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Clinical Sports Medicine Update

The Diagnosis and Treatment of Superior Labrum, Anterior and Posterior (SLAP) Lesions

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The advent of shoulder arthroscopy, as well as our improved understanding of shoulder anatomy and biomechanics, has led to the identification of previously undiagnosed lesions involving the superior labrum and biceps tendon anchor. Although the history and physical examination, as well as improved imaging modalities such as magnetic resonance arthrography, are extremely important in understanding the abnormalities, the definitive diagnosis of superior labrum, anterior and posterior lesions is best made through diagnostic arthroscopy. Treatment of these lesions is directed according to its type. In general, type I and III lesions are debrided, whereas type II and many type IV lesions are repaired. The purpose of this article is to review the anatomy, biomechanics, classification, diagnosis, and current treatment recommendations for these lesions, as well as to review the literature.

The use of arthroscopy for treatment of shoulder maladies has led to a tremendous increase in our understanding of shoulder abnormalities. The 20-power magnification of the arthroscope has led to the identification of lesions once missed by conventional "open" techniques. One group of lesions involves tearing of the superior labrum near the insertion of the long head of the biceps tendon. The first description of labral tears involving the superior quadrant of the glenoid was made by Andrews et al.[1] in 1985. The study, reporting on 73 overhead throwing athletes, identified labral tears specifically located in the anterosuperior quadrant of the glenoid near the origin of the long head of the biceps. The authors theorized that the biceps tendon acted to "pull off" the labrum. In 1990, Snyder et al.[28] coined the name SLAP lesion (superior labrum, anterior and posterior) to describe a more extensive injury pattern involving the superior labrum, extending from anterior to posterior in relation to the biceps tendon anchor. However, unlike the lesion described by Andrews et al., the most common mechanism of injury was compression loading with the shoulder in a flexed and abducted position. Superior labral lesions can be a source of considerable pain and disability in active persons. The purpose of this article is to review the anatomy, biomechanics, classification, diagnosis, and current treatment recommendations, as well as to review the literature, for SLAP lesions.

ANATOMY

Histologically, the glenoid labrum is composed of fibrocartilaginous tissue, unlike the adjacent hyaline articular cartilage of the glenoid and the fibrous joint capsule.[23] In addition, delicate elastin fibers may be sparsely distributed in the fibrocartilaginous matrix. As in other cartilaginous tissues, there is a decrease in chondrocyte number with aging. The vascular supply of the labrum arises from branches of the suprascapular, circumflex scapular, and posterior humeral circumflex arteries. The labrum receives its blood supply from capsular or periosteal vessels and not from underlying bone.[6] Similar to that of knee menisci, vascularity is typically more abundant peripherally than centrally, although vascular penetration does occur in a radial and circumferential fashion.[6,23] The anterior, anterosuperior, and superior portion of the labrum has decreased vascularity relative to other portions of the labrum. The anterosuperior labrum, as well as labrums with a "meniscal" configuration, has direct vascular penetration only to the peripheral attachment of the labrum.[6]

From a gross perspective, the inferior labrum is typically a rounded fibrous structure, which is continuous with the articular cartilage. The superior labrum, however, may have a meniscus appearance with a loose at-

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tachment to the glenoid. At the 12-o'clock position, the supraglenoid tubercle is approximately 5 mm medial to the superior rim of the glenoid.[32] The long head of the biceps tendon originates from both the supraglenoid tubercle and the superior labrum. Not uncommonly, a significant portion of the tendon originates from the superior labrum with only a small portion attached to the supraglenoid tubercle.[22] Normal variations of labral anatomy must be appreciated to accurately diagnose labral abnormalities. In 1994, Williams and Snyder et al.[33] described the "Buford complex," a rare but normal anatomic finding. In this variant, which occurred in 1.5% of their patients (3 of 200), a "cord-like" middle glenohumeral ligament originates directly from the superior labrum at the base of the biceps tendon with an absence of anterosuperior labral tissue. Misdirected surgical attachment of the cord-like middle glenohumeral ligament to the anterosuperior glenoid results in painful restriction of external rotation and elevation. However, failure to appreciate a pathologically loose superior labrum with this anatomic variant may render the middle glenohumeral ligament incompetent (Fig. 1). Another more common finding, seen in 12% (24 of 200 patients), was the "sublabral foramen." This lesion is also commonly associated (75%; 18 of 24) with a cord-like middle glenohumeral ligament with a direct attachment to the anterosuperior labrum, but with a "hole" of variable size below it.

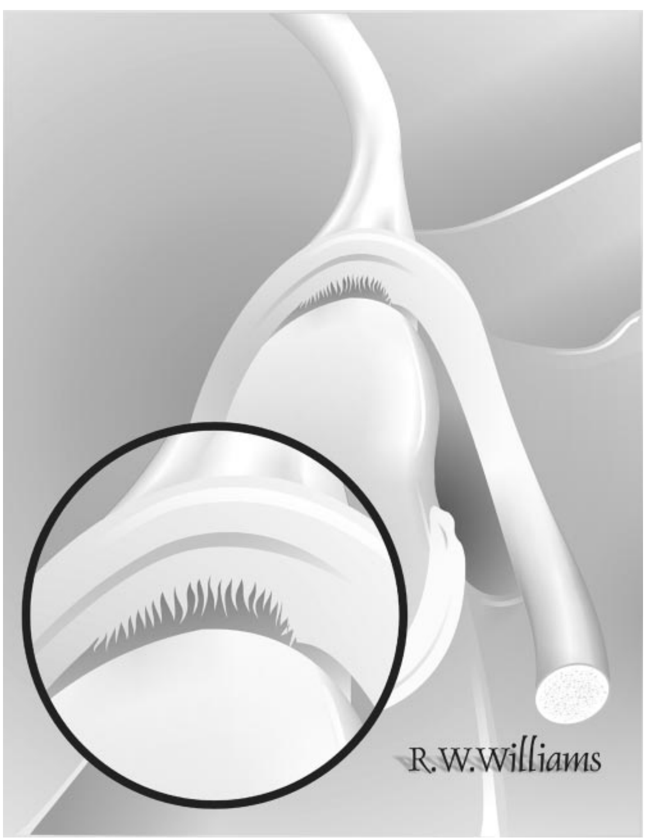

Figure 1. A cordlike middle glenohumeral ligament, especially with the Buford complex, may be incompetent when it is attached to a loose superior labrum.

BIOMECHANICS

The shoulder has more freedom of movement than any other joint in the body. The large range of motion and the relatively shallow configuration of the joint predispose the shoulder to injury. The soft tissue structures around the joint play a vital role in the stability of the shoulder. Normally, the stability of the glenohumeral joint is maintained by complex interactions of the muscles and ligaments that cross the joint. No single structure is responsible for stability of the joint in all positions of the shoulder. The labrum adds stability by providing depth to the glenoid.[29] With the addition of the labrum, the diameters of the glenoid surface are increased to 75% of the humeral head vertically and up to 57% in the transverse direction.[10]

The long head of the biceps tendon has been regarded as a humeral head depressor. Also, recent studies have demonstrated the role of the biceps tendon as a dynamic stabilizer to anterior stability of the glenohumeral joint. A biomechanical study by Itoi et al.[11] demonstrated that application of a 3-kg load to the long head of the biceps resulted in decreased anterior humeral head translation with the shoulder in 90° of abduction and 60° to 90° of external rotation. Rodosky et al.[25] determined the effect of a SLAP lesion on glenohumeral stability. The authors found that the creation of a SLAP lesion resulted in a 102% to 120% increase in the amount of strain recorded in the anterosuperior band of the inferior glenohumeral ligament with shoulder abduction and external rotation. The absence of an intact superior labrum results in increased forces on the inferior glenohumeral ligament, which may compromise the stability of the glenohumeral joint. Recently, Burkart et al.[3] demonstrated that repair of a type II SLAP lesion restored greater glenohumeral stability to inferior translation than to anterior translation.

CLASSIFICATION

In 1990, the senior author (SJS) described his classification of SLAP lesions.[28] We will review the classification here.

Type I Lesions

In this lesion, which occurred in 11% (3 of 27) of the study patient population, there is marked fraying with a degenerative appearance involving the superior labrum (Fig. 2). The peripheral labral edge remains firmly attached to the glenoid, with an intact attachment of the biceps tendon. This lesion is considered by the senior author to be a degenerative process, which is commonly encountered in middle-aged to older patients. This lesion is a possible, but uncommon, source of clinical symptoms.

