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Diagnosis and Management of Superior Labral Anterior Posterior Tears in Throwing Athletes

Michael Knesek,* MD, Jack G. Skendzel,* MD, Joshua S. Dines,†‡ MD, David W. Altchek,† MD, Answorth A. Allen,† MD, and Asheesh Bedi,*§ MD

Investigation performed at the Department of Orthopaedic Surgery, University of Michigan, Ann Arbor, Michigan

Injury to the superior glenoid labrum is increasingly recognized as a significant source of shoulder pain and dysfunction in the throwing athlete. Several theories have been proposed to explain the pathogenesis of superior labral anterior posterior (SLAP) tears. The clinical examination of the superior labrum–biceps tendon complex remains challenging because of a high association of other shoulder injuries in overhead athletes. Many physical examination findings have high sensitivity and low specificity. Advances in soft tissue imaging such as magnetic resonance arthrography allow for improved detection of labrum and biceps tendon lesions, although correlation with history and physical examination is critical to identify symptomatic lesions. Proper treatment of throwers with SLAP tears requires a thorough understanding of the altered biomechanics and the indications for nonoperative management and arthroscopic treatment of these lesions.

Keywords: glenoid labrum; superior labral anterior posterior (SLAP) tears; shoulder; throwing athletes; arthroscopy

With the increasing physical demands and training requirements for athletes involved in repetitive overhead activities, injuries to the glenoid labrum represent a significant cause of shoulder pain and dysfunction. In addition, the number of arthroscopic superior labral anterior posterior (SLAP) repairs performed in the United States continues to increase each year.[97] Andrews et al[4] provided the first description of anterosuperior labral tears near the biceps origin in a series of 73 throwing athletes with painful shoulders who underwent diagnostic shoulder arthroscopic surgery. It was not until Snyder and colleagues[81] reviewed a larger series of 700 shoulder arthroscopic procedures that the term "SLAP" was coined in the literature. Although the true incidence of SLAP lesions is unknown, several authors have reported rates over a range of 6% (in Snyder et al's[81] original series) to 26% in the general population undergoing shoulder arthroscopic surgery.[44,56,58,80] These SLAP lesions occur either in isolation or in association with a broad spectrum of other shoulder injuries, including rotator cuff tears, glenohumeral instability, and isolated biceps tendon ruptures.[41,58] Superior labral tears are commonly found in throwing athletes because of the high stresses of repetitive overhead throwing and subsequent alterations in normal shoulder kinematics. Several theories have been proposed to explain the pathogenesis of SLAP tears.[4,16,28] Detection of SLAP lesions has improved through advances in diagnostic imaging, including the widespread use of magnetic resonance imaging (MRI). Despite these improvements, diagnosis of the throwing athlete's shoulder remains a challenge because of physical examination tests that are nonspecific and an often variable and inconclusive patient history. This article reviews the relevant anatomy, shoulder biomechanics, classification system, and diagnostic evaluation of SLAP tears. In addition, nonoperative treatment strategies and surgical techniques, including labral debridement, labral repair, and biceps tenodesis/tenotomy are presented.

ANATOMY

The glenoid labrum consists of fibrocartilage tissue that surrounds the glenohumeral joint.[26,71] The glenoid labrum improves glenohumeral joint stability through limitation of humeral head translation, enhancement of the concavity-compression mechanism, the stabilizing effect of the long head of the biceps complex, and an increase in the depth of the glenoid fossa.[2,26,87,88,91] This structure is distinct from the hyaline articular cartilage and fibrous tissue of the joint capsule.[71] The superior portion of the labrum

§Address correspondence to Asheesh Bedi, MD, MedSport, University of Michigan, 24 Frank Lloyd Wright Drive, Lobby A, Ann Arbor, MI 48106 (e-mail: abedi@umich.edu).

*Sports Medicine and Shoulder Surgery, Department of Orthopaedic Surgery, University of Michigan, Ann Arbor, Michigan.

†Sports Medicine and Shoulder Service, Hospital for Special Surgery, New York, New York.

‡Shoulder Surgery Service, Long Island Jewish Medical Center, New Hyde Park, New York.

