Subscapularis Tears: Diagnosis and Treatment

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While the subscapularis is the largest of the rotator cuff muscles, the relative prevalence of injuries to the subscapularis tendon has only recently been recognized. The primary function of the subscapularis is to internally rotate the humerus. Injury to this muscle may occur from trauma or through a degenerative process related to aging. Patients with such injury often present with anterior shoulder pain, and increased external rotation compared to the contralateral limb. Specific physical examination tests have been developed to aid in diagnosis, all of which have high specificity, with the 'Bear Hug' test having been shown to be the most sensitive. Magnetic resonance imaging is the imaging study of choice for subscapularis tears, but many tears can be missed if only imaging is relied on to make the diagnosis. Small tears in older patients can often be treated conservatively. Larger tears that are secondary to trauma can be fixed either open or arthroscopically. Early recognition and repair, when indicated, usually produces excellent results. Arthroscopic management affords enhanced visualization, improved mobilization and lessened morbidity.

Introduction

Historically, subscapularis tears were thought to be very low in prevalence[1]. However, arthroscopic studies in patients with rotator cuff pathology have shown the prevalence to be between 27 and 43%[2]. Subscapularis tears have been reported to be associated with rotator cuff pathology in 27 to 35% of cases[3]. As subscapularis tears are now being recognized to be more common than previously thought, increasing emphasis is now being placed on diagnosis and treatment of this pathology.

Anatomy

The largest and strongest of the rotator cuff muscles, the subscapularis originates from the anteromedial two-thirds of the scapula. It inserts in two areas: the upper two-thirds on the lesser tuberosity and the lower one-third of the humeral metaphysis. The insertion of the upper part is enlarged by four to six tendon slips that arise from the muscle belly and converge to form a strong tendon which inserts on the upper portion of the lesser tuberosity and converges with fibers of the joint capsule[4]. This tendon is thus principally intra-articular. Tendon tears are therefore best visualized arthroscopically and may be missed by gross external inspection. This tendon helps to concentrate the force vector of the subscapularis muscle[5]. The footprint of the superior insertion is shaped like a trapezoid with a broad superior border that tapers to a point inferiorly[6]. D'Addessi et al., in an anatomic study of 12 human shoulders, found that the subscapularis footprint is shaped like an ear with cephalocaudal height of 25.8mm and an average width of 18.1 mm[7]. A cadaveric study by Richards et al. showed the footprint to have similar dimensions with a mean length of 25mm, mean superior width of 18mm, and mean inferior width of 3mm[6].

The anterior supraspinatus tendon fibers unite with the upper fibers of the subscapularis tendon to form the rotator cuff interval as well as a part of the coracohumeral ligament. The rotator interval is a triangular portion of the joint capsule containing the coracohumeral ligament, superior glenohumeral ligament, and the long head of the biceps tendon. This superior aspect of the footprint is where most tears of the subscapularis tendon, as well as where most load transmission, occur[6]. The intimate association of the subscapularis tendon and the biceps explains why upper subscapularis tendon lesions are associated with biceps tendon instability. The upper and lower subscapular nerves innervate the subscapularis muscle.

Some patients may also have a middle subscapular nerve that is related to the upper subscapular nerve. The upper subscapular nerve usually arises from the posterior cord of the brachial plexus while the lower subscapular nerve has a more varied origin[8]. A cadaver study showed that the latter nerve arose most commonly from an independent branch of the posterior cord in 60% of specimens, and near the origin of the axillary nerve in 23%. The upper nerve innervates the majority of the subscapularis muscle, while the lower nerve supplies the teres major as well as the axillary portion of the subscapularis muscle.

Function

The subscapularis muscle functions primarily to internally rotate the humerus. It is aided in this function by the latissimus dorsi, pectoralis major and teres major. Together with the supraspinatus and infraspinatus, the subscapularis muscle also functions to oppose the deltoid by exerting an inferior pull on the humeral head during abduction and elevation of the humerus. Another role of the subscapularis is as a contributor to glenohumeral stability;

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contraction of the subscapularis causes tension of the capsular structures[9].