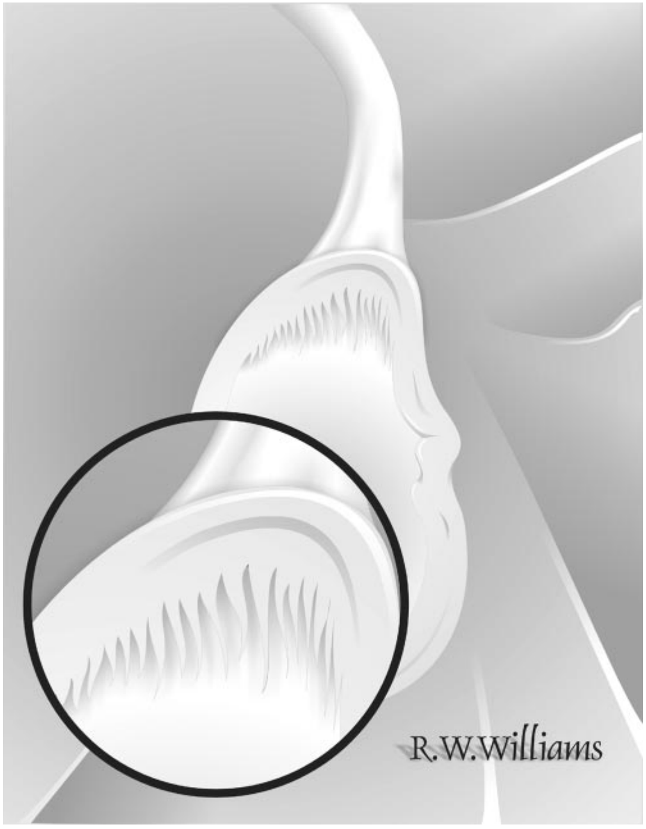

Figure 2. The type I SLAP lesion has fraying of the edge of the superior labrum.

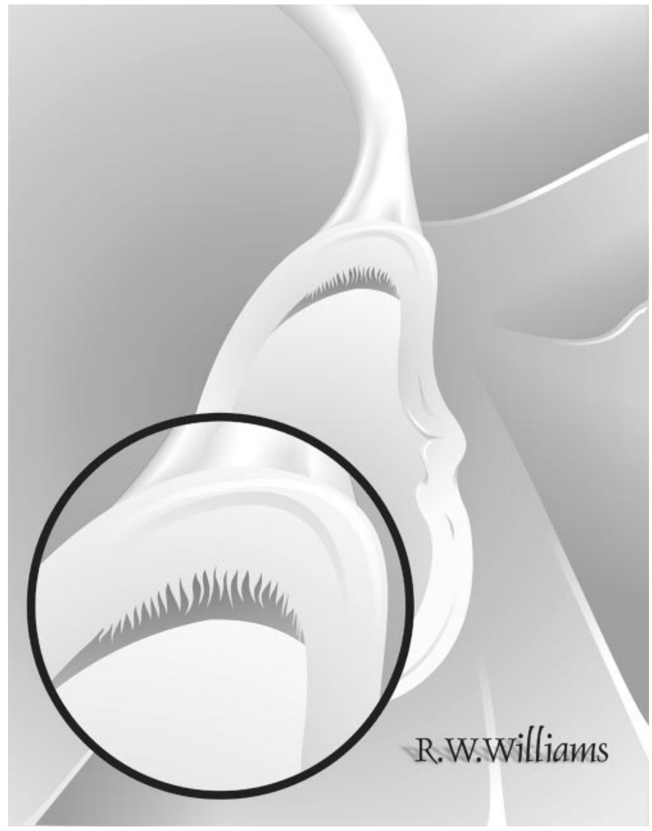

Figure 3. The type II SLAP lesion has a detached biceps anchor.

Type II Lesions

The majority of described lesions (41%; 11 of 27) are type II lesions (Fig. 3). In this situation, there is usually fraying of the edge of the labrum, similar to type I lesions. However, the significant finding is a detached biceps anchor from the superior glenoid tubercle. Situations with a high attachment of the middle glenohumeral ligament to the superior labrum must be evaluated carefully for instability.

Type III Lesions

These lesions occurred in 33% (9 of 27) of the study population (Fig. 4). Type III SLAP lesions consist of a bucket-handle tear of a meniscoid superior labrum with an otherwise normal biceps tendon attachment. Symptoms develop as a result of the mobile fragment of labrum, akin to a bucket-handle tear of a knee meniscus. On rare occasions, the middle glenohumeral ligament may be confluent with the free fragment of labrum and consequently rendered unstable.

Type IV Lesions

Fifteen percent (4 of 27) of the patients had type IV lesions (Fig. 5). Similar to a type III lesion, there is a bucket-handle tear of a meniscoid superior labrum. However, in this group, there is extension of the tear into the biceps tendon. There is large variability in the extent of biceps tendon tearing. Once again, stability of the shoulder must be assessed with tears extending into the attachment site of the middle glenohumeral ligament.

Combined Lesions

We have also observed numerous cases of combined or complex SLAP lesions. Most often, these are type III or IV lesions combined with a significantly detached biceps anchor, type II lesions. These lesions are classified as complex SLAP type II and III or type II and IV.

Maffet et al.[15] expanded this classification to include 1) anteroinferior Bankart-type labral lesions in continuity with SLAP lesions, 2) biceps tendon separation with an unstable flap tear of the labrum, and 3) extension of the superior labrum-biceps tendon separation to beneath the middle glenohumeral ligament. Morgan et al.[18] subclassified type II SLAP lesions into 1) anterior, 2) posterior, and 3) combined anterior and posterior lesions. They believe that SLAP lesions with a posterior component develop posterosuperior instability that manifests itself by a secondary anteroinferior pseudolaxity (drive-through sign), and that chronic superior instability leads to rotator cuff tears that begin as partial-thickness tears from inside the joint.

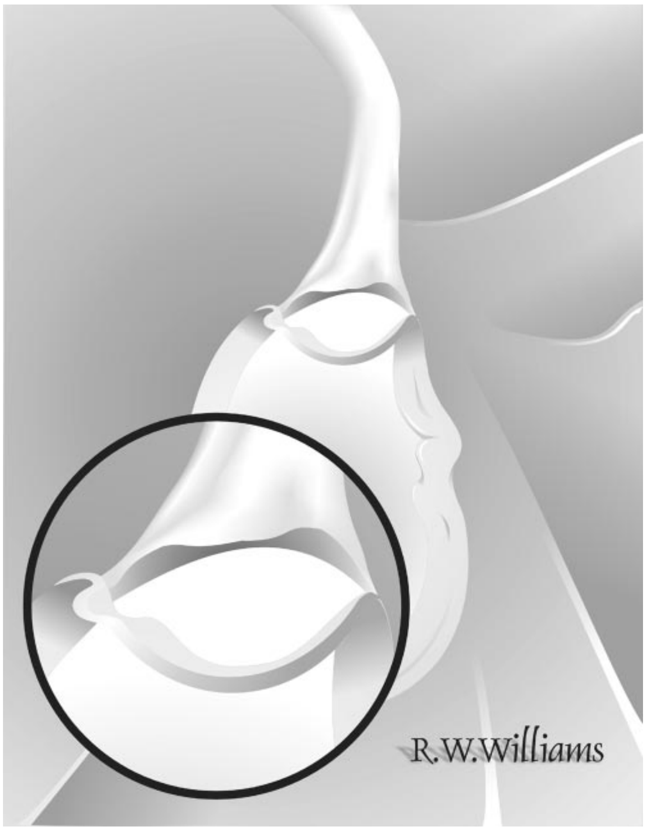

Figure 4. The type III SLAP lesion has a bucket-handle tear of the superior labrum.