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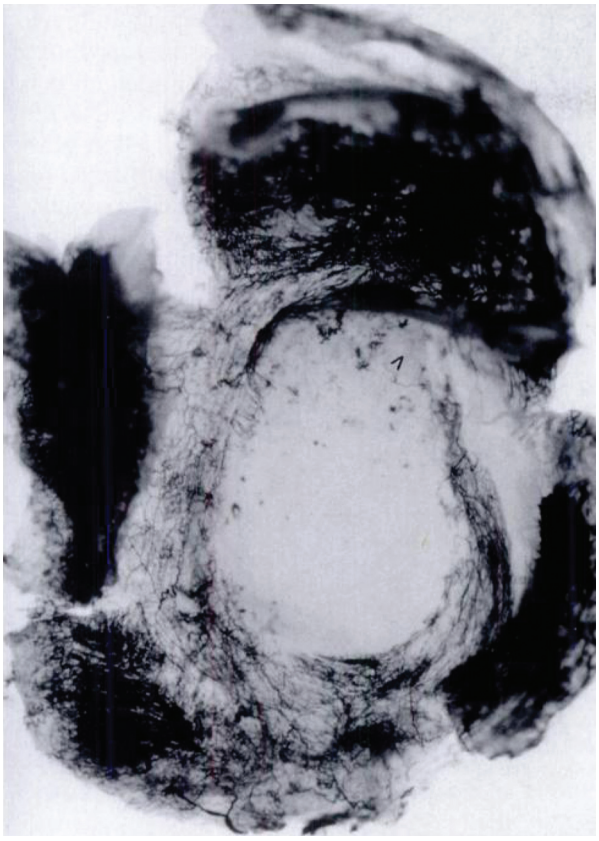


Figure 1. Sagittal view of the glenoid after disarticulation demonstrates the vascular architecture stained with India ink. There is a relative paucity of blood supply in the anterosuperior portion of the labrum (arrow). From Cooper et al.[26] ©1992 *The Journal of Bone and Jount Surgery*. Reprinted with permission.

inserts directly into the biceps tendon distal to its insertion on the supraglenoid tubercle. The hyaline articular cartilage and labral tissue are linked by a fibrocartilaginous transition zone.[26] At the 12-o'clock position, the labrum extends over the glenoid rim because of the more medial location of the supraglenoid tubercle, forming a synovial reflection and small recess. In some people, the anterosuperior labrum may insert into the fibers of the middle glenohumeral ligament rather than the glenoid margin. While the superior labrum is more meniscal in nature and more mobile, the inferior labrum is firmly attached to and continuous with the articular cartilage. The labral vascular supply originates from several vessels, including the suprascapular, circumflex scapular, and posterior humeral circumflex arteries.[26] Similar to the knee meniscus, the vascular penetration of the labrum is limited to the peripheral margin (Figure 1).[26] Some authors have suggested that the limited vascularity in the anterosuperior region of the glenoid rim may render the superior labrum vulnerable to injury and impaired healing.[26]

There is considerable anatomic variability of the superior labrum and long head of the biceps tendon. As reported by Rao and colleagues,[72] there are 3 predominant labral variations that occur in over 10% of people. One such anatomic variation is the sublabral recess, which represents a potential space located under the biceps anchor and the anterosuperior portion of the labrum. It is often identified at the 12-o'clock position of the glenoid during arthroscopic surgery. Similarly, another described variant is the sublabral foramen, which is a groove between the normal anterosuperior labrum and the anterior cartilaginous border of the glenoid rim.[51] Lastly, the presence of a thick, cord-like middle glenohumeral ligament and the absence of anterosuperior labral tissue are termed the "Buford complex."[93] Kanatli and colleagues[51] retrospectively examined 713 patients who underwent shoulder arthroscopic surgery and identified 17 sublabral recesses (2.46%), 53 sublabral foramens (7.67%), and 23 Buford complexes (4.05%) (Figure 2). The variable relationship of the biceps tendon to the labrum must also be recognized during diagnosis and treatment of superior labral lesions. Vangsness and colleagues[82] studied 105 cadaveric shoulders to elucidate the origin of the long head of the biceps tendon and its relationship to the superior labrum and supraglenoid tubercle. In all shoulders, 40% to 60% of the biceps tendons took origin from the supraglenoid tubercle with the remaining fibers attached to the superior labral complex. In more than half of the specimens, the major labral origin of the tendon was from its posterosuperior portion. It is critical to recognize these anatomic variants and distinguish them from a pathological labral lesion, as errant repair can result in significant pain and stiffness and a poor clinical outcome.

