic bursitis or osseous impingement. In their study, 13 patients underwent bursectomy, while 3 of these patients also underwent resection of the superomedial scapular angle. After a mean 18.5-month follow-up period (range, 9-52 months), 9 of the 13 patients (69.2%) demonstrated improvement in pain and function, with a median postoperative Constant score of 87 (range, 58-95). The 4 patients who did not show significant improvement had a median postoperative Constant score of 55 (range, 32-66). In a large series of 23 shoulders with a minimum 2-year follow-up, Millett et al[49] demonstrated measurable improvement in pain and function after arthroscopic bursectomy with or without scapuloplasty. However, despite these improvements, median patient satisfaction was only 6 of 10 in this series. Recently, Blønd and Rechter[5] also showed measurable improvement in outcomes after arthroscopic bursectomy and scapuloplasty. After a mean follow-up of 2.9 years, 18 of 20 patients (90.0%) reported noticeable improvement in pain and function over preoperative baseline values: the median Western Ontario Rotator Cuff Index (WORC) improved from 35.0 preoperatively to 86.4 postoperatively.

Outcomes of Arthroscopically Assisted Techniques

When an osseous lesion is present, removal of bone from the superomedial angle seems to reduce symptoms in the majority of patients. However, some have questioned the ability of an arthroscopic approach to allow for the removal of sufficient bone from the superomedial angle to prevent symptomatic recurrence. Therefore, when an osseous lesion is present, some surgeons prefer to use a modified mini-open approach in which bursectomy is performed arthroscopically and scapuloplasty is performed using an open technique to allow for adequate bone resection. Lien et al[42] reported on 12 patients with a snapping scapula who were treated with arthroscopic bursectomy and open partial scapulectomy. After a minimum 2-year follow-up period, the mean ASES score improved from 36 preoperatively to 88 postoperatively ($P < .01$). In addition, the visual analog scale score for pain improved from 8 preoperatively to 2 at final follow-up ($P < .01$). One of the 12 (8.3%) patients required a second procedure after developing additional symptoms along the inferomedial scapular angle. In 1 other study, Lehtinen et al[40] reported the outcomes in 16 patients after arthroscopic or mini-open bursectomy with or without arthroscopic or mini-open scapuloplasty. Thirteen of the 16 patients (81.3%) reported complete satisfaction with their pain relief, and the Simple Shoulder Test (SST) score at final follow-up was 9.8 (range, 2-12). Although there were insufficient numbers to compare the different techniques, the authors concluded that the combination of arthroscopic bursectomy with open partial scapulectomy appeared to have superior results.

Complications

The rate of complications after surgical management of scapulothoracic bursitis ranges from 5% to 29%.[5,28,61] In addition to inadequate bursectomy or partial scapulectomy that may result in symptomatic recurrence, iatrogenic injuries may also occur. Injuries to the dorsal scapular nerve and/or artery can occur as a result of arthroscopic portal placement <3 cm medial to the medial scapular border. A spinal accessory nerve injury may be seen when portals are placed superior to the level of the scapular spine. In addition, increased risk of injury to the long thoracic nerve occurs when extensive lateral dissection is undertaken during an open approach.

FUTURE RESEARCH

Clearly, much has been done over the past decade to identify the many potential causes of scapulothoracic crepitus and bursitis. In addition, many authors have provided outcomes data after either operative[‖] or nonoperative management.[14,24,36,60,62,74] However, there exist several questions that, once investigated, may help to improve clinical outcomes and patient satisfaction.

One question regards whether scapulothoracic crepitus or bursitis can be predicted in patients with predisposing anatomy. Several studies have demonstrated the widely variable shape of the anterior scapula and specifically the superomedial and inferomedial scapular angles.[2,7,19,47,75,76] While these data are interesting, few studies, if any, have evaluated specific aspects of these morphological changes in patients with snapping scapula syndrome as a result of an anatomic lesion. The ability to predict which patients are most likely to develop a snapping scapula due to an anatomic abnormality would allow us to possibly undertake prophylactic measures to prevent future symptoms that, in many cases, are functionally debilitating.

Inadequate scapular resection is one of the primary causes of recurrent symptoms after surgical treatment. Therefore, another question regards the amount of scapular bone that should be resected to prevent the recurrence of scapulothoracic crepitus and/or bursitis after surgery. When performing superomedial angle resection, we typically remove a 2-cm (superior to inferior) by 3-cm (medial to lateral) triangular section of bone; however, this is based primarily on the size of the scapula, the specific intraoperative findings, and the experience of the senior surgeon.

Finally, available outcomes studies are composed of low patient numbers that utilize widely variable outcomes measures. While it is recognized that the relative infrequency of snapping scapula syndrome hinders the ability of investigators to accumulate large numbers of patients with similar injuries, multicenter studies may help to improve patient numbers, which will allow for comparisons between different surgical techniques. Identification of modifiable factors associated with poor outcomes should also be investigated. Although randomized controlled clinical trials are the current gold standard, several well-performed comparative studies with sufficient numbers would significantly improve our ability to manage patients with this often disabling condition.

CONCLUSION

Snapping scapula syndrome, a likely underdiagnosed condition, can produce significant shoulder dysfunction in many patients. Because the precise cause is typically unknown, specific treatments that are effective for some patients may not be effective for others. Nevertheless, bursectomy with or without partial scapulectomy is currently the most beneficial primary method of treatment in patients who fail nonoperative therapy. However, still, many patients experience continued shoulder disability even after surgical intervention. Future studies should focus on identifying the modifiable factors associated with poor outcomes after operative and nonoperative

[‖]References 5, 28, 40, 42, 46, 47, 49, 54, 61, 74.

management for snapping scapula syndrome in an effort to improve clinical outcomes and patient satisfaction.

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