IJSPT

INVITED CLINICAL COMMENTARY

THE RECOGNITION AND TREATMENT OF SUPERIOR LABRAL (SLAP) LESIONS IN THE OVERHEAD ATHLETE

Kevin E. Wilk, PT, DPT, FAPTA[1]
Leonard C. Macrina, MSPT, SCS, CSCS[1]
E. Lyle Cain, MD[2]
Jeffrey R. Dugas, MD[2]
James R. Andrews, MD[2]

ABSTRACT

The overhead athlete presents with a unique profile that may predispose them to specific pathology. Injury to the superior aspect of the glenoid labrum (SLAP lesions) poses a significant challenge to the rehabilitation specialist due to the complex nature and wide variety of etiological factors associated with these lesions. A thorough clinical evaluation and proper identification of the extent of labral injury is important in order to determine the most appropriate non-operative and/or surgical management. Postoperative rehabilitation is based on the specific surgical procedure that has been performed, as well as the extent, location, and mechanism of labral pathology and associated lesions. Emphasis is placed on protecting the healing labrum while gradually restoring range of motion, strength, and dynamic stability of the glenohumeral joint. The purpose of this paper is to provide an overview of the anatomy and pathomechanics of SLAP lesions and review specific clinical examination techniques used to identify these lesions in the overhead athlete. Furthermore, a review of the current surgical management and postoperative rehabilitation guidelines is provided.

Keywords: Dynamic stability, glenohumeral, overhead athlete, rehabilitation, shoulder

Level of Evidence: 5

[1] Champion Sports Medicine, A Physiotherapy Associates Clinic, American Sports Medicine Institute, Birmingham, AL, USA
[2] Andrews Sports Medicine and Orthopaedic Center, American Sports Medicine Institute, Birmingham, AL, USA

CORRESPONDING AUTHOR

Kevin E Wilk, PT, DPT, FAPTA
Champion Sports Medicine
805 St. Vincent's Dr.
Suite G100
Birmingham, AL 35205
Phone (205) 939-1557
Fax (205) 939-1536
Email: kwilkpt@hotmail.com

INTRODUCTION

The inherently complicated nature of injuries involving the superior aspect of the glenoid labrum can present a substantial clinical challenge. Successful return to unrestricted function requires integrating the appropriate diagnosis, surgical management, and rehabilitation in a coordinated effort. The advent of arthroscopy has helped to provide a better understanding of normal labral anatomy, capsulolabral anomalies, and the pathomechanics of conditions involving this structure. Likewise these techniques have also drastically improved the surgical treatment options available to successfully address these pathologies. Andrews et al[1] originally described the detachment of the superior labrum in a subset of throwing athletes in 1985. Later Snyder et al[2] introduced the term SLAP lesion - indicating an injury located within the superior labrum extending anterior to posterior. They originally classified these lesions into 4 distinct categories based on the type of lesion present, emphasizing that this lesion may disrupt the origin of the long head of the biceps brachii.[2] Subsequent authors have added additional classification categories and specific sub-types, further expanding on the 4 originally described categories.[3-5] Based on these subtle differences in labral pathology an appropriate treatment plan may be developed to adequately address the specific pathology present.

In recent years it has become clear that symptomatic superior labral lesions and detachments can be treated effectively with either arthroscopic debridement or repair depending on the specific type of pathology present.[6-10] We believe that it is critical to carefully follow a postoperative rehabilitation program that has been based on an accurate diagnosis that specifies extent of superior labral pathology to ensure a successful outcome. The purpose of this paper is to describe the normal anatomy, biomechanics, pathomechanics, physical exam, surgical management, and rehabilitation of lesions involving the superior labrum in the overhead thrower, which will assist rehabilitation professionals in effectively managing patients presenting with these complex lesions. The recognition and specific treatment of these lesions presented in this paper is based on the authors' collective clinical experience and numerous published materials.

Normal Anatomy and Biomechanics of the Glenoid Labrum

The labrum is a fibrous structure strongly attached around the edge of the glenoid that serves to increase the contact surface area between the glenoid and the humeral head.[11] Although the glenoid labrum consists mainly of fibrous cartilage, some studies have shown that it is composed of dense fibrous collagen tissue.[11,12] Moseley and Overgaard[12] also noted that the superior and inferior labrum exhibit significantly different anatomy and that the labrum changes appearance in varying degrees of humeral rotation. The superior labrum is rather loose, mobile and has a "meniscal-like" aspect, while the inferior labrum appears rounded and more tightly attached to the glenoid rim. Histologically, the attachment of the labrum to the glenoid rim consists of loose connective fibers above the equator of the glenoid while the inferior portion of the labral attachment is fixed by inelastic fibrous tissue.[11] The labrum is attached to the lateral portion of the biceps anchor superiorly. Additionally, approximately 50% of the fibers of the long head of the biceps brachii originate from the superior labrum and the remaining fibers originate from the supraglenoid tubercle of the glenoid.[11] The fibers of the biceps tendon blend with the superior labrum continuing posteriorly to become a periarticular fiber bundle, making up the bulk of the labrum.[13] The anterosuperior labral fibers appear to be attached more to the middle and inferior glenohumeral ligaments rather than directly to the glenoid rim itself.

Vascular supply to the labrum arises mostly from its peripheral attachment to the capsule and is from a combination of the suprascapular, the circumflex scapular branch of the subscapular, and the posterior circumflex humeral arteries.[11] The anterosuperior labrum appears to generally have poor blood supply, whereas the inferior labrum exhibits significant blood flow.[11] Vascularity of the labrum decreases with increasing age.[11] No mechanoreceptors have been identified within the glenoid labrum.[14] However, free nerve endings have been isolated in the fibrocartilagenous tissue of the labrum, the biceps-labrum complex, and the connective tissue surrounding the labrum.[14,15]

The glenoid labrum enhances shoulder stability in 4 distinct ways: 1) it produces a "chock-block" effect between the glenoid and the humeral head that serves to limit humeral head translation[11,16,17]; 2) it increases the "concavity-compression" effect between the humeral head and the glenoid[11,16-19]; 3) it contributes to the stabilizing effect of the long head of the biceps anchor[20]; 4) and it increases the overall depth of the glenoid fossa.[11,17, 21] Therefore, the glenoid labrum plays an important role in contributing to joint stability[16, 17, 19, 22, 23] Perry[24] demonstrated that the depth of the glenoid fossa across its equatorial line is doubled, from 2.5 to 5 mm, by the presence of the labrum.

Normal Anatomic Variations

The cross-sectional shape of the superior labrum is similar in appearance to a knee meniscus. It is normally triangular with the sharp free edge pointing to the center of the joint.[11] Sometimes the free edge of the labrum is more prominent than the normal anatomy and may extend into the center of the joint without any pathological significance. The presence of this finding is termed a "meniscoid-type" superior labrum and must not be considered pathological unless frayed or torn.[3,11] The presence of a meniscoid superior labrum may lead to an incorrect diagnosis of a SLAP lesion during magnetic resonance imaging (MRI) interpretation. A meniscoid superior labrum may tear in some athletes performing overhead sports or following a trauma and evolve into a type III SLAP lesion.

Another common normal finding is a minimal recess or anterior sub-labral hole that must not be confused with a SLAP lesion.[12] This anterior sublabral hole can exist below the biceps attachment at or just above the 3 o'clock position (in a right shoulder) on the glenoid rim where a small notch is typically found.[12,15] Occasionally the labrum in front of this opening looks detached from the bone without any signs of a lesion. This is a normal anatomical variation and does not appear to contribute to glenohumeral joint instability.

In addition to the meniscoid superior labrum and sub-labral hole variations, a third normal anatomical variation of the glenoid labrum, the Buford complex, also exists.[26] Williams et al[26] noted this variation in 1.5% of shoulders evaluated, and described it as a cord-like middle glenohumeral ligament that blended with the anterior superior labrum with the absence of any anterior superior labrum from the 12 to the 3 o'clock position (in a right shoulder) on the glenoid. The authors recommended not treating this variation surgically as it does not appear to lead to instability and/or pain when present in isolation.

Pathomechanics of SLAP Lesions

There are several injury mechanisms that are speculated to be responsible for creating SLAP lesions. These mechanisms range from single traumatic events to repetitive microtraumatic injuries. Traumatic events, such as falling on an outstretched arm or bracing oneself during a motor vehicle accident, may result in SLAP lesions due to compression of the superior joint surfaces superimposed with subluxation of the humeral head. Snyder et al[2] referred to this as a pinching mechanism of injury. Other traumatic injury mechanisms include direct blows, falling onto the point of the shoulder, and forceful traction injuries of the upper extremity.