Pathomechanics/Mechanism of Injury

Injury to the subscapularis occurs mainly by two methods. Most commonly, the subscapularis tendon is torn as part of a degenerative process related to aging. Trauma can also cause a tear, and is usually seen in younger patients[10]. However, older patients may present with traumatic subscapularis tears secondary to an anterior dislocation of the glenohumeral joint[11]. Most injuries to the subscapularis occur when the humerus is hyperextended and externally rotated. A study by Gerber and Krushall showed isolated and complete tears of the subscapularis following forced external rotation of the arm at the side[12].

Coracoid impingement has also been shown to contribute to subscapularis tearing through an effect described by Burkhart as the "roller wringer effect"[13]. In this process, subcoracoid stenosis and subcoracoid impingement place a tensile force on the undersurface fibers of the subscapularis tendon which in turn leads to wear and tear of the fibers at the tendon insertion. With forward elevation, cross body adduction, and internal rotation of the arm, the subscapularis tendon is impinged between the coracoid process and the lesser tuberosity. Another source of impingement occurs in the same position when the rotator cuff interval and undersurface of the subscapularis rub against the anterior superior glenoid rim. This 'anterior internal impingement' is difficult to discern clinically from coracoid impingement.

Subscapularis tears may be classified in general terms as partial versus full thickness, partial versus complete width of the tendon, and tears with or without retraction. Pfirmann proposed a classification scheme that categorized tears according to their size[14]. Grade one tears are less than one-fourth of the cephalocaudal width of the tendon, grade two tears are more than one-fourth the width, and grade three tears involve the separation of the entire tendon from the lesser tuberosity.

Diagnosis

Patients with subscapularis tears usually present with anterior shoulder pain. They may also have symptoms of biceps tendinopathy or instability, manifested as anterior shoulder 'clicking' with rotational movements. Patients also complain of difficulty tucking in their shirts or reaching for objects, such as a wallet, from their back pocket. This is secondary to the loss of internal rotation strength. In addition, patients also present with symptoms commonly found with rotator cuff pathology such as night pain, weakness, and pain with elevation of the shoulder.

On physical examination, patients frequently have tenderness over the anterior shoulder, with tenderness especially noted at the coracoid tip. In addition they may have increased passive external rotation of the affected shoulder compared to the contralateral side. They will generally have weakness of internal rotation.

A number of tests can be used to identify subscapularis tears on physical exam[15]. The lift-off test is performed by having a patient place his hand on the lumbar spine and then lift his hand away from the back. This test is positive when the patient is unable to lift his hand off his back. Patients without a full range of motion may lack the internal rotation necessary to perform this test.

In the belly press test, a patient places his palm against his abdomen with the wrist in neutral position. The patient's elbow is then pressed anteriorly by the examiner. A patient with a positive test will be unable to keep the elbow anterior, with concomitant wrist flexion. This position is often called the 'Napoleon sign' as it was often the pose Napoleon used in his portraits[15.5].

Scheibel described the 'belly-off' sign to help diagnose lesions of the upper subscapularis[16]. In this 'lag type' of test, the elbow is flexed 90 degrees and the arm is placed in flexion and maximal internal rotation. The examiner holds the elbow with one hand and places the patient's hand on his abdomen with the examiner's other hand to maximally internally rotate the arm. The examiner then releases the patient's wrist and instructs the patient to keep the wrist straight while maintaining maximal internal rotation of the arm. A positive belly-off test is seen if the patient cannot maintain this position and the hand lifts off the abdomen. In Scheibel's series of 60 patients with confirmed subscapularis tears, the belly-off sign was shown to be more reliable in diagnosing partial upper subscapularis tears or post-operative subscapular insufficiency than the belly-press or lift-off test, and internal rotation lag sign. This test was as reliable as the other tests in detecting completing subscapularis tears. However, the test was less reliable in patients who had large deficits of external rotation.