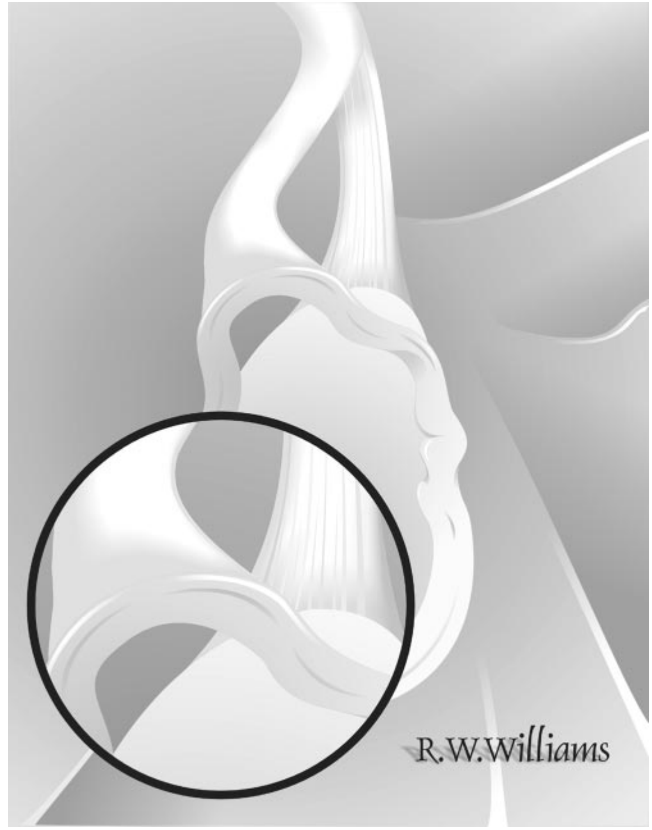

Figure 5. The type IV SLAP lesion has a splitting of the superior labrum that continues into the biceps tendon.

DIAGNOSIS

History

Because SLAP lesions are often associated with other abnormalities of the shoulder, the diagnosis is difficult. Nevertheless, a thorough history is necessary to elucidate the underlying lesion. Patients complaining of this problem usually have vague shoulder pain exacerbated by activity with the arm overhead and possibly associated with popping, locking, and snapping if the unstable fragment is trapped between the humerus and glenoid surface. Instability symptoms may be present if the tear extends into the anterior ligament and labrum, resulting in a Bankart lesion. Additionally, the rotator cuff may be compressed between the tuberosity attachment and the superior glenoid, resulting in an undersurface or complete cuff tear, with associated night pain and weakness. Weakness may also be a result of ganglion cyst formation secondary to the labral tear.

The most commonly cited mechanisms are traction and compression of the shoulder, although in many instances, no antecedent trauma can be elucidated.[15,28] In the series by Maffet et al.,[15] traction injuries occurred in the majority of their study population. Anterior traction injuries were a result of water skiing, superior traction injuries were a result of attempting to break a fall from a height, and inferior traction injuries were a result of a sudden pull when losing hold of a heavy object. Traction injuries also occurred after throwing or in other sports involving overhead motion or in the form of an overt glenohumeral dislocation. Although these are significant causes of SLAP lesions, other studies have cited compression of the glenohumeral joint as a result of a fall onto an outstretched hand in forward flexion and abduction or a direct blow to the glenohumeral joint as the mechanism of injury.[8,9,24,27,28] These mechanisms result in an impaction injury to the shoulder as a result of the superiorly directed force of the humeral head against the superior labrum and the biceps anchor. If a meniscoid-type superior labrum is present, a type III or IV lesion may result with the formation of a bucket-handle fragment. With large forces, a SLAP fracture of the humeral head may result (Fig. 6). The appearance of this lesion is similar to a Hill-Sachs instability lesion; however, this is located more anteriorly in the superior portion of the humeral head. A type II lesion results when the biceps tendon is avulsed from the superior glenoid as it is tensioned over the humeral head.

Physical Examination

As with the history, the physical examination is often nonspecific secondary to other associated abnormalities associated with SLAP lesions. The senior author and oth-

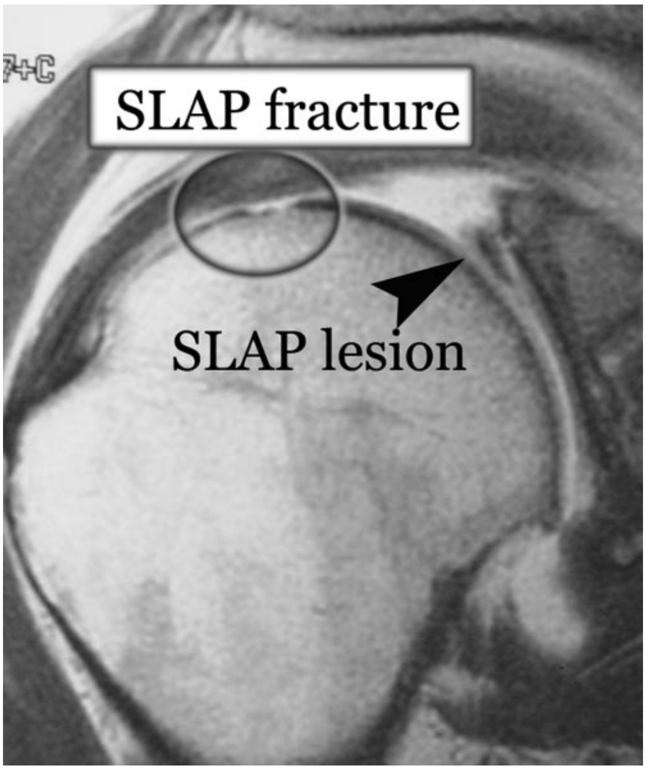

Figure 6. The magnetic resonance arthrogram shows a SLAP fracture of the dome of the humeral head and a split in the superior labrum with a type III SLAP lesion.

ers have reported that no single or combination of tests could conclusively and reliably predict when and what type of lesion would be found at arthroscopy.[16,30] However, there are several described tests that may prove useful. We have found that Speed's biceps tension test is an accurate examination for SLAP lesions.[8,24,27,30] This is performed by having the patient resist downward pressure with his or her arm in 90° of forward elevation with the elbow extended and the forearm supinated. This examination produces pain when the biceps tendon or its attachment site at the superior labrum is inflamed or damaged. Although this test is more suggestive of biceps tendon damage, it reproduces symptoms with an unstable anchor. Another test we use is the compression-rotation test, which is similar to MacMurray's test of the knee.[30] This test is performed by compressing the glenohumeral joint and then rotating the humerus in an attempt to trap the labrum in the joint. An uncomfortable clunk may be associated with a labral tear. We believe the O'Brien test has shown good correlation for type II SLAP lesions.[20] In this test, the arm is positioned in 20° of adduction and 90° of forward elevation. The examiner applies downward force on the forearm while the hand is both pronated and supinated and compares the resulting pain and weakness. A positive test occurs when the patient reports pain that is worse in the pronated position.

In addition to these findings, patients may demonstrate a positive Neer sign (pain with passive forward elevation of the arm) and a positive Hawkins sign (pain with passive internal rotation of the arm, forward-flexed to 90°), which may falsely lead the examiner to attribute the patient's complaints to impingement or rotator cuff abnormalities. To further complicate the diagnosis, as mentioned earlier, partial- and full-thickness rotator cuff tears have frequently been associated with SLAP lesions.[8,15,24,27,28] We noted crepitation in 43% (10 of 23) of our patients with isolated SLAP lesions.[30] Furthermore, the patient may have a positive apprehension sign (as was found in 39%, 9 of 23, of our study population) secondary to traction on the torn labrum.[30] This may be differentiated from "true" instability of the shoulder as only 4% had a positive apprehension suppression test (posterior-directed force on the humeral head in the abducted and externally rotated shoulder with subsequent relief of symptoms).

Kim et al.[13] recently described the biceps load test II. With the patient in the supine position, the arm is elevated to 120° and externally rotated to its maximal point, with the elbow in 90° of flexion and the forearm in the supinated position. If pain is elicited with resisted elbow flexion, the test is considered positive. The authors demonstrated a sensitivity of 89.7% and a specificity of 96.9% in predicting SLAP lesions of the shoulder.

Weakness with external rotation or ipsilateral atrophy of the rotator cuff suggests possible compression of the suprascapular nerve by a ganglion cyst, which should be further evaluated with an MRI and neurodiagnostic testing with an EMG of the suprascapular nerve.

Imaging

Radiographic evaluation includes the standard three views of the shoulder (AP, axillary, and outlet views). Although radiographs are usually normal in cases of isolated SLAP lesions, other potential sources of abnormalities can be evaluated. Occasionally, a superior humeral head compression or SLAP fracture may be noted on the AP radiograph.