Repetitive overhead activity, such as throwing a baseball, is another common mechanism of injury frequently responsible for producing SLAP injuries.[1,5,27] Andrews et al[1,28] first hypothesized that SLAP pathology in overhead throwing athletes was the result of the high eccentric activity of the biceps brachii during the arm deceleration and follow-through phases of the overhead throw. The authors applied electrical stimulation to the biceps during arthroscopic evaluation and noted that the biceps contraction raised the labrum off of the glenoid rim, simulating the hypothesized mechanism.[1,28]

Burkhart and Morgan[27] and Morgan et al[5] have hypothesized a "peel back" mechanism that produces SLAP lesion in the overhead athlete. They suggest that when the shoulder is placed in a position of abduction and maximal external rotation, the rotation produces a twist at the base of the biceps, transmitting torsional force to the anchor. (Figure 1) Pradhan et al[29] recently measured superior labral strain in a cadaveric model during each phase of the throwing motion. They noted that increased superior labral strain occurred during the late-cocking phase of throwing. Furthermore, Jobe[30] and Walch et al[31] have also demonstrated that when the arm is in a maximally externally rotated position there is

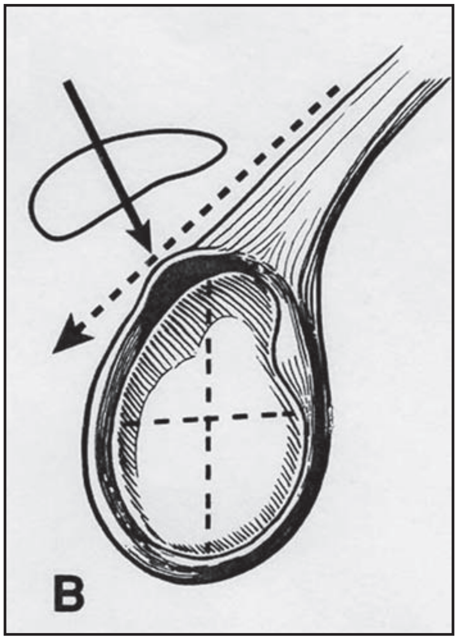

Figure 1. *Peel back mechanism of SLAP injury. When the shoulder is placed in a position of maximal external rotation, the rotation produces a torsional force to the base of the biceps anchor. (Reproduced with permission from Burkhart and Morgan[27])*

contact between the posterior-superior labral lesions and the rotator cuff.

A recent study conducted at the authors' research center[20] simulated each of these mechanisms using cadaveric models. Nine pairs of cadaveric shoulders were loaded to biceps anchor complex failure in either a position of simulated in-line loading (similar to the deceleration phase of throwing) or simulated peel back mechanism (similar to the cocking phase of overhead throwing). Results showed that 7 of 8 of the in-line loading group failed in the midsubstance of the biceps tendon with 1 of 8 fracturing at the supraglenoid tubercle. However, all 8 of the simulated peel back group failures resulted in a type II SLAP lesion. The ultimate strength of the biceps anchor was significantly different when the 2 loading techniques were compared. The biceps anchor demonstrated significantly higher ultimate strength with the in-line loading (508 N) as opposed to the ultimate strength seen during the peel back loading mechanism (202 N).

A subsequent follow-up study evaluated the same mechanisms of injury pattern (peel-back versus in-line loading) in 7 paired cadaveric models following repair of a SLAP II lesion.[32] The results were similar to those published by Sheppard et al on intact structures[20] with a 51% lower load to failure in the peel-back group compared to the in-line loading group. However, the mean load to failure was 77% of the load to failure of the intact biceps labral complexes as determined by Shepard et al.[20] Interestingly, the location of failure was found to occur at the biceps attachment to the glenoid tubercle in 5 of 7 seven specimens, rather than at the posterosuperior labrum, suggesting that the strength of the SLAP repair was stronger than the biceps insertion on the glenoid tubercle. In theory, SLAP lesions most likely occur in overhead athletes from a combination of these 2 previously described forces. The eccentric biceps activity during deceleration may serve to weaken the biceps-labrum complex, while the torsional peel back force may result in the posterosuperior detachment of the labral anchor.

Several authors have also reported a strong correlation between SLAP lesions and glenohumeral instability.[16,22,27,33-35] Normal biceps function and glenohumeral stability is dependent on a stable superior labrum and biceps anchor. Pagnani et al[16] found that a complete lesion of the superior portion of the labrum large enough to destabilize the insertion of the biceps was associated with significant increases in anterior-posterior and superior-inferior glenohumeral translation. Reinold et al[34] reported that in a series of 130 overhead athletes with symptomatic hyper laxity undergoing thermal assisted capsular shrinkage (TACS) of the glenohumeral joint, 69% exhibited superior labral degeneration while 35% had type II SLAP lesions. Furthermore, Pagnani et al[16] reported that the presence of a simulated SLAP lesion in seven cadaveric shoulders resulted in a 6 mm increase in anterior glenohumeral translation. These studies are in agreement with the results of Glousman[36] who showed increased EMG activity of the biceps brachii in baseball pitchers with anterior instability. Furthermore, Kim et al[33] reported that maximal biceps activity occurred when the shoulder was abducted to 90 degrees and externally rotated to 120 degrees in patients with anterior instability. Because this position is remarkably similar to the cocking position of the overhand throwing motion, the finding of instability may cause or facilitate the progression of internal impingement (impingement of the infraspinatus on the posterosuperior glenoid rim) in the overhead athlete.

Classification of SLAP Lesions

Because the glenoid labrum is involved in the stability of the glenohumeral joint, pathological conditions of the labrum appear in cases of instability, whether due to repetitive loads or frank traumatic injury.[4,12,18] Clinically these instabilities may be either gross or subtle. Although instability may occur, SLAP lesions most often result in symptoms of mechanical pain and dysfunction, rather than instability.

The prevalence of SLAP lesions is disputed in the published literature. Some authors have reported encountering SLAP lesions in as many as 26% of shoulders undergoing arthroscopy.[2,4,37-40] These percentages rise dramatically in reports specific to overhead throwing athletes. Andrews et al[28] noted that 83% of 73 throwers exhibited labral lesions when evaluated arthroscopically. Reinold et al[34] noted 91% of overhead athletes undergoing TACS for glenohumeral instability had superior labral pathology of some type.

Following a retrospective review of 700 shoulder arthroscopies, Snyder et al[2] identified 4 types of superior labrum lesions involving the biceps anchor. Collectively they termed these SLAP lesions, in reference to their anatomic location: superior labrum extending from anterior to posterior. Type I SLAP lesions were described as being indicative of isolated fraying of the superior labrum with a firm attachment of the labrum to the glenoid. These lesions are typically degenerative in nature. Type II SLAP lesions are characterized by a detachment of the superior labrum and the origin of the tendon of the long head of the biceps brachii from the glenoid resulting in instability of the biceps-labral anchor. A bucket-handle tear of the labrum with an intact biceps insertion is the characteristic presentation of a type III SLAP lesion. Type IV SLAP lesions have a bucket-handle tear of the labrum that extends into the biceps tendon. In this lesion, instability of the biceps-labrum anchor is also present, similar to that seen in the type II SLAP lesion.

Maffet et al[4] noted that 38% of the SLAP lesions identified in their retrospective review of 712 arthroscopies were not classifiable using the I-IV terminology previously defined by Snyder et al[2]. They suggested expanding the classification scale for SLAP lesions to a total of 7 categories, adding descriptions for types V-VII.[4] Type V SLAP lesions are characterized by the presence of a Bankart lesion of the anterior capsule that extends into the anterior superior labrum. Disruption of the biceps tendon anchor with an anterior or posterior superior labral flap tear is indicative of a type VI SLAP lesion. Type VII SLAP lesions are described as the extension of a SLAP lesion anteriorly to involve the area inferior to the middle glenohumeral ligament. Furthermore, a type VIII lesion involves a type II tear with a posterior labral extension to the 6 o'clock position.[41] A type IX tear is a circumferential lesion involving the full 360 degrees of labral attachment to the glenoid rim.[41] Finally, a type X lesion involves a superior labral tear combined with a posteroinferior labral tear (a reverse Bankart lesion).[41] Thus, the surgical treatment and rehabilitation will vary based on these concomitant pathologies.

Three distinct sub-categories of type II SLAP lesions have been further identified by Morgan et al.[5] They reported that in a series of 102 patients undergoing arthroscopic evaluation 37% presented with an anterosuperior lesion, 31% with a posterosuperior lesion, and 31% exhibited a combined anterior and posterior lesion.[5] These findings are consistent with the authors' clinical observations. In the authors' experience, the majority of overhead athletes present with posterosuperior lesions while individuals who have traumatic SLAP lesions typically present with anterosuperior lesions. These variations may become important when selecting which special tests to perform based on the patient's history and mechanism of injury.

Clinical Evaluation

As with appropriately assessing any pathology, a thorough clinical examination is essential to establishing the potential presence of glenoid labral pathology. Clinical examination to detect SLAP lesions is often difficult because of the common presence of concomitant pathology in patients presenting with this type of condition. Andrews et al[28] reported 45% of patients (and 73% of baseball pitchers) with superior labral lesions had concomitant partial thickness tears of the supraspinatus portion of the rotator cuff. Mileski and Snyder[18] reported that 29% of their patients with SLAP lesions exhibited partial thickness rotator cuff tears, 11% complete rotator cuff tears, and 22% Bankart lesions of the anterior glenoid. Kim et al[38] prospectively analyzed the clinical features of different types of SLAP lesion as they vary with patient population in 139 cases. They demonstrated that type I SLAP lesions are typically associated with rotator cuff pathology while type III and IV lesions are associated with traumatic instability. They also note that injuries presenting concomitant with type II SLAP lesions vary by patient age, with older patients presenting more often with rotator cuff pathology and younger patients instability.