Kim and colleagues[56] prospectively documented associated pathological findings and clinical features of different types of SLAP tears. In their series of 544 patients who underwent shoulder arthroscopic surgery for various diagnoses, including rotator cuff disease, glenohumeral instability, acromioclavicular joint arthritis, and adhesive capsulitis, 26% (139 of 544) had evidence of a SLAP tear. Both Kanatli et al[51] and Kim et al[56] demonstrated a significant correlation between the presence of a SLAP tear and patient activity level as well as predictable patterns of injury. Sports activity was the most common cause of all SLAP lesions, and type II lesions were most commonly observed in overhead athletes. These authors demonstrated an association between the presence of a sublabral foramen and the Buford complex with type II SLAP lesions, supporting a strong relationship between anatomic labral variations and the subsequent development of SLAP lesions.

CLASSIFICATION

Snyder et al[81] developed a system of classification of SLAP tears into 4 distinct types (Figure 3). Type I lesions are characterized by fraying and degeneration of the free edge of the superior labrum with a normal biceps anchor; 11% of patients from Snyder et al's[81] original series were type I. Type I lesions are infrequently associated with clinical symptoms without concomitant pathological abnormalities.[66] Type II lesions demonstrate an element of

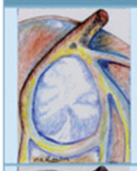
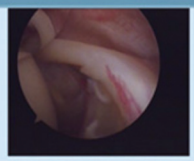
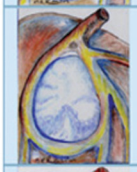
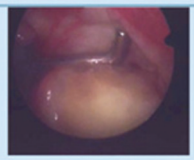
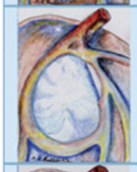
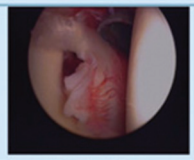
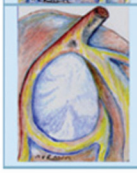
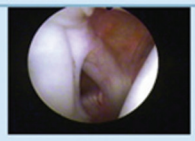
Illustration	Labrum anatomy	Description	Prevalence	Arthroscopic view
	**Normal**	Intact labrum attached to anterosuperior glenoid rim	593 patients 85.82%	
	**Superior sublabral recess**	Sulcus located under the bicipitolabral junction	17 patients 2.46%	
	**Sublabral foramen**	Orifice between anterosuperior labrum and the anterior glenoid	53 patients 7.67%	
	**Buford complex**	Absent labrum + thick, cord-like MGHL	28 patients 4.05%	

Figure 2. Classification of 3 common anterosuperior anatomic labral variations with corresponding arthroscopic view. MGHL, middle glenohumeral ligament. From Kanatli et al.[51] ©2010 Elsevier. Reprinted with permission.