The bear hug test, as described by Barth et al., can also be used to diagnose tears of the upper subscapularis[17]. To perform this test, the patient is asked to place the palm of the affected extremity on the contralateral shoulder. The fingers of the affected extremity are extended and the wrist is kept in neutral position. The patient is then instructed to hold that position while the examiner attempts to pull the patient's hand away from his shoulder by externally rotating the forearm. A positive test is demonstrated if the patient is unable to hold his palm on his contralateral shoulder against the examiner's pull or if the patient's strength shows at least a 20% difference as compared to the unaffected contralateral side. Barth and colleagues examined 68 patients preoperatively prior to shoulder arthroscopy. Compared to the lift-off, belly press and Napoleon tests, the bear hug test was most sensitive in identifying subscapularis tears, although all tests showed high specificity. In addition, patients with positive bear-hug and belly-press tests tended to have subscapularis tears of at least 30%, patients with positive Napoleon tests had tears of at least 50%, and positive lift-off tests were generally not seen until patients had tears of at least 75% of the tendon. Chao et al. examined the EMG activity of the internal rotator muscles including pectoralis major, latissimus dorsi and upper and lower subscapularis during the lift-off and belly-press tests as

well as the bear-hug test at 0, 45, and 90 degrees of shoulder flexion[18]. The lower subscapularis had significantly greater peak EMG activity at 90 degrees of shoulder flexion in the bear-hug test than the upper subscapularis. At 45 degrees, the upper and lower subscapularis had significantly greater EMG activity as compared to the pectoralis major and latissimus dorsi. This suggests that the 'Bear Hug' test may be useful in discerning upper subscapularis lesions – where tears tend to originate.

Imaging

In evaluating patients with possible subscapularis tears, anteroposterior, axillary lateral, and outlet view x-rays of the shoulder should be obtained but are often negative. Anterior subluxation of the humeral head on the axillary lateral view may be seen in patients with chronic tears. An AP view showing humeral head elevation with narrowing of the subacromial space is often seen in patients with massive rotator cuff pathology, which usually includes a significant subscapularis lesion. In addition, patients with subscapularis injury may also have associated biceps tendon pathology including osteophytes at the bicipital groove and medial subluxation of the biceps. Since the subscapularis insertion is intimately associated with the coracohumeral ligament and superior glenohumeral ligament, significant subscapularis tendon tears usually weaken the medial restraints to the biceps 'pulley' system. Further, subcoracoid narrowing, usually measured on magnetic resonance imaging (MRI) or arthroscopy, and defined as a coracohumeral interval of 6 mm or less, is often seen in patients with subscapularis tears[19].

A subscapularis tear can be identified using ultrasound, CT or MR arthrography, as well as MRI. Farin et al. used ultrasound to accurately diagnosis 82% of subscapularis tears in a group of 17 patients with arthroscopically-confirmed tears[20]. However, it was noted that a position of maximal external rotation was often needed to fully evaluate these tears.

Abnormal high signal intensity on T2-weighted MR images with indistinct tendon contours is often indicative of a subscapularis tear[21]. An evaluation of the chronicity of the injury can be made by evaluating the subscapularis muscle quality which is best seen on sagittal oblique MR images. A study by Tung et al. looking at radiologist-reviewed preoperative MRIs showed identification of only 31% (5/16) of subscapularis tears that were positively identified at surgery[22]. Another review by Adams et al. of 1220 patients who underwent arthroscopy, with 44 surgically confirmed subscapularis tears showed a 100% specificity of 16 radiologist-identified subscapularis tears on MRI[23]. However, the sensitivity of radiologist-reviewed MRI was only 36% (16/44). When the authors looked at tears >50% of tendon length, the radiologists' sensitivity improved to 56% suggesting that smaller tears are harder to diagnose on MRI.

Treatment and Results

There are multiple treatment options in the management of subscapularis tears, with non-operative care indicated in some. Less active, older patients with smaller atraumatic tears should first engage in a conservative treatment plan comprised of physical therapy, anti-inflammatories, and activity modification. Patients unresponsive to conservative management may be candidates for operative intervention. Patients with traumatic tears will likely have better outcomes with early operative intervention[24]. Just as partial supraspinatus tears tend to enlarge with time, partial subscapularis lesions will likely progress; symptoms must be followed closely.