The clinical examination should include subjective history, physical examinations, specific special tests, and an enhanced MRI. In combination, the goal of these measures is to make an accurate clinical diagnosis. A comprehensive history including the exact mechanism of injury must be obtained and should clearly define all overhead activities and sports participation. The clinician should keep in mind that while labral pathologies frequently present as repetitive overuse conditions, such as those commonly seen in overhead athletics, the patient may also describe a single traumatic event such as a fall onto the outstretched arm or an episode of sudden traction, or a blow to the shoulder. A patient with a superior labral injury may have non-specific complaints. Pain complaints are typically intermittent and are most frequently associated with overhead activity. Often patients exhibit mechanical symptoms of painful clicking or catching of the shoulder.[42] Pain is typically elicited with specific movements and the condition is not painful at rest. We refer to this as "mechanical pain" as opposed to pain at rest, which is often present when rotator cuff pathology is present. Overhead athletes typically report a loss of velocity and accuracy along with general uneasiness of the shoulder. Snyder et al[39] have reported that this type of subjective complaint is present in 50% of patients. Probably the most predictive subjective complaint in the athlete is the inability to perform sporting activities at a high level.

The physical examination should include a complete evaluation of bilateral passive and active range of glenohumeral motion with particular emphasis placed on determining the presence, persistence, and behavior of any painful arc of motion. The authors' experience suggests that patients with a SLAP lesion will often exhibit pain with passive external rotation at 90 degrees of shoulder abduction, especially with overpressure. Furthermore, pain may also be present with active arm elevation. A wide variety of potentially useful special test maneuvers have been described to help determine the presence of labral pathology in an overhead thrower, including: the active compression test, the biceps load test,[43] the biceps load test II,[33] the pain provocation test.[44] and the resisted supination and external rotation test,[45] and the pronated load test.

The active compression test as described by O'Brien et al[46] is used to evaluate labral lesions and acromioclavicular joint injuries. The shoulder is placed into approximately 90 degrees of elevation and 30 degrees of horizontal adduction across the midline of the body. Resistance is applied, using an isometric hold, in this position with both full shoulder internal and external rotation (altering humeral rotation against the glenoid in the process). A positive test for labral involvement is when pain is elicited when testing with the shoulder in internal rotation and forearm in pronation (thumb pointing toward the floor). Symptoms are typically decreased when tested in the externally rotated position or the pain is localized at the acromioclavicular (AC) joint. O'Brien et al[46] found this maneuver to be 100% sensitive and 95% specific as it relates to assessing the presence of labral pathology. Pain provocation using this test is common, challenging the validity of the results. In the authors' experience, the presence of deep and diffuse glenohumeral joint pain is most indicative of the presence of a SLAP lesion. Pain localized in the AC joint or in the posterior rotator cuff is not specific for the presence of a SLAP lesion. The posterior shoulder symptoms are indicative of provocative strain on the rotator cuff musculature when the shoulder is placed in this position.

The biceps load test was originally described by Kim et al.[26] During this test, the shoulder is placed in 90 degrees of abduction and maximally externally rotated. At maximal external rotation and with the forearm in a supinated position, the patient is instructed to perform a biceps contraction against resistance. Deep pain within the shoulder during this contraction is indicative of a SLAP lesion. The

Figure 2. *Biceps Load II Test. The patient is passively positioned in maximal external rotation at 120° of abduction, with the forearm in a supinated position. In this position, an isometric biceps contraction is performed in an attempt to peel-back the labrum.*

Figure 3. *The resisted supination external rotation test. The patient is passively positioned at 90° of abduction, 65-70° of elbow flexion, and neutral rotation. The examiner simultaneously resists forearm supination during passive external rotation in an attempt to peel-back the labrum.*

original authors further refined this test with the description of the biceps load II maneuver.[25] The examination technique is similar, although the shoulder is placed into a position of 120 degrees of abduction rather than the originally described 90 degrees. (Figure 2) The biceps load II test was noted to have greater sensitivity than the original test.[25]

Mimori et al[44] described the pain provocation test. During this maneuver, the shoulder is passively abducted to 90-100 degrees and passively externally rotated with the forearm in full pronation and then full supination. The authors determined that a SLAP lesion was present if pain was produced with shoulder external rotation with the forearm in the pronated position or if the severity of the symptoms was greater in the pronated position. The authors suggest that positive symptoms with this test are due to the additional stretch placed on the biceps tendon when the shoulder is externally rotated with the forearm pronated.

The resisted supination external rotation test[45] (Figure 3) is performed with the patient in supine and the shoulder at 90 degrees of shoulder abduction, and 65-70 degrees of elbow flexion and the forearm in neutral position. The examiner resists against a maximal supination effort while passively externally rotating the shoulder. Myers et al[45] note that this test simulates the peel-back mechanism of SLAP injuries by placing maximal tension on the long head of the biceps. A preliminary study of 40 patients revealed that this test had better sensitivity (82.8%), specificity (81.8%), positive predictive value (PPV) (92.3%), negative predictive value (NPV) (64.3%), and diagnostic accuracy (82.5%) compared to the crank test and active compression test.[45]

The pronated load test is performed in the seated position with the shoulder abducted to 90 degrees and externally rotated. However, the forearm is in a fully pronated position to increase tension on the biceps and subsequently the labral attachment. When maximal external rotation is achieved, the patient is instructed to perform a resisted isometric contraction of the biceps to simulate the peel-back mechanism. This test combines the active bicipital contraction of the biceps load test with the passive external rotation in the pronated position similar to the pain provocation test.

McFarland et al[47] evaluated the ability of 3 clinical tests to predict the presence of labral pathology. In this investigation 3 tests (active compression test, anterior slide test, and compression-rotation test) were performed on 426 patients who subsequently underwent arthroscopic examination. Of these patients, 39 had type II-IV SLAP lesions while 387 had type I lesions. The active compression test was found to be the most sensitive and have the highest predictive value, although both values were low (47% sensitivity, 10% positive predictive value). The anterior slide test was the most specific maneuver with an 84% specificity. All 3 tests were found to have high associated accuracy, although the majority of patients presented with only Type I lesions. It is also interesting to note that the presence of clicking and the location of pain was not a reliable predictor of the presence or severity of labral involvement.

The reliability of MRI for the diagnosis of SLAP lesions is disputed[48,49] and definitive diagnosis requires arthroscopy. Several authors recommend MR enhanced arthrography in order to detect SLAP lesions.[50,51] Bencardino et al[50] retrospectively reviewed preoperative MR arthrography following shoulder arthroscopy. The authors report MR arthrography has a sensitivity of 89%, a specificity of 91%, and an accuracy of 90% (47 of 52 patients) in detecting SLAP lesions. Thus, enhanced MR arthrography is routinely utilized at the authors' center to assess the glenoid labrum.

Thus, it appears that each of the current SLAP tests have limited diagnostic accuracy. (Table 1) A limitation of previous studies is the lack of differentiation among the different types of SLAP lesions during the differential diagnosis process. In most studies, several variations of SLAP lesions are grouped together to obtain enough statistical power to analyze the data. It is the authors' opinion that different tests will result in different specificity and sensitivity results based on the variation of SLAP lesion present. Therefore, the authors feel that it is imperative to correlate the clinical examination findings to the patient's complaints, symptoms, and injury mechanism. The selection of specific SLAP tests to perform may be based on the symptomatic complaints as well as mechanism of injury described by the patient.

Surgical Management

Conservative management of SLAP lesions is often the first line of defense and has been shown to be successful. Edwards et al[52] showed that 10 of 15 overhead throwers with a known SLAP lesion who were treated with non-operative management were able to return to play at the same level or better. However, frequently, rehabilitation is unsuccessful, particularly type II & type IV lesions with labral instability and underlying shoulder instability. Therefore, surgical intervention is often warranted to repair the labral lesion while addressing any concomitant pathology. In the event that an athlete does undergo conservative rehabilitation, many of the same prin-

Table 1. *Diagnostic Accuracy of Special Tests Associated with SLAP Lesions.*

Test	N	Sensitivity	Specificity	PPV*	NPV**
Active Compression[18]	33	54	47	55	45
Active Compression[30]	426	47	55	10	91
Active Compression[37]	318	100	99.5	94.6	100
Active Compression[35]	37	78	11	70	14
Active Compression[51]	65	54	31	34	50
Biceps Load II[25]	127	90	97	92	96
MRI[5]	52	89	91	90	
MRI[8]	46	89	88	89	
MR[51]	65	42	92	63	83
Resisted Supination ER[35]	40	83	82	92	64

* Positive Predictive Value

** Negative Predictive Value

ciples discussed in the upcoming sections may be applied.

The authors' experience suggests that a type I SLAP lesion may represent age related fraying of the superior labrum and does not necessarily require specific treatment. Often the overhead athlete may exhibit fraying of the superior and posterior labrum due to internal impingement.[31] Isolated debridement of labral fraying has not been shown to reliably relieve symptoms over the long term.[32,53] However, if symptoms are progressive in nature or warrant surgical intervention, type I SLAP lesions are generally debrided back to a stable labral rim. Type III SLAP lesions should also be excised and debrided back to a stable rim, much like some bucket handle meniscus tears in the knee. The exception to this is a type III lesion involving a Buford complex, which should be treated as a type II SLAP lesion.