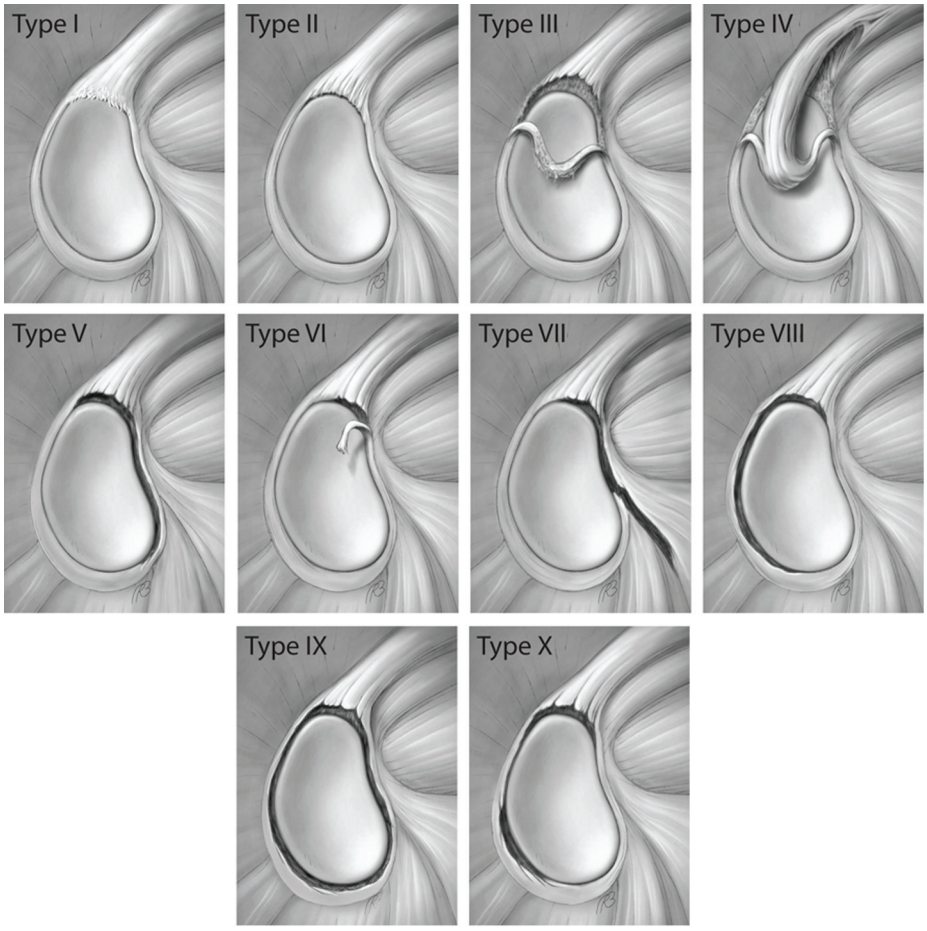


Figure 3. Illustration of SLAP types including modifications. Type I shows superior labral fraying and degeneration. Type II shows a detached superior labrum and biceps anchor from the superior glenoid. Type III involves a bucket-handle tear of the superior labrum but an intact biceps anchor. Type IV lesions have a type III bucket-handle tear that extends into the biceps tendon root. Type V lesions include anteroinferior Bankart disruption in continuity with type II. Type VI is a type II lesion with an unstable labral flap. Type VII involves extension of a type II tear through the capsule beneath the middle glenohumeral ligament. Type VIII is a type II variant with extensions into the posterior labrum. Type IX lesions are type II tears with circumferential labral involvement. Type X tears are type II with posteroinferior labral disruption. Modified from Powell et al.[70] ©2004 Elsevier. Reprinted with permission.

TABLE 1
Modifications to Original SLAP Classification by Snyder et al[81]

Tear Type	Tear Pattern
Type II	
Posterior[65]	Predominant anterior detachment of the superior labrum–biceps tendon anchor
Anterior[65]	Predominant posterior detachment of the superior labrum–biceps tendon anchor
Combined anterior and posterior[65]	Combined anterior and posterior detachment of the superior labrum–biceps tendon anchor
Type V[58]	Bankart lesion that extends to the superior labrum and biceps anchor
Type VI[58]	Unstable labral flap with biceps tendon separation
Type VII[58]	Separation of the biceps tendon–labral complex that extends to the middle glenohumeral ligament
Type VIII[70]	Type II tear with a posterior labral extension to the 6-o'clock position
Type IX[70]	More severe labral tears with circumferential involvement

degenerative labral fraying similar to type I lesions; however, the significant finding is a biceps anchor detached from the superior glenoid tubercle, frequently with displacement of the biceps–superior labrum complex into the glenohumeral joint. Type II lesions are the most common subtype, involving 41% of those shoulders identified in Snyder et al's[81] original series. Type III lesions involve a bucket-handle tear of a meniscoid superior labrum with an intact biceps tendon root. Just as a bucket-handle meniscus fragment located in the knee can subluxate into the joint, so can a displaced labral tear cause shoulder pain and mechanical symptoms. Type IV lesions involve a bucket-handle tear similar to type III tears with extension of the tear into the biceps tendon root. The amount of biceps tendon involvement is variable and affects surgical management. Commonly, complex SLAP lesions present with combined injuries that involve type III or IV lesions in association with a detached biceps anchor (type II lesion).[66]