Magnetic resonance imaging should be ordered when an alternative diagnosis is not evident. Standard multiplanar T1- and T2-weighted MRI images can be useful in detecting supraglenoid cysts, which have been associated with type II SLAP lesions. As with the development of parameniscal cysts in the knee, supraglenoid cysts arise as a result of labral injury with a communication through the capsule. Since it is often difficult to image labral lesions with standard MRI technique, we prefer magnetic resonance arthrogram with an intraarticular injection of gadolinium. This technique provides improved visualization of labral lesions.[2,5,12,31] Bencardino et al.[2] demonstrated a sensitivity of 89%, a specificity of 91%, and an accuracy of 90% in detecting labral lesions. The SLAP lesions may be appreciated on the coronal oblique sequence as a deep cleft between the superior labrum and the glenoid that extends well around and below the biceps anchor. Often, contrast will diffuse into the labral fragment, causing it to appear ragged or indistinct. The axial view is sometimes helpful to visualize the displaced superior labral fragment. Knowledge of normal labral variants must be understood because a congenital cleft and congenital variations of the anterosuperior labrum (such as a sublabral hole or Buford complex) can be misleading. If there is an associated labral split or biceps tear, as seen in a type III or IV lesion, the displaced fragment may be difficult to visualize unless the superior labral area is carefully examined. The split biceps tendon can sometimes be seen associated with a displaced superior labrum in a type IV lesion.

Arthroscopic Evaluation

Although MRI can provide useful information in the diagnosis of SLAP lesions, currently the best method for diagnosis is arthroscopic evaluation.[17] Examination under anesthesia is initially performed to assess mobility and stability of the joint. Shoulder translation in all four directions should be assessed and compared with the opposite side. With isolated SLAP lesions, we can often appreciate excess anterior translation both to the inferior and superior quadrants. Of course, some increased motion is normal in the shoulder of throwing athletes, and this finding alone, although not diagnostic, may be suggestive of abnormalities.

Standard arthroscopic evaluation will usually allow diagnosis of SLAP lesions. Types I, III, and IV lesions are obvious when fraying or splitting of the labrum is noted. It is mandatory to view from both the anterior and posterior portals to entirely assess the degree of involvement. Diagnosis of type II lesions is more difficult. The normal superior labrum often has a small cleft between it and the glenoid. An abnormal degree of laxity in the biceps anchor and the attached labrum and ligaments must be demonstrated to label it a SLAP lesion. After carefully debriding the labral edge, the stability of the biceps anchor is determined by probing and attempting to elevate the labral edge. The glenoid articular cartilage usually extends medially over the superior corner of the glenoid, and absence of cartilage in this area raises suspicion of injury. Significant areas of fraying, hemorrhage, granulation tissue, or an unusually deep cleft also suggest lesions. Traction on the biceps tendon will demonstrate any loss of integrity at the labral attachment as well as instability of the attached ligaments. If traction causes the labrum to arch away from the glenoid, revealing a significant gap of 5 mm or more, the stability of the anchor is questionable. Likewise, if the attached anterosuperior labrum, middle glenohumeral ligament, or Buford complex is tensioned when the biceps is pulled, then the stability of the biceps-labral-ligament complex is likely deficient.

Burkhart and Morgan[4] have suggested an additional test for SLAP lesions. They described a subgroup of SLAP lesions that were caused by a peeling off of the labrum from the glenoid, posterior to the biceps anchor. Their findings suggest that the windup phase of throwing tightens the biceps tendon anchor and may cause it to peel off the bone. They believe that this may lead to progressive anterior laxity in some patients. To test for this problem during surgery, the arm is removed from traction and placed in a throwing position. As it is rotated in internal and external rotation, the labrum can be observed to peel back away from the posterosuperior glenoid.

SURGICAL MANAGEMENT

Type I SLAP lesions are treated with conservative debridement of the frayed labrum. We prefer to use a 4.0-mm, full radius shaver blade and excise only the torn tissues, avoiding damage to the biceps anchor, the attached anterosuperior labrum, or any attached middle glenohumeral ligament. The shaver should be used through the anterior and posterior cannulae while viewing from the opposite side. After shaving, a probe is used to evaluate labral stability, as described earlier.

Type II SLAP lesions are repaired using a single-anchor, double-suture technique (a discussion of this technique follows). We prefer to use either a 4-mm Big Eye Revo (Linvatec, Inc., Largo, Florida) or a 5-mm Super Revo (Linvatec) screw-in anchor loaded with two strands of strong braided suture and inserted into the superior glenoid just below the biceps tendon. The sutures are passed through the labrum, one posterior and one anterior to the biceps, forming a sling or harness around the anchor point, affording secure stability for healing. An additional single-suture Mini Revo anchor (Linvatec) may be inserted at the posterosuperior corner for additional fixation if necessary.

Type III SLAP lesions are treated by initial resection of the unstable bucket-handle labral fragment, followed by inspection of the biceps anchor attachment for stability. We use a curved basket punch and then a motorized shaver via the posterior cannula to trim the posterior attachment of the fragment. Next, we use the shaver through the anterior cannula to remove the remaining anterior portion. Careful attention must be made to the location and attachment site of the middle glenohumeral ligament before completing the anterior resection. On occasion, a significant cord-like middle ligament will attach to the anterosuperior labrum, sometimes extending into the detached labral fragment. If one inadvertently excises the labral attachment in this situation, rendering the middle glenohumeral ligament incompetent, significant anterior instability will likely occur. In this situation, we suggest a conservative debridement of the fragment, leaving a robust tag attached anteriorly. If traction applied to the middle glenohumeral ligament with a probe results in instability of the superior labrum anchor, the tissues can be reattached securely to the glenoid using one or two suture anchors.

Type IV SLAP lesions are treated similarly to type III lesions unless the biceps tendon split is severe. When more than approximately 30% of the tendon is included with the displaced labral tear, one must consider either repairing the tendon, releasing it and repairing the labrum as with a type II SLAP, or performing a biceps tenodesis. The decision depends on the age and activity level of the patient and the condition of the remainder of the biceps tendon. In most cases, we prefer to excise the labral fragment along with the attached portion of torn biceps. If the remaining tendon seems healthy, without significant fraying, and the anchor site is stable, the senior author will not release it or perform a tenodesis. If the tendon appears degenerative, it will be released and tenodesis will be performed, especially in the young active patient.

Postoperatively, we protect the shoulder in an Ultra Sling (DJ Orthopedics, Carlsbad, California) for 3 weeks in older patients. The patient begins elbow, wrist, and hand exercises immediately, and gentle pendulum exercises in 1 week. The shoulder should be protected so there is no excess stress on the biceps tendon for 6 weeks. Progressive resistance exercises are allowed at that point. Vigorous throwing or strenuous lifting activities are allowed after 3 months if motion is back to normal and pain with motion is absent.

SINGLE-ANCHOR, DOUBLE-SUTURE TECHNIQUE

Here follows a description of the steps for successfully performing this technique.

1. Begin with the arthroscope in the standard posterior portal and a clear, smooth, 6-mm operating cannula in the anterosuperior portal. The key to proper placement of the anchor into the superior glenoid tubercle is exact placement of the anterosuperior portal, it must be in the superior aspect of the rotator interval anteriorly and slightly superior to the biceps tendon. Accurate placement is ensured by using an outside-in technique with initial placement of a spinal needle 2 cm from the anterolateral corner of the acromion.

2. Create an anterior midglenoid portal with a second smooth, clear cannula using an outside-in technique, entering just above the subscapularis tendon.

3. Debride any remaining soft tissue off the superior glenoid below the detached labrum/biceps anchor and trim the frayed edge of the labrum. It is often helpful to trim the posterior portion of the lesion and glenoid with the arthroscope anterior and the shaver in the posterior portal. The bone of the superior glenoid is often relatively soft and it is seldom necessary to use a bur to expose cancellous bone.

4. Insert a standard-sized punch via the anterosuperior portal and create a pilot hole in the glenoid neck directly posterior to the biceps anchor, 2 to 3 mm medial from the articular cartilage (Fig. 7). Ensure that the punch does not skive off the bone to prevent injury to the suprascapular nerve or anchor cutout. It is necessary to direct the *handle* of the punch in a posterior and lateral direction with a little pressure to direct the tip into bone.

5. Insert a double-loaded screw-in anchor with different colored No. 2 nonabsorbable braided sutures (that is, white and dark green) via the anterosuperior portal into the pilot hole (Fig. 8). We prefer to mark one-half of each suture with a purple surgical marker to aid with suture management. This results in four dissimilar sutures: white, white-purple, green, and green-purple. The sutures are arranged in the anchor so that the purple limbs of each suture exit the same side of the eyelet. Seat the anchor so that the purple limbs of the suture directly face the biceps tendon. This ensures that the sutures exiting the eyelet are properly aligned as they leave the anchor. The screwdriver is removed and the sutures are tested for security by gently pulling on them outside the anterosuperior portal.