The outcomes following debridement (without repair) of unstable type II and IV SLAP lesions have been poor and thus these two types of lesions should be repaired in order to restore the normal anatomy.[32,53] In the presence of a type II SLAP lesion, the superior labrum should be reattached to the glenoid and the biceps anchor stabilized. (Figure 4) The type II lesion is often stabilized utilizing suture anchors. Treatment of type IV SLAP lesions is generally based on the extent to which the biceps anchor is involved. When biceps involvement is less than approximately 30% of the entire anchor, the torn tissue is typically resected and the superior labrum reattached. If the biceps tear is more substantial, a side-to-side repair

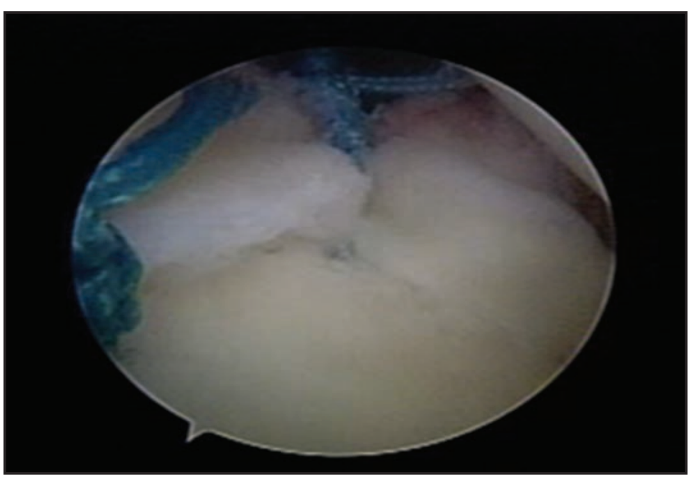

Figure 4. *SLAP II repair using suture anchors.*

of the biceps tendon, in addition to reattachment of the superior labrum is generally performed. However, if the biceps tear is extensive enough to substantially alter the biceps origin, a biceps tenodesis or tenotomy is more practical than a direct repair. In addition to the treatment of the SLAP lesion, associated rotator cuff pathology or glenohumeral joint instability should be independently evaluated and treated at the time of surgery.

With the advent of improved surgical techniques, the ability to observe and fix all aspects of the labrum has recently been seen. Complete disruption of the labrum, known as a 360-degree tear or type IX lesion has been reported in the literature.[41,54] Due to the severe nature of the injury and the amount of tissue involved, the surgical intervention often requires multiple suture anchors in order to address the circumferential pathology. Limited results have been reported however a case report involving complete disruption with a concomitant rotator cuff tear in an NFL thrower reported excellent outcomes.[54]

Operative SLAP Repair Surgical Technique

The goal of surgical repair of a SLAP lesion is to obtain a strong repair that allows the patient to aggressively rehabilitate the shoulder and return to full activities or sports competition. Using arthroscopic surgical techniques, the superior labrum is mobilized along the entire area of detachment using a 4.5 mm motorized shaver to take down any fibrous adhesions. This area usually extends from approximately the 11 to the 1 o'clock positions of the glenoid (in a right shoulder). The bony area of attachment is abraded to create a bleeding bed to facilitate healing. The repair surface of the labrum is also gently debrided to stimulate a healing response. Two suture anchors are usually adequate to secure the biceps anchor and superior labrum. The authors' center prefers to use bioabsorbable suture anchors with number 2 braided nonabsorbable suture loaded on the eyelet. The number of anchors utilized is based on the size of the SLAP lesion present. The suture anchors are positioned so that each one splits the difference between the biceps and the normal area of labral insertion, usually 11:30 and 12:30 on a clock face. The suture anchors are placed at the junction of the articular cartilage and cortical bone. The security of anchor fixation is tested with a firm pull on the sutures. Once the suture anchors are in place, one end of each suture is passed through the labrum. The surgeon may choose to incorporate some of the biceps tendon near the junction of the biceps and labrum if necessary to secure the biceps anchor. Arthroscopic knot tying techniques are utilized. In general, the placement of anchors and tying knots progresses from posterior to anterior.

The outcomes following repair of unstable SLAP II and IV lesions have been good with satisfactory results in over 80% of patients in the majority of published articles.[1,6,7,55-57] Reinold et al[34] reported that 87% of athletes undergoing TACS with concomitant debridement of a SLAP lesion and 84% of athletes with a concomitant SLAP repair returned to competition with good to excellent outcomes as measured using the Modified Athletic Shoulder Outcome Scale.

SLAP Lesion Rehabilitation Guidelines

The specific rehabilitation program following surgical intervention involving the superior glenoid labrum is dependent on the severity of the pathology and should specifically match the type of SLAP lesion, the exact surgical procedure performed (debridement vs. repair), and other possible concomitant procedures performed because of the underlying glenohumeral joint instability that is often present. The rehabilitation process should be individualized to the many variables and needs associated with each patient. Overall, emphasis should be placed on restoring and enhancing dynamic stability of the glenohumeral joint, while at the same time ensuring that adverse stresses are not applied to healing tissue.

Prior to rehabilitation, the authors believe that it is imperative that a thorough subjective and clinical exam be performed to determine the exact mechanism and nature of labral pathology. For patients who sustained a SLAP lesion via a compressive injury, such as a fall on an outstretched hand, weight-bearing exercises should be avoided to minimize compression and sheer on the superior labrum. Patients with traction injuries should avoid heavy resisted or excessive eccentric biceps contractions. Furthermore, patients with peel-back lesions, such as overhead athletes, should avoid excessive amounts of shoulder external rotation while the SLAP lesion is healing. Thus the mechanism of injury is an important factor to individually assess when determining appropriate rehabilitation guidelines for each patient.

Debridement of Type I and III SLAP Lesions

Type I and Type III SLAP lesions normally undergo a simple arthroscopic debridement of the frayed labrum without an anatomic repair. Table 2 outlines the rehabilitation program following this type of procedure. This program can be somewhat aggressive in restoring motion and function because the biceps-labral anchor is stable and intact. The rate of progression during the course of postoperative rehabilitation is based on the presence and extent of concomitant lesions. If, for example, significant rotator cuff fraying (partial thickness tear) is present and treated with arthroscopic debridement, the rehabilitative program must be appropriately adapted. Generally, a sling is worn for comfort during the first 3 to 4 days following surgery. Active-assistive range of motion (AAROM) and passive range of motion (PROM) exercises are initiated immediately following surgery, with full PROM expected within 10 to 14 days post-operatively. Flexion ROM is performed to tolerance. External rotation (ER) and internal rotation (IR) in the scapular plane are initiated at 45 degrees of glenohumeral abduction and advanced to 90 degrees of abduction usually by post-operative day 5 or 7. ROM exercises may be performed early because an anatomical repair has not been performed.

Isometric strengthening in all planes of shoulder motion is performed sub-maximally and pain free during the first 7 days after surgery to retard muscular atrophy. Light isotonic strengthening for the shoulder and scapular musculature (with the exception of the biceps) are initiated during the second week following surgery. This includes ER/IR exercise tubing, sidelying ER, prone rowing, prone horizontal abduction, and prone ER. Active elevation exercises such as scapular plane elevation (full can position)[58] and lateral raises are also included. Weighted resistance begins at 0.45 kg (1 lb) and advances by 0.45 kg per week in a gradual controlled progressive resistance fashion. This progression is used to gradually challenge the musculature. Light biceps resistance is usually not initiated until 2 weeks following surgery in an attempt to prevent debridement site irritation. Furthermore, caution should be placed on early

Table 2. *Rehabilitation Protocol Following Arthroscopic Debridement of Type I/III SLAP Lesions.*

I. PHASE I - MOTION PHASE (Day 1 to Day 10)

Goals: Re-establish non-painful Range of Motion
Retard Muscular Atrophy
Decrease pain/inflammation

Range of Motion: (PROM/AAROM)
* Pendulum Exercise
* Rope and Pulley
* L-bar exercises
  - Flexion/Extension
  - Abduction/Adduction
  - ER/IR (Begin at 0 degrees AB, progress to 45 degrees AB, then 90 degrees AB)
* Self-stretches (capsular stretches)

Exercises:
* Isometrics
**NO BICEPS Isometrics for 5-7 days Post-Op
* May initiate tubing for ER/IR at 0 degrees AB late phase (Usually 7-10 days Post-Op)

Decrease Pain/Inflammation: * Ice, NSAIDS, Modalities

II. PHASE II - INTERMEDIATE PHASE (Week 2-4)

Goals: Regain & Improve Muscular Strength
Normalize Arthrokinematics
Improve Neuromuscular Control of Shoulder Complex

Criteria To Progress to Phase II
1. Full PROM
2. Minimal Pain & Tenderness
3. 4/5 MMT of IR, ER, Flex

Week 2:

Exercises: *Initiate Isotonic Program with Dumbbells
  - GH and scapulothoracic musculature
  - Scapulothoracic
  - Tubing ER/IR at 0 degrees Abduction
  - Sidelying External Rotation
  - Prone Rowing External Rotation
  - PNF Manual Resistance with Dynamic Stabilization
* Normalize Arthrokinematics of Shoulder Complex
  - Joint Mobilization
  - Continue Stretching of Shoulder (ER/IR at 90 degrees of Abduction)
* Initiate Neuromuscular Control Exercises
* Initiate Proprioception Training
* Initiate Trunk Exercises
* Initiate UE Endurance Exercises

Decrease Pain/Inflammation: * Continue use of modalities, ice, as needed

Table 2. *Rehabilitation Protocol Following Arthroscopic Debridement of Type I/III SLAP Lesions. (continued)*

Week 3:

Exercises:

* Throwers Ten Program
* Emphasis Rotator Cuff & Scapular Strengthening
* Dynamic Stabilization Drills

III. PHASE III - DYNAMIC STRENGTHENING PHASE - Advanced Strengthening Phase (Week 4-6)

Goals: Improve Strength/Power/Endurance
Improve Neuromuscular Control
Prepare athlete to begin to throw, etc.