Several modifications have been made to the original classification scheme (Table 1).[21,58,65,70] Maffet et al[58] reviewed a cohort of patients who underwent shoulder surgery, noting that only 62% had lesions that fit within the classification described by Snyder et al.[81] As a result, the authors expanded the original schema to include the following: type V lesions with an anteroinferior capsulolabral injury (Bankart lesion) that extends to the biceps anchor and superior labrum; type VI lesions with an unstable labral flap and biceps tendon separation; and type VII lesions with a separation of the biceps tendon–superior labrum complex that extends anteriorly to the middle glenohumeral ligament. Morgan and colleagues[65] further expanded type II lesions based on observations in overhead athletes with 3 commonly encountered injury patterns: anterior, posterior, and a combined anterior and posterior lesion. Powell and colleagues[70] also added 3 types of SLAP lesions to the classification. Type VIII lesions represent a type II tear with extension posteriorly along the labrum as far as 6 o'clock, type IX lesions are more severe tears with circumferential labrum involvement, and type X lesions involve a superior labral tear combined with a posteroinferior labral tear (reverse Bankart lesion).

Several studies have attempted to quantify the agreement between observers when using the Snyder criteria to diagnose superior labral tears. Jia and colleagues[46] evaluated the intraobserver and interobserver reliability of the Snyder classification between experienced fellowship-trained shoulder surgeons who performed, on average, more than 305 shoulder arthroscopic procedures per year. The authors expanded on the previous study by Gobezie et al[40] to include the descriptions of type II lesions as described by Morgan and colleagues,[65] in addition to providing a simplified classification of a normal versus abnormal labrum and evaluating the effect of videotape quality on the diagnosis and confidence of the evaluator making the diagnosis. The authors showed substantial interobserver agreement ($\kappa = .804$) and intraobserver agreement ($\kappa = .670$). Further simplification into normal or abnormal labrums resulted in an increase in the intraobserver reliability and absolute agreement, but there was not an associated improvement in the interobserver reliability. Additions to the modified classification system by Morgan and colleagues[65] did not affect the average correlation coefficient, and the quality of the videotapes significantly correlated with the examiner's ability to confidently make the diagnosis. While the authors cite the limitations of this study, including the lack of footage showing the labrum "peeling off," the inability to physically probe the labrum, and the lack of strict definitions of the types of SLAP lesions, their results demonstrate substantial agreement in the classification of labral tears as described by Snyder et al.[81] In addition, the modifications introduced by Morgan and colleagues[65] can be reliably used by experienced surgeons.

Wolf and colleagues[94] sought to investigate the influence of clinical variables such as the patient's age, sex, job activity, participation in sports, and history and physical examination findings on the classification and treatment of superior labral lesions by surgeons in the Multicenter Orthopaedic Outcomes Network (MOON) shoulder group. The results showed that among those surgeons surveyed, the patient's job, sporting activity, age, and physical examination findings are the most important variables that may affect treatment decisions. Overall, these variables caused the surgeon to pick a different classification 28.5% of the time, and a different classification was chosen 71.5% of the time when a clinical vignette was provided. The authors concluded that clinical history, physical examination, and surgical findings can significantly affect the classification of SLAP tears in addition to selecting a treatment plan.

PATHOPHYSIOLOGY

Repetitive overhead throwing places the shoulder at the extremes of motion, such as hyperabduction and external rotation, which increase shear and compressive forces on the glenohumeral joint and strain on the rotator cuff and capsulolabral structures.[16] Throwing requires a complex series of coordinated motions to efficiently transfer large forces and high amounts of energy from the legs, back, and trunk through individual body segments to the arm and hand.[52] The movement of these individual segments is linked through muscle activity and body position to transfer kinetic energy from the base (usually the ground) to the terminal segment (usually the hand) and eventually to the ball.[52] This concept is termed the "kinetic chain." Alterations in kinetic chain function can lead to motions and forces that may injure the labrum and rotator cuff and stretch the shoulder capsule.[42] In addition, the athlete is often unable to throw at his or her preinjury velocity, the so-called dead arm syndrome, as a result of pain and altered shoulder mechanics.[19] Weakness of shoulder muscles, especially during the late cocking phase, may contribute to anterior glenohumeral instability and play a role in the development of SLAP tears.[39] Reinold et al[73] hypothesized that altered range of motion in baseball pitchers was the result of muscle damage from eccentric contractions during pitching, resulting in musculotendinous adaptations. Capsular laxity and weakness of dynamic stabilizers during throwing motions can lead to humeral head translation and secondary labral damage.[33,62] As described by Wilk and colleagues,[90] the thrower's shoulder must possess a delicate balance between sufficient laxity to allow for excessive external rotation yet sufficient stability to prevent glenohumeral joint subluxation. This is referred to as the "thrower's paradox."[90] Although numerous authors have described alterations in the kinetic chain that are associated with pathological changes in the labrum and rotator cuff, no single process is entirely responsible for the spectrum of damage observed in the throwing shoulder.