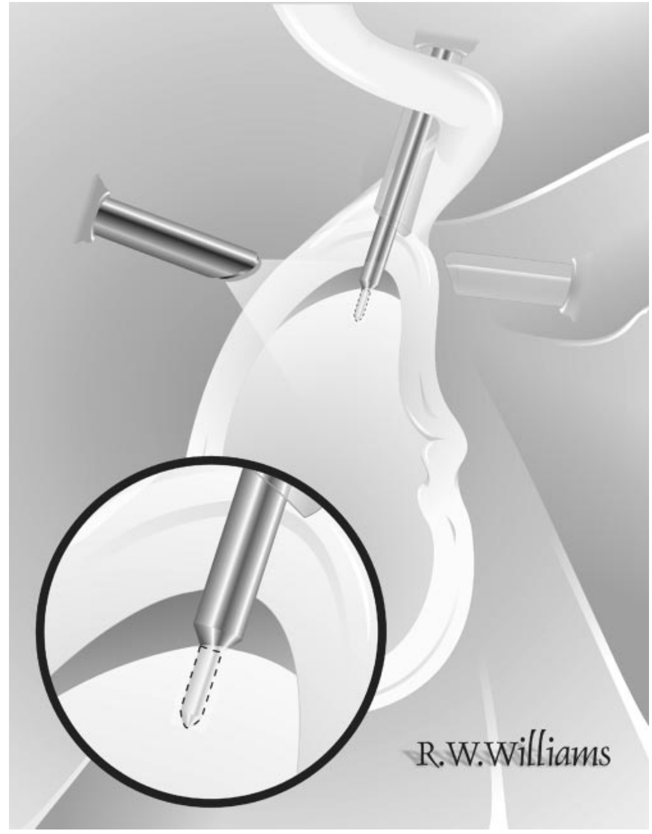

Figure 7. A punch must be used to create the superior glenoid pilot hole below the edge of the cartilage.

Preliminary Step of Arranging the Sutures to Facilitate Passing

6. Change the arthroscope to the anterior midglenoid portal and insert a clear cannula through the posterior portal. Retrieve the all-white suture out the posterior portal using a crochet hook and store it outside the cannula by inserting a guide rod, removing the cannula, and reinserting the scope cannula over the rod. Return the arthroscope to the posterior portal and insert a clear cannula in the anterior midglenoid portal (Fig. 9).

7. Retrieve the all-green suture out the anterior midglenoid portal with a crochet hook and store it outside this cannula.

8. Retrieve the green-purple and white-purple sutures into the anterior midglenoid portal and store them in the cannula. The green-purple suture is the first suture that will be passed through the labrum posterior to the biceps (Fig. 10).

9. Move the anterosuperior cannula anterior to the biceps tendon and retrieve the white-purple suture into it.

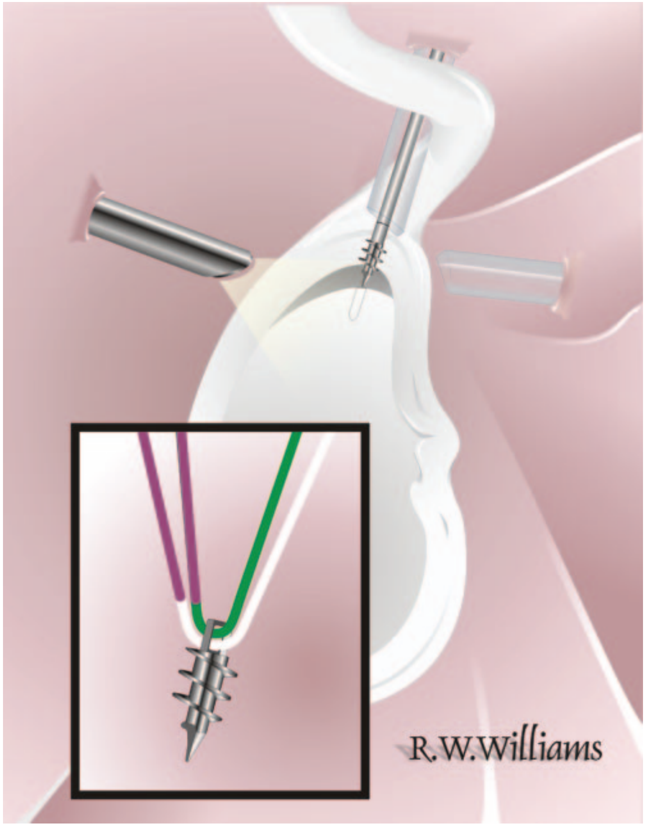

Figure 8. Insert the anchor into the pilot hole until the seating line is below the surface.

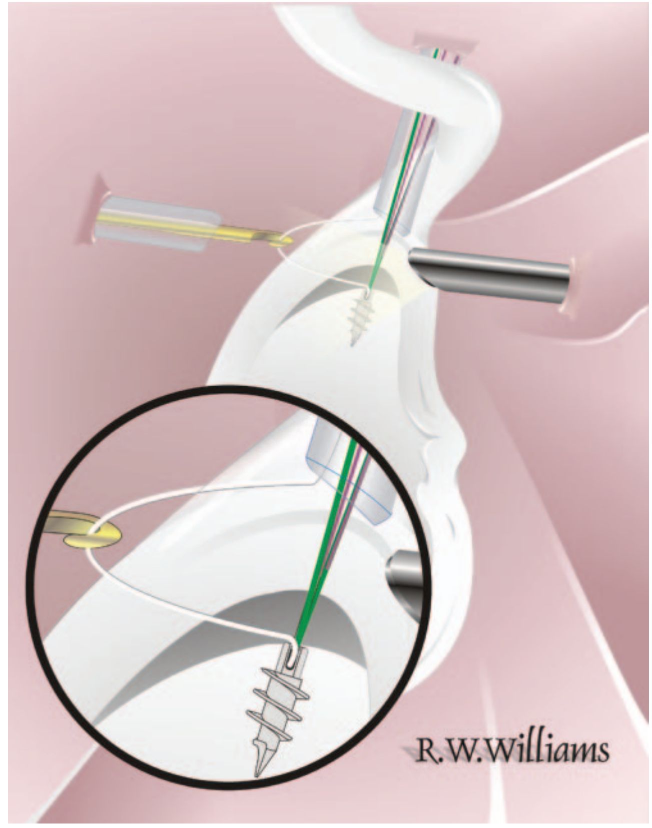

Figure 9. The first step in arranging the sutures is to retrieve and store the all-white suture outside the posterior portal.

Store the white-purple suture outside the anterosuperior cannula.

Passing Sutures Through the Labrum

10. Insert a medium-sized Spectrum Crescent Hook loaded with a Shuttle-Relay Suture Passer (Linvatec) through the clear cannula of the anterosuperior portal. Puncture the superior labrum on the posterior edge of the biceps attachment, angling the needle to exit just behind the anchor (Fig. 11). Pass 3 cm of the Shuttle-Relay Suture Passer into the joint. Retrieve the Shuttle-Relay Suture Passer out of the anterior midglenoid portal with a grasping clamp.

11. Load the green-purple suture into the Shuttle-Relay Suture Passer and pull it back through the tissue and out the anterosuperior cannula (Fig. 12). Before pulling the suture tight, observe it carefully to ensure that it is not twisted around any other suture.

12. Retrieve the all-green suture that was stored outside the cannula of the anterior midglenoid portal, into the cannula of the anterosuperior portal posterior to the biceps tendon by using a crochet hook (Fig. 13).

13. Retrieve and store the white-purple suture in the anterior midglenoid portal with a crochet hook.

14. Pull the green-purple suture (the one passing through the labral tissue) to make it the shorter one and use it as the initial post strand. Tie the suture tails together by using a sliding/locking knot (Fig. 14).

15. Insert the Spectrum Crescent Hook down the anterosuperior cannula and pierce the superior labrum at a point just anterior to the biceps tendon (Fig. 15). This point should be in the vicinity of the attachment of the superior glenohumeral ligament and may be at or near the junction on the cord-like middle glenohumeral ligament associated with a Buford complex. Pass the Shuttle-Relay Suture Passer into the joint and carry it out of the anterior midglenoid portal using a grasping clamp.

16. Load the Shuttle-Relay Suture Passer with the white-purple suture and carry it back through the joint and the labrum and out the anterosuperior cannula.

17. Retrieve the all-white suture with the crochet hook from its storage position outside the posterior portal and carry it into the cannula of the anterosuperior portal anterior to the biceps tendon (Fig. 16).

18. Pull the white-purple end of the suture to make it the shorter limb and tie the sutures together by using a sliding/locking knot. If there has been a twist in the sutures and they will not slide easily, tie them instead with a multiple half-hitch knot.