Criteria To Enter Phase III:

1. Full non-painful AROM & PROM
2. No pain or tenderness
3. Strength 70% compared to contralateral side with handheld dynomometer

Exercises:

* Continue Throwers Ten Program
* Continue dumbbell strengthening (supraspinatus, deltoid)
• Initiate Tubing Exercises in the 90/90 degree position for ER/IR (slow/fast sets)
* Exercises for scapulothoracic musculature
* Tubing exercises for biceps
* Initiate Plyometrics (2 hand drills progress to 1 hand drills)
* Diagonal Patterns (PNF)
* Initiate Isokinetic Strengthening
* Continue endurance exercises: neuromuscular control exercises
* Continue Proprioception Exercises

IV. PHASE IV - RETURN TO ACTIVITY PHASE (Week 7 and Beyond)

Goals: Progressively Increase Activities to prepare patient for full functional return

Criteria To Progress to Phase IV

1. Full PROM
2. No pain or tenderness
3. Isokinetic Test that fulfills criteria to throw[63]
4. Satisfactory Clinical Exam

Exercises:

* Initiate Interval Sport Program (i.e., Throwing, Tennis, etc.)
* Continue all exercises as in Phase III
(Throw and Train on Same Day), (LE and ROM on Opposite Days)
* Progress Interval Program

Follow-Up Visits:

- Isokinetic Tests
- Clinical Exam

Table 2. *Rehabilitation Protocol Following Arthroscopic Debridement of Type I/III SLAP Lesions. (continued)*

KEY TO ABBREVIATIONS: PROM – passive range of motion AAROM = active assisted range of motion ER = external rotation IR = internal rotation AB = abduction NSAIDS = non-steroidal anti-inflammatory medication ROM = range of motion MMT = manual muscle test PNF = proprioceptive neuromuscular facilitation UE = upper extremity LE = lower extremity

overaggressive elbow flexion and forearm supination exercises, particularly the use of eccentric exercises of these motions.

As the strengthening program progresses after this type of surgical procedure, the emphasis of rehabilitative interventions should be on obtaining muscular balance and promoting dynamic stability of the complete upper extremity including the glenohumeral and scapulothoracic joints. This is accomplished through a variety of manual resistance and end range rhythmic stabilization drills performed in conjunction with isotonic strengthening and core stabilization exercises. The primary goal of these drills is to re-establish dynamic humeral head control, especially if the pathomechanics of the labral lesion was due to excessive glenohumeral laxity.

The individual is advanced to controlled weight training activities between post-operative weeks 4 and 6. The athlete is instructed on proper technique, such as avoiding excessive shoulder extension and horizontal abduction during bench press and seated rows, to minimize strain on the shoulder. Plyometric exercises are initiated at week 6-8 to train the upper extremity to absorb and develop forces. Two-hand plyometrics, such as chest pass, side throws, and overhead throws are performed initially, progressing to include 1-hand drills such as baseball throws in 7-10 days. The athlete is allowed to begin a gradual return to sport-specific activities between the seventh and tenth post-operative weeks, typically using an interval sport program. The rate of return to overhead sports is often dependent on the extent of concomitant injuries. For example, an athlete with rotator cuff debridement involving 20-30% penetration of the rotator cuff will usually begin an interval sport program following these guidelines, while an athlete with more extensive pathology may need to delay initiation of the interval sport program for up to 4 months. An interval sport program is used to ensure that the athlete allows a gradual application of applied loads to the healing tissues.[59] The start date for initiating any interval sport program is often varied based on the time of year, the goals of the patient, and the competitive athletic season. The ultimate success of return to high level activity following this procedure is dependent on the individual's ability to dynamically stabilize their glenohumeral joint during the performance of high demand activities, thus appropriate and adequate rehabilitation is paramount.

Criteria to begin an interval return to sports activity includes minimal pain, full ROM, adequate strength and dynamic stability, and an appropriate rehabilitation progression as previously described.[7] To determine if the athlete has adequate strength the authors perform isokinetic testing with the goals of ER peak torque/body weight of 18-23%, ER/IR ratio of 66-76%, and ER/abduction ratio 67-75% at 180°/sec.[60-63]

Repair of Type II SLAP Lesions

Overhead throwing athletes commonly present with a Type II SLAP lesion with the biceps tendon detached from the glenoid rim. Frequently a peel back lesion is also present. The initial rehabilitative concern is to ensure that forces and loads on the repaired labrum are appropriately controlled. The authors believe that

Table 3. *Rehabilitation Protocol Following Arthroscopic Type II SLAP Repair.*

I. Phase I - Immediate Postoperative Phase "Protected Motion" (Day 1 to Week 6)

Goals: Protect the anatomic repair
Prevent negative effects of immobilization
Promote dynamic stability
Diminish pain and inflammation

Week 0-2:

- Sling for 4 weeks
- Sleep in abduction pillow for 4 weeks
- Elbow/hand PROM
- Hand gripping exercises
- Passive and gentle shoulder active assistive ROM exercise
    - Flexion to 60° (Week2: Flexion to 75°)
    - Elevation in scapular plane to 60°
    - ER/IR with arm in scapular plane
    - ER to 10-15°
    - IR to 45°

  ** NO active ER or Extension or Abduction
- Submaximal isometrics for shoulder musculature
- NO Isolated Biceps Contractions
- Cryotherapy, modalities as indicated

Week 3-4

- Discontinue use of sling at 4 weeks
- Sleep in abduction pillow until Week 4
- Continue gentle ROM exercises (PROM and AAROM)
    - Flexion to 90°
    - Abduction to 75-85°
    - ER in scapular plane to 25-30°
    - IR in scapular plane to 55-60°

  ** NOTE: Rate of progression based on evaluation of the patient.
- No active ER, Extension or Elevation
- Initiate rhythmic stabilization drills
- Initiate proprioception training
- Tubing ER/IR at 0° Abduction
- Continue isometrics
- Continue use of cryotherapy

Week 5-6

- Gradually improve ROM
    - Flexion to 145°
    - ER at 45° abduction: 45-50°
    - ER at 45° abduction: 55-60°
- May initiate stretching exercises
- May initiate light (easy) ROM at 90° Abduction
- Continue tubing ER/IR (arm at side)
- PNF manual resistance
- Initiate Active Shoulder Abduction (without resistance)
- Initiate "Full Can" Exercise (only using weight of arm)
- Initiate Prone Rowing, Prone Horizontal Abduction
- NO Biceps Strengthening

Table 3. *Rehabilitation Protocol Following Arthroscopic Type II SLAP Repair. (continued)*

II. Phase II - Intermediate Phase: Moderate Protection Phase (Week 7-12)

Goals: Gradually restore full ROM (week 10)
Preserve the integrity of the surgical repair
Restore muscular strength and balance

Week 7-9

- Gradually progress ROM:
  - Flexion to 180°
  - ER at 90° abduction: 90-95°
  - IR at 90° abduction: 70-75°
- Continue to progress isotonic strengthening program
- Continue PNF strengthening
- Initiate Throwers Ten Program
- May begin AROM biceps

Week 10-12

- May initiate slightly more aggressive strengthening
- Progress ER to Throwers Motion
  - ER at 90° abduction: 110-115° in throwers (Week 10-12)
- Progress isotonic strengthening exercises
- Continue all stretching exercises
  **Progress ROM to functional demands (i.e. overhead athlete)
- Continue all strengthening exercises

III. Phase III - Minimal Protection Phase (Week 12-20)

Goals: Establish and maintain full PROM & AROM
Improve muscular strength, power and endurance
Gradually initiate functional activities

Criteria to enter Phase III:

1) Full non-painful AROM
2) Satisfactory stability
3) Muscular strength (4/5 or better)
4) No pain or tenderness

Week 12-16

- Continue all stretching exercises (capsular stretches)
- Maintain Throwers Motion (Especially ER)
- May begin resisted biceps and forearm supination exercises
- Continue strengthening exercises:
  - Throwers Ten Program or Fundamental Exercises
  - PNF Manual Resistance
  - Endurance training
  - Initiate light plyometric program
  - Restricted sport activities (light swimming, half golf swings)

Table 3. *Rehabilitation Protocol Following Arthroscopic Type II SLAP Repair. (continued)*