Overhead athletes commonly develop a shift in shoulder range of motion as a result of repetitive throwing. Most commonly, there is an increase in external rotation and a decrease in internal rotation at 90° of abduction in the throwing arm when compared with the nondominant side. Bigliani and colleagues[9] examined 72 professional pitchers and reported an average increase in external rotation of the dominant arm of 15.2° at 90° of abduction. Similarly, Brown and colleagues[14] analyzed 41 professional baseball pitchers with an average 9° increase in external rotation at 90° of abduction and an average 15° decrease in internal rotation comparing the dominant and nondominant arms, demonstrating the adaptive changes noted in the throwing shoulder. Similarly, Wilk et al[90] reported an average glenohumeral external rotation of 130° and an average internal rotation of 63° in 372 professional baseball players. This pattern of motion has been termed "glenohumeral internal rotation deficit," or GIRD.[16] This can be observed by careful examination of restricted internal rotation compared with the contralateral shoulder and is performed with the patient lying supine and the arm positioned at 90° of both shoulder abduction and elbow flexion. The examiner then stabilizes the scapula and measures both the amount of internal and external shoulder rotation with the use of a goniometer. While the cause of this phenomenon is not exactly known, most researchers suggest that either capsular changes or osseous changes, or both, are responsible.[16,17,27,48,65] Wilk and colleagues[89] recently examined 122 professional pitchers over 3 competitive seasons to determine whether GIRD and decreased internal rotation were associated with shoulder injuries. The authors showed that those pitchers with GIRD were nearly twice as likely to be injured, although the results did not reach statistical significance. While changes in the shoulder arc of motion are beneficial for elite throwing athletes to maximize hyper–external rotation in late cocking and to increase ball velocity at release, they may also predispose to disabling and pathological shoulder conditions such as injury to the labrum, long head of the biceps tendon, and rotator cuff.

Several potential mechanisms for the pathophysiology of superior labral tears in overhead athletes have been proposed.[4,15-18,43] Andrews et al[4] have speculated that a superior labral injury in throwing athletes is caused by a deceleration traction injury from the pull of the biceps tendon on the labrum during the follow-through phase, whereas Burkhart and colleagues[16] proposed that the primary cause of labral injuries is a contracture of the posterior shoulder capsule that results in a posterosuperior migration of the humeral head. The authors theorized that thickening and contracture of the posteroinferior capsule may be the result of large traction loads measuring approximately 750 N during the follow-through phase. While some force is resisted by eccentric contracture of the musculature, a large portion is transmitted through the capsule and leads to hypertrophy. This posterior contracture shifts the humeral head center of rotation to a more posterosuperior location, allowing for hyper–external rotation of the humerus (Figure 4). It also increases shear forces across the glenohumeral joint and creates internal impingement of the rotator cuff and labrum between the humeral head and posterosuperior glenoid.[16,28,48,84] Subtle anterior shoulder instability secondary to fatigue or ligamentous injury in the throwing athlete leads to anterior humeral translation in a position of abduction and external rotation. This mechanism subsequently leads to impingement of the articular side of the rotator cuff tendons and posterosuperior labrum between the humerus and glenoid rim, precipitating a SLAP lesion.[55,84] Grossman and colleagues[43] confirmed posterosuperior humeral head migration in a cadaveric study with simulated anterior capsular laxity and posterior capsular contraction.