19. Test the repair by pulling on the biceps tendon with a probe via the anterior midglenoid cannula (Fig. 17). The labrum should be firmly attached to bone and there should be no gap when tension is applied. In addition, the antero-

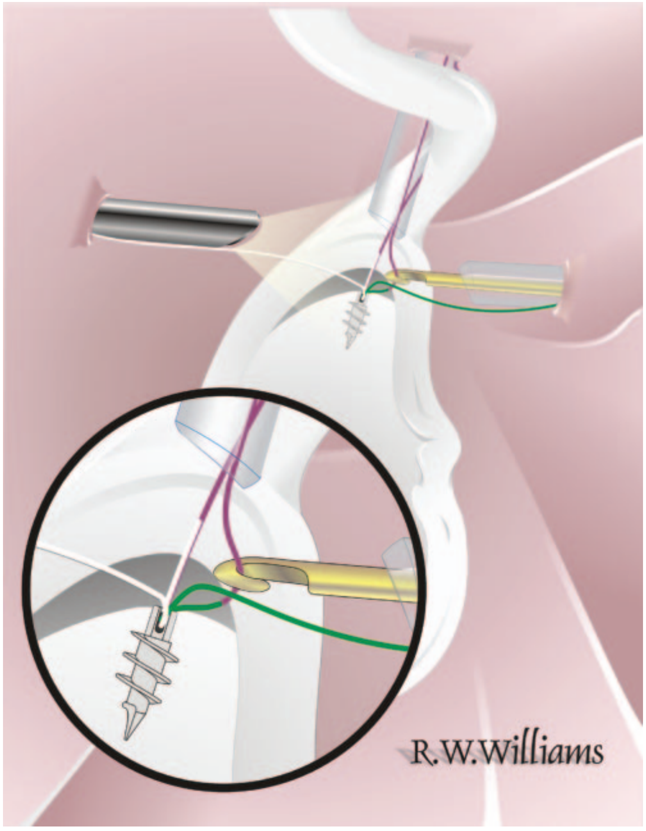

Figure 10. Retrieve the green-purple suture into the anterior midglenoid portal. This is the first suture that will be passed through the labrum.

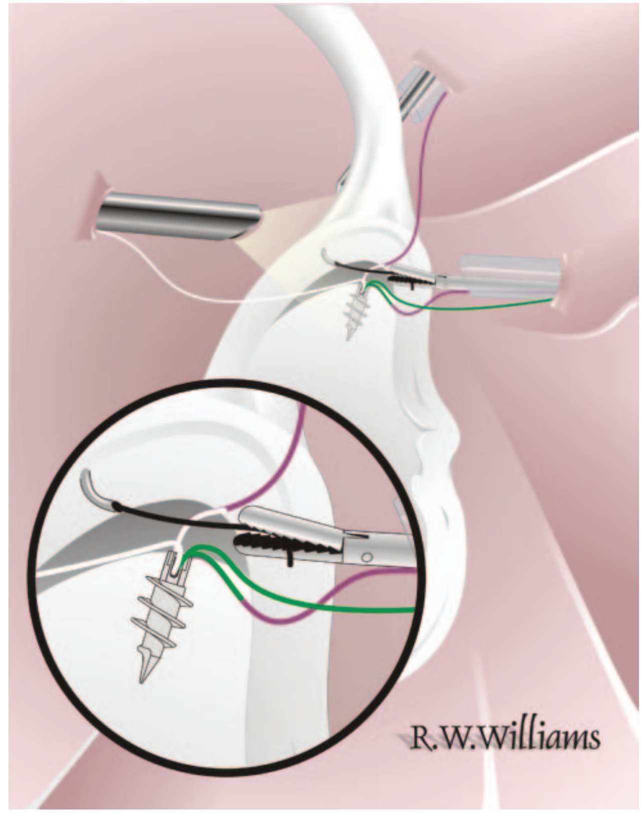

Figure 11. The Spectrum Crescent Hook is inserted through the labrum just posterior to the biceps tendon and the Shuttle-Relay Suture Passer is retrieved out the anterior midglenoid portal.

inferior ligaments should have a stable anchor site and no tension should be created in them when the biceps is pulled (Fig. 18).

REVIEW OF THE LITERATURE

As the surgical equipment and our understanding of SLAP lesions continue to evolve, more effective surgical treatment modalities are possibly emerging. In general, nonoperative management has proven unsuccessful for a large number of patients with unstable SLAP lesions. In many studies, patients underwent diagnostic arthroscopy at an average of 12 to 30 months from their initial symptoms.[1,7,8,15,24,27,28,34] In one study, patients had an extended trial of activity modification and rehabilitation exercises.[21] Indeed, most patients had been treated with rest, physical therapy, steroid injections, and nonsteroidal antiinflammatory drugs without relief of their symptoms before diagnostic arthroscopy.

For unstable SLAP lesions, simple debridement has proven ineffective. Cordasco et al.[7] treated 27 patients with simple debridement. At 1-year follow-up, 78% of the patients had excellent pain relief; however, at 2-year follow-up, this number decreased to 63%. In addition, only 45% of these patients returned to their preinjury level of athletic activity. These diminishing results were attributed to the occult instability that is commonly associated with these lesions. Although none of these patients demonstrated historical or clinical evidence of a frank dislocation, 70% of them demonstrated instability on examination under anesthesia. This finding underscores the importance of assessing shoulders for instability. Early in our experience, we also demonstrated the ineffectiveness of simple debridement and glenoid abrasion of type II SLAP lesions. Of five patients treated in this manner, only three demonstrated healing at second-look arthroscopy.[27] We believe that if occult instability is present and no other capsular or labral lesion can be identified, then secure reattachment of the biceps anchor should restore stability.

A variety of surgical techniques have been used to repair SLAP lesions. In 1991, Yoneda et al.[34] repaired 10 type II SLAP lesions with a high-profile staple. At a minimum of 24 months of follow-up, the authors reported 80% good-to-excellent results. At repeat arthroscopy performed for staple removal at 3 to 6 months, four patients demonstrated complete healing, while the other six patients demonstrated superficial healing with good stability. Because of the need for hardware removal, the authors recommended using an absorbable staple.

Field and Savoie[8] reported their results with a technically difficult transosseous approach used to repair 15 type II and 5 type IV SLAP lesions. Four to seven sutures

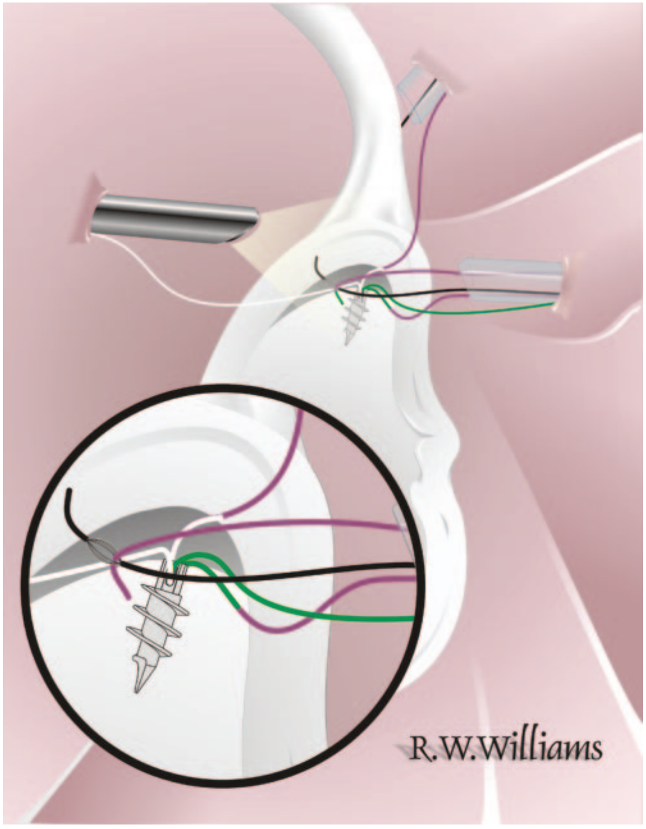

Figure 12. The Shuttle-Relay Suture Passer is pulled back out the anterosuperior portal, carrying the green-purple suture through the labrum.