Week 16-20

- Continue all exercise listed above
- Continue all stretching
- Continue Throwers Ten Program
- Continue Plyometric Program
- Initiate interval sport program (throwing, etc)
  **See Interval Throwing Program

IV. Phase IV - Advanced Strengthening Phase (Week 20-26)

Goals: Enhance muscular strength, power and endurance
Progress functional activities
Maintain shoulder mobility

Criteria to enter Phase IV

1) Full non-painful AROM
2) Satisfactory static stability
3) Muscular strength 75-80% of contralateral side
4) No pain or tenderness

Week 20-26

- Continue flexibility exercises
- Continue isotonic strengthening program
- PNF manual resistance patterns
- Plyometric strengthening
- Progress interval sport programs

V. Phase V - Return to Activity Phase (Month 6 to 9)

Goals: Gradual return to sport activities
Maintain strength, mobility and stability

Criteria to enter Phase V:

1) Full functional ROM
2) Muscular performance isokinetic (fulfills criteria)
3) Satisfactory shoulder stability
4) No pain or tenderness

Exercises:

- Gradually progress sport activities to unrestrictive participation
- Continue stretching and strengthening program

Table 3. *Rehabilitation Protocol Following Arthroscopic Type II SLAP Repair. (continued)*

KEY TO ABBREVIATIONS:
ROM = range of motion
ER = external rotation
IR = internal rotation
PROM = passive range of motion
AAROM = active assisted range of motion
PNF = proprioceptive neuromuscular facilitation

it is important to determine the extent of the lesion and understand its exact location and number of suture anchors utilized to in surgery, when constructing an appropriate rehabilitation program. For instance, the rate of rehabilitation progression would be slower for a SLAP repair completed with 3 anchors than a 1-anchor repair, based on the extent of the pathology and tissue involvement. Postoperative progression is slowed to allow healing of the more extensive anatomical repair required to reattach the biceps tendon anchor in a Type II lesion, in comparison to Type I and III lesions.

The patient is instructed to sleep in a shoulder abduction sling for the first 4 weeks following surgery to protect the healing structures from excessive amounts of motion. Gradual range of motion in a protective range is performed for the first 4 weeks below 90 degrees of elevation in order to avoid strain on the labral repair.[19] During the first 2 weeks internal and external rotation ROM exercises are performed passively in the scapula plane to approximately 10 to 15 degrees of ER and 45 degrees of IR. Initial ER ROM is performed cautiously to minimize strain on the labrum through the peel back mechanism. Internal and external rotation ROM activities are progressed, to be performed at 90^{o} of shoulder abduction at week 4. Motion is gradually increased to restore full range of motion (90-100° of ER at 90° of abduction) by 8 weeks and progressed to thrower's motion (approximately 115-120 degrees of ER) through week 12. Restoring motion is usually accomplished with minimal difficulty.

Isometric exercises are performed immediately postoperatively. Exercises are initially performed with rhythmic stabilization drills for ER/IR, and flexion/extension. These rhythmic stabilizations theoretically promote dynamic stabilization and co-contraction of the entire shoulder musculature.[17,62,64-67] This concept is important when considering the underlying glenohumeral joint instability often observed in patients with SLAP lesions. Rhythmic stabilizations may also be performed with manual resistance external rotation exercises by incorporating the alternating isometric contractions within sets of external rotation. (Figure 5) Other exercises designed to promote proprioception, dynamic stability, and neuromuscular control include joint repositioning exercises and proprioceptive neuromuscular facilitation (PNF) drills.

ER/IR exercise tubing is initiated week 3-4 and progressed to include lateral raises, full can, prone rowing, and prone horizontal abduction by week 6. As the patient progresses, a full isotonic exercise program, such as the Thrower's Ten program[58,68-71] is initiated by week 7-8. Emphasis is placed on strengthening exercises for the external rotators and scapular stabi-

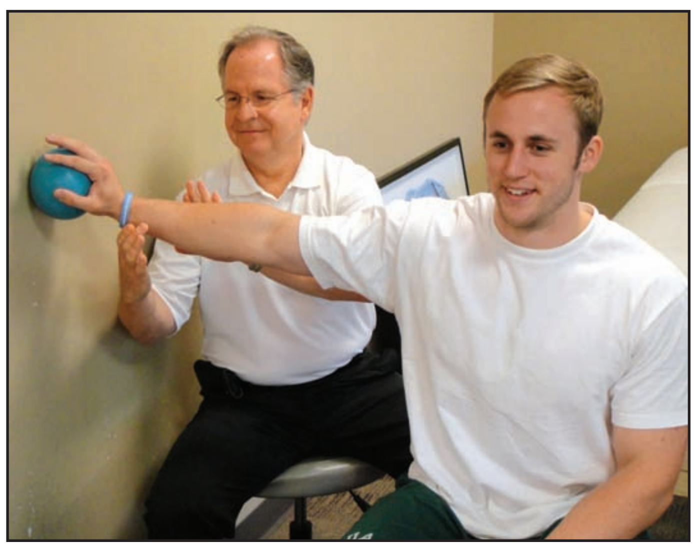

Figure 5. *Rhythmic stabilizations performed on a wall in the scapular plane with the hand placed on an unstable surface and the athlete seated on a ball.*

Figure 6. *Perturbation and rhythmic stabilization drills incorporated into external rotation at 0° abduction with exercise tubing.*

lizers, such as sidelying external rotation, prone rowing, and prone horizontal abduction.[70,71] No resisted biceps activity (including both elbow flexion and forearm supination) is allowed for the first 8 weeks in order to protect healing of the biceps anchor. Neuromuscular control drills are integrated as tolerated to enhance dynamic stability of the shoulder. These include rhythmic stabilization and perturbation drills incorporated into manual resistance and exercise tubing exercises. (Figure 6)

Aggressive strengthening of the biceps is avoided for 12 weeks following surgery. Furthermore, weight-bearing exercises are typically not performed for at least 8 weeks to avoid compression and shearing forces on the healing labrum. The Advanced Thrower's Ten program is initiated to progress rotator cuff and periscapular strengthening.[67] This program is intended to enhance co-contraction, dynamic stabilization and improve endurance by utilizing sustained holds and alternating reps for both the involved and uninvolved sides. In Figure 7 and Figure 8, the athlete is performing prone horizontal and seated full can on the involved side (right side) while the uninvolved side is maintaining a sustained hold. The authors believe this attempts to recruit core musculature while working on endurance of both extremities. For further information, please refer to the published manuscript.[67] Core stabilization drills are

Figure 7. *Prone horizontal abduction performed under the guidelines of the Advanced Thrower's Ten program.*

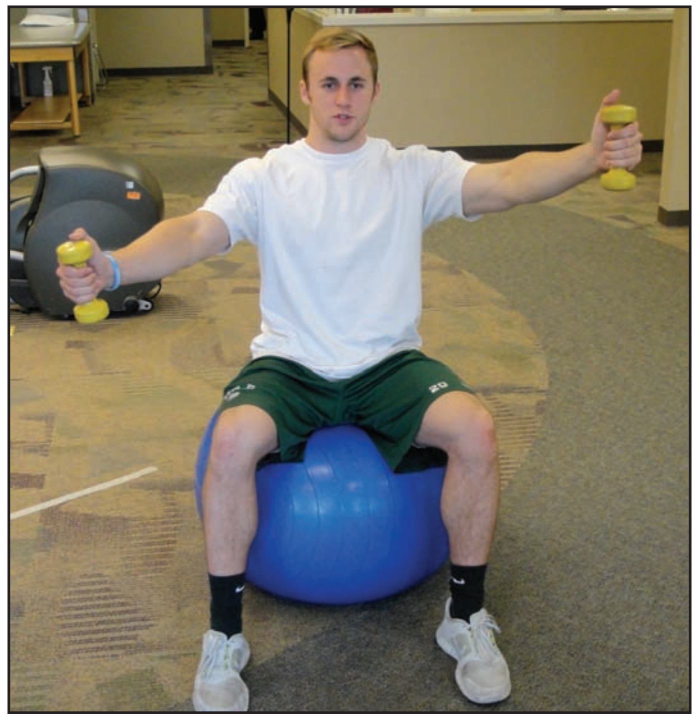

Figure 8. *Seated on a ball and performing the full can exercise with a sustained hold on the left side as part of the Advanced Thrower's Ten program.*

progressed to include ball flips in the modified-side plank position (Figure 9) and in the prone position on a ball (Figure 10). Both are utilized to improve posterior rotator cuff strength while challenging the core musculature. Two-handed plyometrics, as well as more advanced strengthening activities are allowed between 10-12 weeks, progressing to the initiation of an interval sport program at post-operative week 16. The same criteria described previously are utilized to determine if it is appropriate for an interval sport program to be initiated. Return to play following the surgical repair of a type II SLAP lesion

Figure 9. *Modified left sided plank on a ball while performing ER ball flips.*

Figure 10. *Prone ball flips performed on a ball to challenge the posterior musculature while challenging the core.*

typically occurs at approximately 9 to 12 months following surgery.[23,55,72-77]

Often a type II SLAP repair may be performed with a concomitant glenohumeral stabilization procedure such as arthroscopic plication, capsular shift or Bankart repair. In these instances, the rehabilitation program must be a combined approach that considers the healing constraints inherent to both procedures.