Operative treatment may involve either arthroscopic or open repair of the subscapularis tendon. The senior author favors arthroscopic treatment for its better visualization of the intra-articular subscapularis tendon, as well as for the enhanced mobilization it provides. However, the limited space available during shoulder arthroscopy makes visualization, knot tying, and instrument manipulation more difficult, especially in the hands of an unskilled arthroscopist[25].

The arthroscopic approach begins with the patient in the beach chair or, as the senior author prefers, lateral decubitus position with the affected arm in balanced suspension with approximately forty degrees abduction. The line of pull of the traction should be just anterior to the contralateral side. A diagnostic arthroscopy is performed and careful inspection of the subscapularis tendon is carried out. (Figure 1) To visualize the subscapularis footprint, the arm should be abducted and internally rotated. Burkhart describes the "posterior lever push" maneuver for improved visualization of the footprint. In this technique, the elbow is grasped while a posterior force is placed on the humerus. This movement allows the intact subscapularis fibers to pull away from the footprint, allowing the surgeon to better see the subscapularis insertion site. Burkhart and Brady report that this technique may increase the field of view by 5-10 mm[26]. Another recommendation made by Burkhart is use of a seventy-degree scope for better visualization of the footprint. To fully assess the tear, the size and direction of the tear as well as the amount of retraction should also be evaluated. (Figure 2) When a tendon is fully retracted, the tendon may be difficult to distinguish from the conjoint tendon. In this instance, Burkhart recommend finding "the comma sign", an arc-shaped area of tissue at the superior-most aspect of the subscapularis which shows the surgeon the superolateral subscapularis margin. Fibers from the superior glenohumeral ligament as well as the medial head of the coracohumeral ligament comprise the 'comma' which serves as a useful lighthouse for the tendon edge.

Once the subscapularis insertion site is evaluated, a thorough assessment of the medial sling and bicipital groove must also be performed. As stated, medial dislocation of the biceps secondary to a tear of the insertion of the sling can often be seen with tears of the upper subscapularis. The biceps tendon can be assessed by inserting a probe through an anterior portal and tugging on the tendon. If appreciable medial subluxation is present, a biceps tenotomy or tenodesis is required in order to enhance visualization and protect the repair.

After a tear of the subscapularis has been identified, subsequent repair should be performed before other shoulder

areas are addressed. As the arthroscopy proceeds, the shoulder will get increasingly swollen which will impair visualization of the subscapularis tear and make repair increasingly difficult to perform.

Burkhart describes three portals to repair the subscapularis[27]. The aforementioned posterior portal is the primary viewing portal. An anterosuperolateral portal made just anterior to the biceps tendon and anterolateral edge of the acromion is used to prepare the subscapularis footprint as well as for repair of the tear. An anterior portal, just lateral to the coracoid, is used for anchor placement.

Treatment of retracted subscapularis tears can be difficult because of inadequate mobilization. Chronic retracted tears are most amenable to arthroscopic repair, as mobilization and visualization are facilitated. Essentially, the coracoid tip and neck are skeletonized with elevators and cautery in order to free attachments of the retracted tendon. Lo and Burkhart describe the "interval slide in continuity" in which part of the rotator interval and coracohumeral ligament are resected and released in order to increase mobility of the subscapularis tendon[28]. The coracohumeral ligament is 'peeled away' from the lateral coracoid, which provides the subscapularis with greater excursion. Preservation of the coracohumeral ligament also allows stable tissue for any associated posterior tears to be approximated via margin convergence.

Ide et al. recommend that a coracoplasty be performed in patients with a tight coracohumeral interval <6mm to allow sufficient space for the subscapularis tendon[29]. (Figure 3) Another advantage of the coracoplasty is to allow for a large enough working area to perform the repair.