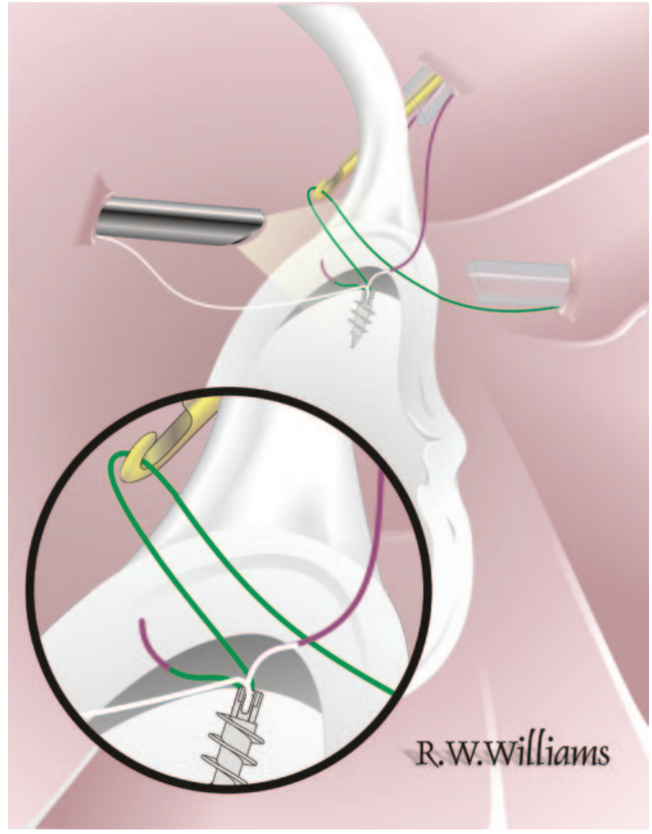

Figure 13. The all-green suture is retrieved into the anterosuperior portal posterior to the biceps tendon.

were placed through the labrum. A Beath pin was drilled across the glenoid neck from the anterosuperior portal exiting the infraspinatus fossa, where the sutures were tied. On follow-up ranging from 12 to 42 months, considerable improvements in pain and function scores were achieved (according to the American Shoulder and Elbow Surgeons rating scale). All 20 patients had good or excellent results according to the Rowe scoring system. There were no reported complications from the transosseous sutures; however, one patient developed adhesive capsulitis, which was successfully managed with manipulation under anesthesia.

In 1993, Resch et al.[24] reported their surgical results in the management of 14 SLAP lesions. The shoulders of six patients were stabilized with a cannulated titanium screw 2.7 mm in diameter with a 5-mm washer. The shoulders of eight patients were stabilized with 6.5-mm absorbable tacks. At follow-up 6 to 30 months after stabilization, eight patients had returned to their preinjury level of sports competition. Four patients were improved; two had returned to sports but at a lower level of performance. Two patients demonstrated no improvement. Complications included two cases of intraoperative repositioning of the metal screw secondary to inadvertent articular penetration and one case of screw loosening, necessitating early screw removal at 11 weeks.

Pagnani et al.[21] reported their results of SLAP lesion repair with an absorbable tack. At a 1-year minimum follow-up, 19 of 22 patients (86%) were satisfied with the operation, with significant improvements in pain, stability, and function. Of the three patients who were dissatisfied, one developed postoperative adhesive capsulitis and the other two had persistent impingement-type symptoms after subacromial decompression. In 2001, Samani et al.[26] reported their experience with an absorbable tack used to treat 25 type II SLAP lesions. At a mean follow-up of 35 months, there was improved shoulder function in 24 of 25 cases according to the UCLA and American Shoulder and Elbow Surgeons shoulder scoring algorithms. Follow-up UCLA scores averaged 32 points, with 9 patients scoring excellent, 13 good, 2 fair, and 1 poor, for an overall success rate of 88%. The American Shoulder and Elbow Surgeons shoulder scores improved from a preoperative average score of 45 points to a postoperative average of 92.

Snyder et al.[27] reported their results of treatment of 140 SLAP lesions from 1985 to 1993. Twenty-one percent of the lesions were type I, 55% were type II, 9% were type III, 10% were type IV, and 5% were complex lesions involving combinations of the types. Partial rotator cuff tearing was identified in 29% of the patients, full rotator cuff tearing was found in 11%, and Bankart lesions, which were also treated at the time of operation, were present in 22%. In only 28% of the patients was the SLAP lesion an isolated

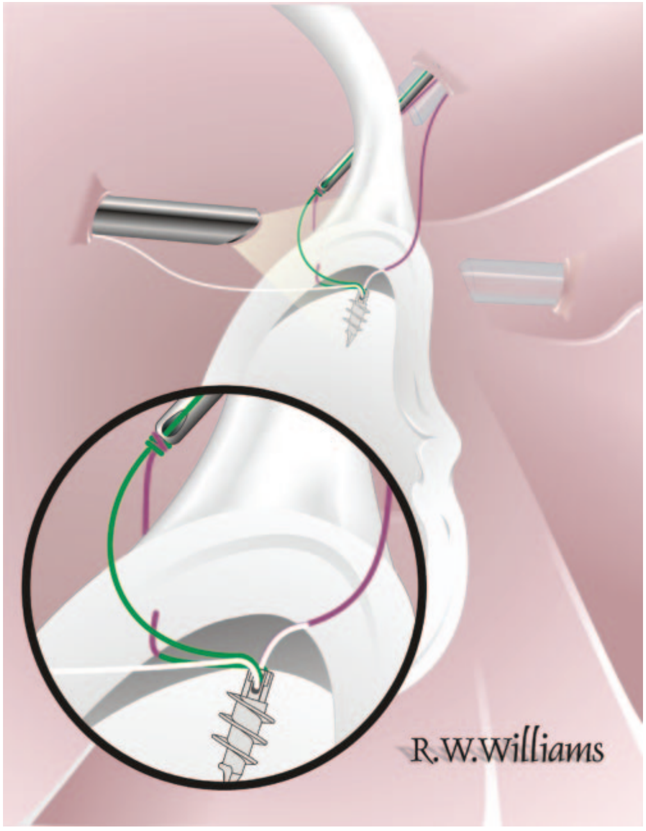

Figure 14. Tie the green suture pair together by using a sliding-locking knot through the anterosuperior portal.

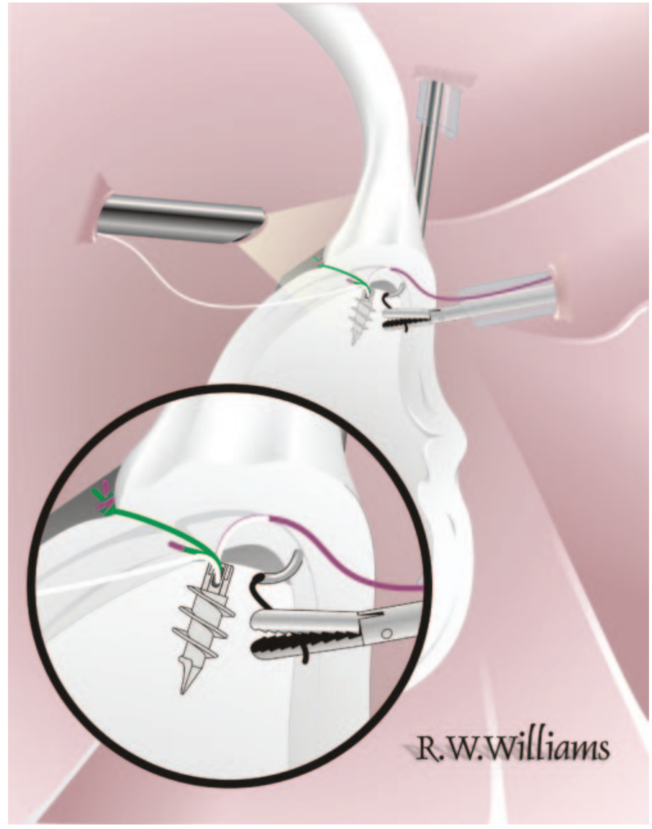

Figure 15. Pass the Spectrum Crescent Hook again through the superior labrum just anterior to the biceps tendon and carry the Shuttle-Relay Suture Passer into the anterior mid-glenoid portal.

entity. The labral lesions were treated with a variety of methods and hardware. A second-look arthroscopy was performed in 18 shoulders. As noted, three of five type II lesions healed after simple debridement and glenoid abrasion. In five type II lesions treated with a bioabsorbable anchor, four had healed. In three type III lesions and one type IV lesion treated with debridement alone, the superior labrum appeared normal. Two type IV lesions treated with suture repair had healed, and two complex type II and III lesions treated with debridement and anchor fixation also had healed. Of note, five of the second-look arthroscopies were performed to remove loose fragments from bioabsorbable anchors, causing the authors to recommend screw-in suture anchors.