Repair of Type IV SLAP Lesion

The surgical repair of a type IV SLAP lesion with either a biceps repair, biceps resection of frayed area, or tenodesis/tenotomy follows much the same postoperative rehabilitation course as that outlined for a type II lesion, in that the ROM and exercise activities are progressed similarly. However there are substantial differences related to controlling both active and resistive biceps activity based on the extent of bicipital involvement. In cases where the biceps is resected, biceps muscular contractions may begin between 6 and 8 weeks post surgery. Conversely, in the cases of repaired biceps tears or biceps tenodesis/tenotomy, the authors recommend no resisted or active biceps for a full 2 months following surgery after which the soft tissue is most likely healed. Light isotonic strengthening for elbow flexion is initiated at 8 weeks postoperatively and progresses gradually as tolerated from that point. Progression to sport specific activities, such as plyometrics and interval sport programs, follows similar guidelines to those outlined for type II SLAP repairs.

SUMMARY

A wide variety of pathology may affect the superior aspect of the labrum. Clinical examination is often difficult due to the numerous injury mechanisms and the widely varied extent of labral pathology. Proper identification of the exact mechanism and specific severity of pathology is vital to accurately diagnose and manage these injuries. Surgical procedures to address SLAP lesions vary from minimal debridement to extensive labral repair. The authors suggest postoperative rehabilitation based on the specific injury and surgical procedure performed, as well as an understanding of basic science related to injury and tissue healing. Rehabilitation places emphasis on gradually restoring ROM, strength, and dynamic stability of the glenohumeral joint while controlling forces on the healing labrum. The aim is for the patient to return to full functional activities as quickly and safely as possible. Because no outcome data exist, research regarding the efficacy of the rehabilitation guidelines that are provided in this clinical commentary is warranted.

REFERENCES

1. Andrews JR, Carson WG, Jr., McLeod WD. Glenoid labrum tears related to the long head of the biceps. *Am J Sports Med*. 1985;13(5):337-41.

2. Snyder SJ, Karzel RP, Del Pizzo W, Ferkel RD, Friedman MJ. SLAP lesions of the shoulder. *Arthroscopy*. 1990;6(4):274-9.
3. Gartsman GM, Hammerman SM. Superior labrum, anterior and posterior lesions. When and how to treat them. *Clin Sports Med*. 2000;19(1):115-24.
4. Maffet MW, Gartsman GM, Moseley B. Superior labrum-biceps tendon complex lesions of the shoulder. *Am J Sports Med*. 1995;23(1):93-8.
5. Morgan CD, Burkhart SS, Palmeri M, Gillespie M. Type II SLAP lesions: three subtypes and their relationships to superior instability and rotator cuff tears. *Arthroscopy*. 1998;14(6):553-65.
6. Field LD, Savoie FH, 3rd. Arthroscopic suture repair of superior labral detachment lesions of the shoulder. *Am J Sports Med*. 1993;21(6):783-90; discussion 90.
7. Pagnani MJ, Speer KP, Altchek DW, Warren RF, Dines DM. Arthroscopic fixation of superior labral lesions using a biodegradable implant: a preliminary report. *Arthroscopy*. 1995;11(2):194-8.
8. Resch H, Golser K, Thoeni H, Sperner G. Arthroscopic repair of superior glenoid labral detachment (the SLAP lesion). *J Shoulder Elbow Surg*. 1993;2(3):147-55.
9. Stetson WB, Templin K. The crank test, the O'Brien test, and routine magnetic resonance imaging scans in the diagnosis of labral tears. *Am J Sports Med*. 2002;30(6):806-9.
10. Yoneda M, Hirooka A, Saito S, Yamamoto T, Ochi T, Shino K. Arthroscopic stapling for detached superior glenoid labrum. *J Bone Joint Surg Br*. 1991;73(5):746-50.
11. Cooper DE, Arnoczky SP, O'Brien SJ, Warren RF, DiCarlo E, Allen AA. Anatomy, histology, and vascularity of the glenoid labrum. An anatomical study. *J Bone Joint Surg Am*. 1992;74(1):46-52.
12. Moseley HF, Overgaard B. The anterior capsule mechanism in recurrent anterior dislocation of the shoulder: Morphological and clinical studies with special reference to the glenoid labrum and glenohumeral ligaments. *J Bone Joint Surg*. 1962;443(4):913-27.
13. Huber WP, Putz RV. Periarticular fiber system of the shoulder joint. *Arthroscopy*. 1997;13(6):680-91.
14. Vangsness CT, Jr., Jorgenson SS, Watson T, Johnson DL. The origin of the long head of the biceps from the scapula and glenoid labrum. An anatomical study of 100 shoulders. *J Bone Joint Surg Br*. 1994;76(6):951-4.
15. Guanche CA, Quick DC. Prospective correlation of clinical examination with artyhroscopy in the diagnosis of glenoid labral tears [abstract]. *Arthroscopy*. 2000;16:432-3.
16. Pagnani MJ, Deng XH, Warren RF, Torzilli PA, Altchek DW. Effect of lesions of the superior portion of the glenoid labrum on glenohumeral translation. *J Bone Joint Surg Am*. 1995;77(7):1003-10.
17. Wilk KE, Arrigo C. Current concepts in the rehabilitation of the athletic shoulder. *J Orthop Sports Phys Ther*. 1993;18(1):365-78.
18. Mileski RA, Snyder SJ. Superior labral lesions in the shoulder: pathoanatomy and surgical management. *J Am Acad Orthop Surg*. 1998;6(2):121-31.
19. Wilk KE, Arrigo CA, Andrews JR. Current concepts: the stabilizing structures of the glenohumeral joint. *J Orthop Sports Phys Ther*. 1997;25(6):364-79.
20. Shepard MF, Dugas JR, Zeng N, Andrews JR. Differences in the ultimate strength of the biceps anchor and the generation of type II superior labral anterior posterior lesions in a cadaveric model. *Am J Sports Med*. 2004;32(5):1197-201.
21. Wilk KE, Andrews JR, Arrigo CA. The physical examination of the glenohumeral joint: emphasis on the stabilizing structures. *J Orthop Sports Phys Ther*. 1997;25(6):380-9.
22. Rodosky MW, Harner CD, Fu FH. The role of the long head of the biceps muscle and superior glenoid labrum in anterior stability of the shoulder. *Am J Sports Med*. 1994;22(1):121-30.
23. Wilk KE, Reinold MM, Dugas JR, Arrigo CA, Moser MW, Andrews JR. Current concepts in the recognition and treatment of superior labral (SLAP) lesions. *J Orthop Sports Phys Ther*. 2005;35(5):273-91.
24. Perry J. Normal upper extremity kinesiology. Phys Ther. 1978 Mar;58(3):265-78.
25. Depalma AF, Callery G, Bennet G. Variational anatomy and degenerative lesions of the shoulder joint. In: Blount W, Banks S, editors. *AAOS Instructional Course Lectures*. Ann Arbor, MI: JW Edwards; 1949.
26. Williams MM, Snyder SJ, Buford D, Jr. The Buford complex--the "cord-like" middle glenohumeral ligament and absent anterosuperior labrum complex: a normal anatomic capsulolabral variant. *Arthroscopy*. 1994;10(3):241-7.
27. Burkhart SS, Morgan CD. The peel-back mechanism: its role in producing and extending posterior type II SLAP lesions and its effect on SLAP repair rehabilitation. *Arthroscopy*. 1998;14(6):637-40.
28. Andrews JR, Broussard TS, Carson WG. Arthroscopy of the shoulder in the management of partial tears of the rotator cuff: a preliminary report. *Arthroscopy*. 1985;1(2):117-22.