Arthroscopic treatment of subscapularis tears has been shown to have good results. In a study of twenty patients with subscapularis tears that were repaired using an arthroscopic suture-anchor technique, Ide et al. reported good or excellent outcome in 18 patients[29]. Those patients with failed repairs were significantly older and had more

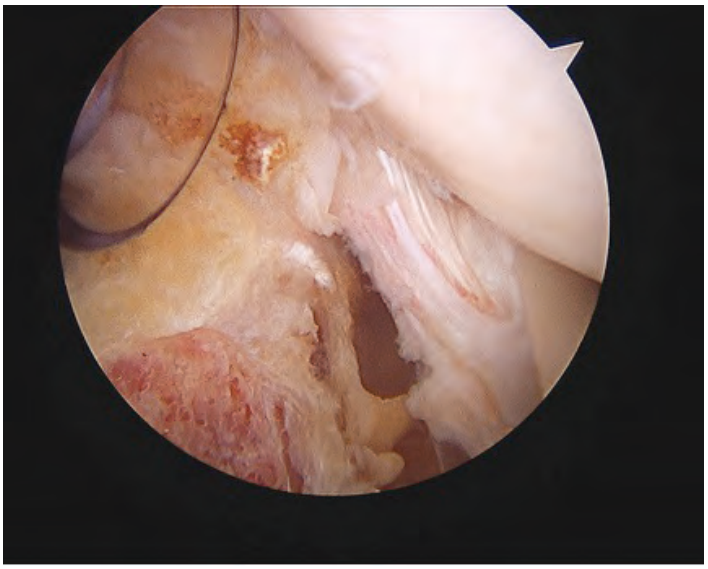

Figure 1. A torn subscapularis tendon is viewed during arthroscopy.

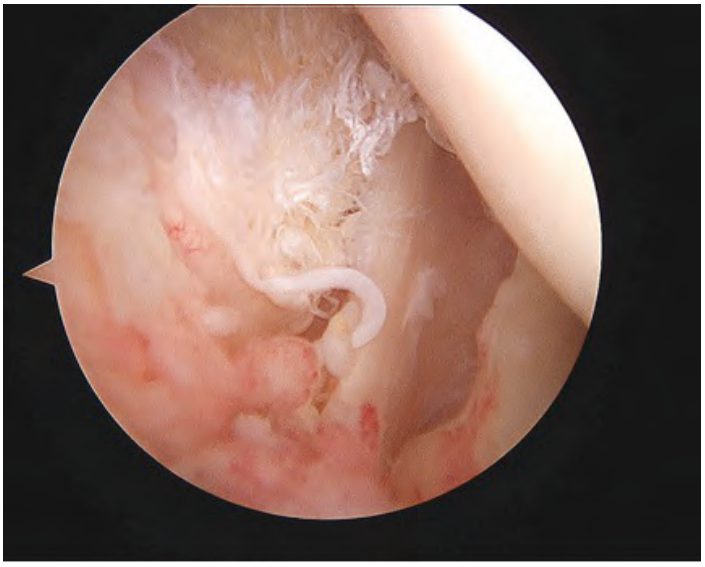

Figure 2. A retracted subscapularis tendon is identified during an arthroscopy.

tendon retraction. In a retrospective review of 22 patients who underwent arthroscopic subscapularis repair without concurrent biceps tenotomy or tenodesis and who had a minimum of one year follow-up, Kelly reported all 22 patients were "satisfied or better" after the surgery and none had complaints regarding the biceps tendon[30]. Adams et al. reported good or excellent results in 32 of 40 patients treated with arthroscopic subscapularis tendon repair who were evaluated approximately five years following surgery[31]. A study of 26 patients treated with arthroscopic subscapularis repair performed by Lafosse et al. showed an improvement of shoulder function from 58 to 86% percent and Constant score improvement 48.6 to 75.2% at two-year follow-up[32].