In 2002, O'Brien et al.[19] described arthroscopic repair of type II SLAP lesions through a transrotator cuff portal. Thirty-one patients were available for follow-up at a mean time of 3.7 years. The average L'Insalata score was 87.0 points and the average American Shoulder and Elbow Surgeons score was 87.2 points. The authors believe that the transrotator cuff portal permitted optimal anchor placement without compromising rotator cuff function.

Because interpretation of the results of treatment of SLAP lesions may be obscured by concomitant abnormal findings, Stetson et al.[30] evaluated a subset of 23 patients with isolated SLAP lesions. In this study, patients with glenohumeral instability, partial or complete rotator cuff tears, acromioclavicular joint arthritis, Bankart lesions, advanced glenohumeral arthritis, or impingement were excluded. Follow-up averaged 3.8 years (range, 14 months to 8 years). Of the 23 SLAP lesions, 1 type I lesion was treated with debridement, 6 type II lesions were treated with debridement and abrasion, 12 type II lesions were treated with suture anchors, 1 type III lesion was treated with debridement, 2 type IV lesions were treated with debridement, and 1 complex type II and III lesion was treated with a combination of debridement and anchor fixation. Three different types of anchors were used: an absorbable tack, a nonabsorbable suture tack, and a 4-mm removable screw-in suture anchor. Overall, on the Rowe scoring system, 82% of patients had good or excellent results, 9% had fair results, and 9% had poor results. Of the two patients with poor results, one had a type II SLAP lesion that was treated with debridement alone; this patient ultimately required open anterior shoulder stabilization. The other patient had a type IV SLAP lesion that was considered to be unstable on further follow-up. Of the two patients with fair results, one with a complex type II and III lesion had cracking in the joint and ultimately required removal of the absorbable tack fragments. The second patient had a type III SLAP lesion that was treated with debridement. Notably, all three patients whose type

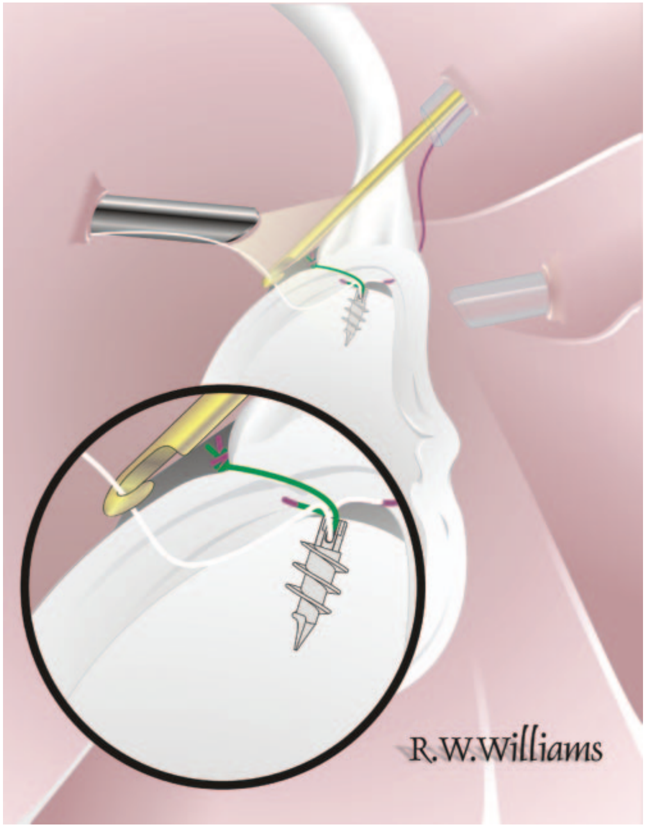

Figure 16. Retrieve and tie the white suture pair together through the anterosuperior portal.

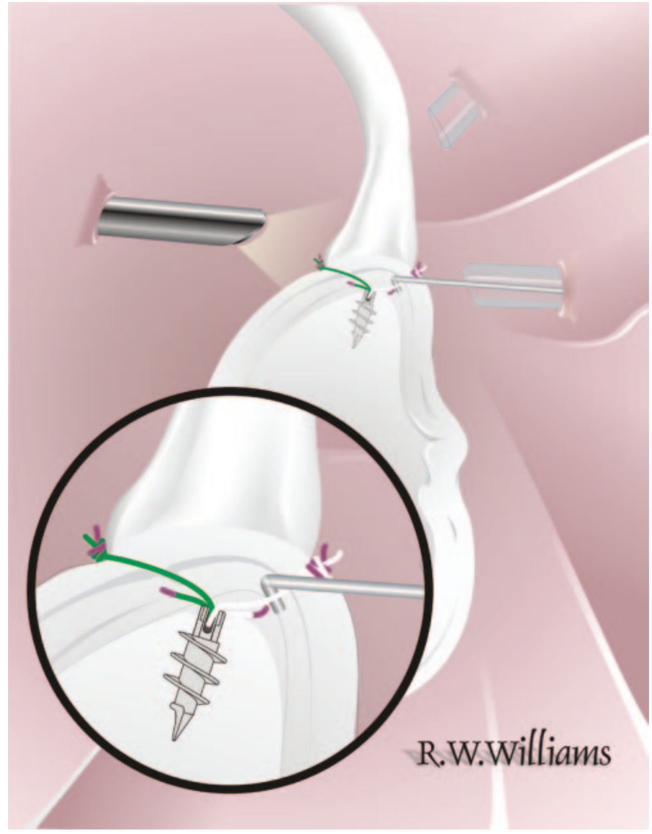

Figure 17. Test the repair with a probe.

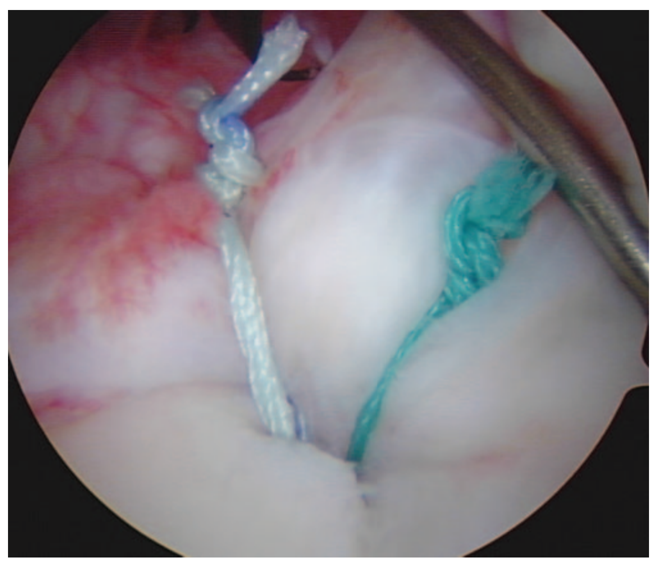

Figure 18. The finished single-anchor, double-suture SLAP repair is balanced and secure.

II SLAP lesion was treated with a screw-type suture anchor were able to return to their previous level of sports competition.

Kim et al.[14] also reported their results of 34 patients with isolated SLAP lesions who underwent arthroscopic repair with suture anchors. At a mean follow-up of 33 months, 32 patients (94%) had a satisfactory result, and 2 patients had an unsatisfactory result, as determined by the UCLA shoulder score. Thirty-one patients (91%) regained their preinjury level of shoulder function. However, they reported inferior results in overhead throwing athletes as compared with patients not involved in overhead athletics.

SUMMARY

Biomechanical studies have proven that the biceps and the superior labrum provide a significant contribution to glenohumeral stability. The SLAP lesion is difficult to diagnose and treat, thus a high index of clinical suspicion must be maintained when evaluating a painful shoulder. There is often a substantial delay in diagnosis of these lesions in patients with shoulder problems. The clinical picture is confusing because these lesions are rarely isolated and are commonly associated with other abnormalities, including rotator cuff tears, glenohumeral instability, and paralabral cysts. Despite advances in magnetic resonance arthrography, the definitive diagnosis is best made through diagnostic glenohumeral arthroscopy. Treatment is determined by the type of lesion identified. Type I and III SLAP lesions are debrided. Type II lesions are stabilized with a double suture anchor. Treatment of type IV SLAP lesions is determined by the extent of involvement and patient factors. The importance of recognizing normal shoulder anatomy (that is, meniscoid superior labrum, sublabral foramen, and Buford complex) cannot be overemphasized to prevent iatrogenic injury. It is hoped that arthroscopic management of superior labral lesions will continue to evolve with further understanding of glenohumeral anatomy and its associated abnormalities.

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