29. Pradhan RL, Itoi E, Hatakeyama Y, Urayama M, Sato K. Superior labral strain during the throwing motion. A cadaveric study. *Am J Sports Med*. 2001;29(4):488-92.
30. Jobe CM. Posterior superior glenoid impingement: expanded spectrum. *Arthroscopy*. 1995;11(5):530-6.
31. Walch G, Boileau P, Noel E, Donell T. Impingement of the deep surface of the infraspinatus tendon on the posterior glenoid rim. An arthroscopic study. *J Shoulder Elbow Surg*. 1992;1:238-45.
32. Davies MR, Dugas JR, Fleisig GS, Shepard MF, Andrews JR. The strength of the repaired Type II SLAP lesion in a cadaveric model. American Sports Medicine Institute; 2004.
33. Kim SH, Ha KI, Ahn JH, Kim SH, Choi HJ. Biceps load test II: A clinical test for SLAP lesions of the shoulder. *Arthroscopy*. 2001;17(2):160-4.
34. Reinold MM, Wilk KE, Hooks TR, Dugas JR, Andrews JR. Thermal-assisted capsular shrinkage of the glenohumeral joint in overhead athletes: a 15- to 47-month follow-up. *J Orthop Sports Phys Ther*. 2003;33(8):455-67.
35. Wilk KE, Reinold MM, Dugas JR, Andrews JR. Rehabilitation following thermal-assisted capsular shrinkage of the glenohumeral joint: current concepts. *J Orthop Sports Phys Ther*. 2002;32(6):268-92.
36. Glousman R, Jobe F, Tibone J, Moynes D, Antonelli D, Perry J. Dynamic electromyographic analysis of the throwing shoulder with glenohumeral instability. *J Bone Joint Surg Am.* 1988;70(2):220-6.
37. Handelberg F, Willems S, Shahabpour M, Huskin JP, Kuta J. SLAP lesions: a retrospective multicenter study. *Arthroscopy*. 1998;14(8):856-62.
38. Kim TK, Queale WS, Cosgarea AJ, McFarland EG. Clinical features of the different types of SLAP lesions: an analysis of one hundred and thirty-nine cases. *J Bone Joint Surg Am*. 2003;85-A(1):66-71.
39. Snyder SJ, Banas MP, Karzel RP. An analysis of 140 injuries to the superior glenoid labrum. *J Shoulder Elbow Surg*. 1995;4(4):243-8.
40. Warner JJ, Kann S, Marks P. Arthroscopic repair of combined Bankart and superior labral detachment anterior and posterior lesions: technique and preliminary results. *Arthroscopy*. 1994;10(4):383-91.
41. Powell SE, Nord KD, Ryu RKN. The diagnosis, classification, and treatment of SLAP lesions. *Oper Tech Sports Med*. 2004;12:99-110.
42. Andrews JR, Carson WR. The arthroscopic tratment of glenoid labrum tears in the throwing athlete. *Orthop Trans*. 1984;8:44-9.
43. Kim SH, Ha KI, Han KY. Biceps load test: a clinical test for superior labrum anterior and posterior lesions in shoulders with recurrent anterior dislocations. *Am J Sports Med*. 1999;27(3):300-3.
44. Mimori K, Muneta T, Nakagawa T, Shinomiya K. A new pain provocation test for superior labral tears of the shoulder. *Am J Sports Med*. 1999;27(2):137-42.
45. Myers TH, Zemanovic JR, Andrews JR. The resisted supination external rotation test: a new test for the diagnosis of superior labral anterior posterior lesions. *Am J Sports Med.* 2005;33(9):1315-20.
46. O'Brien SJ, Pagnani MJ, Fealy S, McGlynn SR, Wilson JB. The active compression test: a new and effective test for diagnosing labral tears and acromioclavicular joint abnormality. *Am J Sports Med*. 1998;26(5):610-3.
47. McFarland EG, Kim TK, Savino RM. Clinical assessment of three common tests for superior labral anterior-posterior lesions. *Am J Sports Med*. 2002;30(6):810-5.
48. Green MR, Christensen KP. Magnetic resonance imaging of the glenoid labrum in anterior shoulder instability. *Am J Sports Med*. 1994;22(4):493-8.
49. Liu SH, Henry MH, Nuccion SL. A prospective evaluation of a new physical examination in predicting glenoid labral tears. *Am J Sports Med*. 1996;24(6):721-5.
50. Bencardino JT, Beltran J, Rosenberg ZS, Rokito A, Schmahmann S, Mota J, et al. Superior labrum anterior-posterior lesions: diagnosis with MR arthrography of the shoulder. *Radiology*. 2000;214(1):267-71.
51. Nam EK, Snyder SJ. The diagnosis and treatment of superior labrum, anterior and posterior (SLAP) lesions. *Am J Sports Med*. 2003;31(5):798-810.
52. Edwards SL, Lee JA, Bell JE, Packer JD, Ahmad CS, Levine WN, et al. Nonoperative treatment of superior labrum anterior posterior tears: improvements in pain, function, and quality of life. *Am J Sports Med*. 2010;38(7):1456-61.
53. Altchek DW, Warren RF, Wickiewicz TL, Ortiz G. Arthroscopic labral debridement. A three-year follow-up study. *Am J Sports Med*. 1992;20(6):702-6.
54. Wilk KE, Macrina LC, Yenchak AJ, Cain EL, Andrews JR. Surgical repair and rehabilitation of a combined 330 degrees capsulolabral lesion and partial-thickness rotator cuff tear in a professional quarterback: a case report. *J Orthop Sports Phys Ther.* 2013;43(3):142-53.
55. Neri BR, ElAttrache NS, Owsley KC, Mohr K, Yocum LA. Outcome of type II superior labral anterior posterior repairs in elite overhead athletes: Effect of

concomitant partial-thickness rotator cuff tears. *Am J Sports Med*. 2011;39(1):114-20.

56. Neri BR, Vollmer EA, Kvitne RS. Isolated type II superior labral anterior posterior lesions: age-related outcome of arthroscopic fixation. *Am J Sports Med*. 2009;37(5):937-42.
57. Brockmeier SF, Voos JE, Williams RJ, 3rd, Altchek DW, Cordasco FA, Allen AA. Outcomes after arthroscopic repair of type-II SLAP lesions. *J Bone Joint Surg Am*. 2009;91(7):1595-603.
58. Reinold MM, Macrina LC, Wilk KE, Fleisig GS, Dun S, Barrentine SW, et al. Electromyographic analysis of the supraspinatus and deltoid muscles during 3 common rehabilitation exercises. *J Athl Train*. 2007;42(4):464-9.
59. Reinold MM, Wilk KE, Reed J, Crenshaw K, Andrews JR. Interval sport programs: guidelines for baseball, tennis, and golf. *J Orthop Sports Phys Ther*. 2002;32(6):293-8.
60. Wilk KE, Andrews JR, Arrigo CA. The abductor and adductor strength characteristics of professional baseball pitchers. *Am J Sports Med*. 1995;23(6):778.
61. Wilk KE, Andrews JR, Arrigo CA, Keirns MA, Erber DJ. The strength characteristics of internal and external rotator muscles in professional baseball pitchers. *Am J Sports Med.* 1993;21(1):61-6.
62. Wilk KE, Obma P, Simpson CD, Cain EL, Dugas JR, Andrews JR. Shoulder injuries in the overhead athlete. *J Orthop Sports Phys Ther*. 2009;39(2):38-54.
63. Wilk KE, Reinold MM, Andrews JR. Postoperative treatment principles in the throwing athlete. *Sports Med Arthrosc Rev.* 2001;9(1):69-95.
64. Andrews JR, Casey PJ. Internal Impingement. In: Krishnan SG, Hawkins RJ, Warren RF, editors. *The Shoulder and the Overhead Athlete*. Philadelphia: Lippincott, Williams and Wilkins; 2004. p. 125-34.
65. Wilk KE, Arrigo CA, Andrews JR. *Functional Training for the Overhead Athlete.* Sports Physical therapy Home Study Course. LaCrosse, WI; 1995.
66. Wilk KE, Meister K, Andrews JR. Current concepts in the rehabilitation of the overhead throwing athlete. *Am J Sports Med*. 2002;30(1):136-51.
67. Wilk KE, Yenchak AJ, Arrigo CA, Andrews JR. The advanced throwers ten exercise program: a new exercise series for enhanced dynamic shoulder control in the overhead throwing athlete. *The Physician and Sportsmedicine*. 2011;39(4):90-7.
68. Wilk KE, Andrews JR, Arrigo C. *Preventitive and Rehabilitative Exercises for the Shoulder and Elbow.* 6th ed. Birmingham, AL; 2001.
69. Wilk K. The Shoulder. In: Malone T MT, Nitz A, editor. *Orthopedic and Sports Physical Therapy*. 3rd ed. St Loius: Mosby; 1997. p. 401-58.
70. Reinold MM, Wilk KE, Fleisig GS, Zheng N, Barrentine SW, Chmielewski T, et al. Electromyographic analysis of the rotator cuff and deltoid musculature during common shoulder external rotation exercises. *J Orthop Sports Phys Ther*. 2004;34(7):385-94.
71. Reinold MM, Escamilla RF, Wilk KE. Current concepts in the scientific and clinical rationale behind exercises for glenohumeral and scapulothoracic musculature. *J Orthop Sports Phys Ther*. 2009;39(2):105-17.
72. Voos JE, Pearle AD, Mattern CJ, Cordasco FA, Allen AA, Warren RF. Outcomes of combined arthroscopic rotator cuff and labral repair. *Am J Sports Med*. 2007;35(7):1174-9.
73. Snyder SJ, Karzel RP, Pizzo WD, Ferkel RD, Friedman MJ. Arthroscopy classics. SLAP lesions of the shoulder. *Arthroscopy*. 2010;26(8):1117.
74. Savoie FH, 3rd, Holt MS, Field LD, Ramsey JR. Arthroscopic management of posterior instability: evolution of technique and results. *Arthroscopy*. 2008;24(4):389-96.
75. Lim MH, Chan BK, Low CO. Arthroscopic management of superior labral anterior and posterior (SLAP) and associated lesions: Clinical features and functional outcome. *Annals of the Academy of Medicine, Singapore*. 2008;37(1):44-8.
76. Gorantla K, Gill C, Wright RW. The outcome of type II SLAP repair: a systematic review. *Arthroscopy*. 2010;26(4):537-45.
77. Bedi A, Allen AA. Superior labral lesions anterior to posterior-evaluation and arthroscopic management. *Clin Sports Med*. 2008;27(4):607-30.