Open Repair

An open approach to subscapularis repair is usually performed with the patient in a beachchair or modified beachchair position using an intermuscular deltopectoral or anterior deltoid-splitting approach. The deltopectoral approach can be used for isolated subscapularis tears while the anterior deltoid-splitting approach is used for subscapularis tears with associated supraspinatus or infraspinatus tears. The deltopectoral approach is advantageous in that the deltoid muscle is left intact while still allowing visualization and mobilization of a retracted subscapularis tendon. The axillary artery and infraclavicular plexus must be protected, especially when releasing adhesions[33]. The axillary nerve passes below the inferior border of the subscapularis tendon and may be protected with a blunt retractor between the nerve and the tendon[34]. Both the deltopectoral and anterior deltoid-splitting approaches require opening of the rotator interval from the bicipital groove to the glenoid. Given the close association of subscapularis tears with biceps pathology[35], the surgeon must carefully examine the biceps tendon and bicipital pulley for any instability or tearing. As in the arthroscopic approach, biceps tenodesis is usually

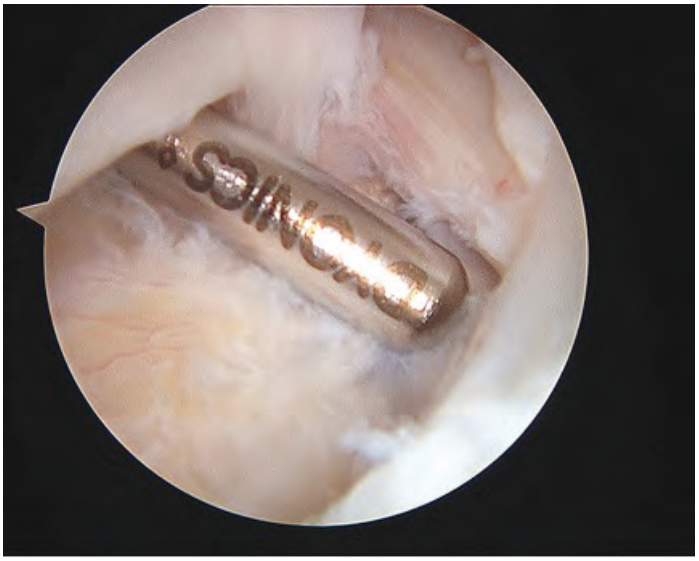

Figure 3. A coracoplasty is performed for a tight coracohumeral interval.

performed in these cases, also allowing for improved visualization. The subscapularis tendon can be examined at its lesser tuberosity attachment. Presence of "bare bone" between the lesser tuberosity and articular humeral head is indicative of a subscapularis tear. To identify the superior subscapular tendon margin, the humeral head must be pushed posteriorly and the tendon seen inside the glenohumeral joint. The tendon should be identified and tagged and then be fully released from its insertion. The detached subscapularis tendon may be reattached using suture anchors, or intraosseous sutures in the bare area on the lesser tuberosity. If the subscapularis tendon is very retracted, then release of the glenohumeral ligaments on the articular side may be necessary to fully mobilize the torn tendon. Once the repair is complete, the surgeon must assess the range of motion of the shoulder as well as the stability of the repair.

A retrospective review of 84 patients who had undergone open subscapularis repair by Edwards et al. showed a mean increase in Constant score from 55 to 79.5 points[36]. Seventy-five of these patients were satisfied or very satisfied with the procedure. Gerber et al.'s review of 16 patients who had undergone open repair of isolated subscapularis injuries showed that at a mean follow-up of approximately 3.6 years, eight patients considered their surgical results to be excellent, five considered their results to be good, while the remainder judged their results to be fair or poor[37]. Ninety-five percent of patients were able to return to their original occupation as compared to 59% pre-operatively.

Rehab

Following repair of the subscapularis, patients are placed in a small abduction pillow, and allowed external rotation to zero for the first six weeks. Following this initial post-operative period, physical therapy is initiated and range of motion is gradually increased. Strengthening exercises are not begun until a minimum of 10 weeks after surgery.

Conclusion

While the largest of the rotator cuff muscles, the relative frequency of subscapularis tendon injuries has only recently been recognized. Early recognition and repair, when indicated, usually produces excellent results. Arthroscopic management affords enhanced visualization, improved mobilization and lessened morbidity.

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