Yet, another potential cause that has been described is the "peel-back" mechanism of a superior labral injury.[15] Translation of the humeral head to a more posterosuperior location causes the anterosuperior capsular structures to become lax as the cam effect is reduced. Torsional forces in the biceps and labrum increase as the arm moves into a position of abduction and hyper–external rotation, causing the biceps tendon to shift from a relatively horizontal position to a more vertical position with greater posterior

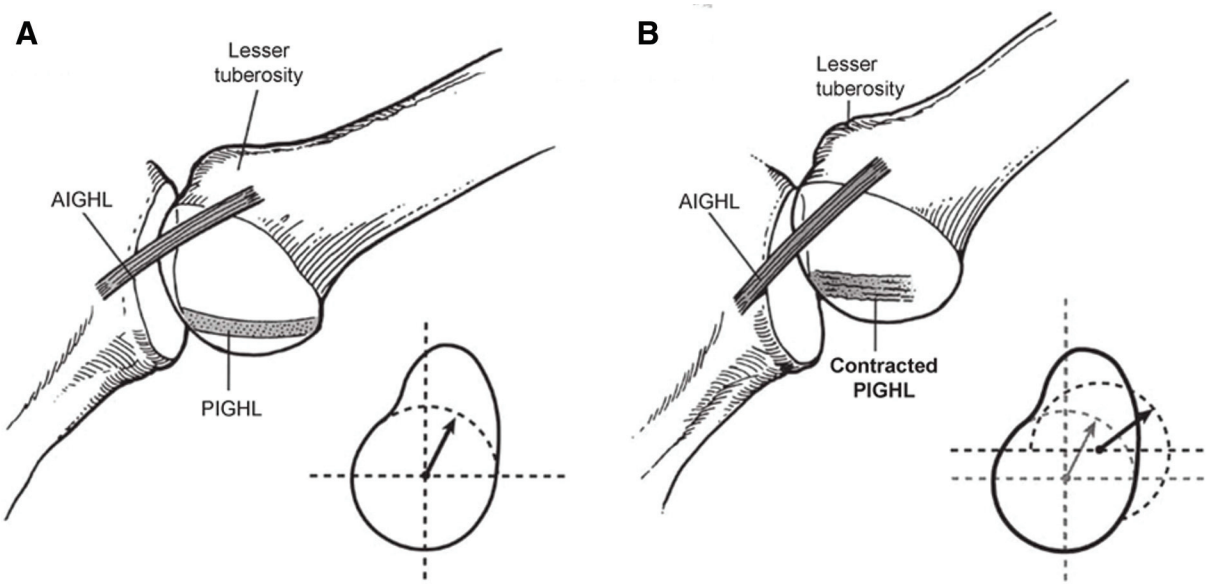


Figure 4. Burkhart and colleagues[16] proposed that a posterior capsular contracture was responsible for the pathological changes seen in a thrower's shoulder. (A) In the normal shoulder, the center of rotation is approximately at the glenoid bare spot. The greater tuberosity has a defined arc (dotted line) before internal impingement occurs. (B) In the thrower's shoulder, there is contracture of the posterior-inferior glenohumeral ligament (PIGHL). With shoulder motion, the center of rotation shifts posterosuperiorly, and the amount of external rotation increases before impingement occurs. From Burkhart et al.[16] ©2003 Elsevier. Reprinted with permission.

angulation (Figure 5). This angle change produces a twist at the base of the biceps, which transmits torsional forces to the posterosuperior labrum, resulting in a "peel back" of the labrum. In a throwing shoulder, repeated initiation of this mechanism can lead to failure of the labrum over time with avulsion from the bone.[15] Kuhn and colleagues[57] investigated the question of acceleration or deceleration as the causative mechanism for labral injuries in a cadaveric model, demonstrating reliable creation of a type II SLAP lesion (9 of 10 specimens) with the biceps tendon loaded in an abducted and externally rotated (ABER) position to simulate late cocking. Their results support the "peel-back" mechanism proposed by Burkhart and Morgan[15] in the pathogenesis of SLAP lesions.

McLeod and Andrews[62] reported that degeneration of the labrum can result from humeral translation that may be increased because of the "shoulder-grinding factor." They proposed that the internal rotation and compressive force acting on the humerus cause it to grind on the labrum. A more traumatic and distinct traumatic injury mechanism, however, was proposed for SLAP tears in which forces imparted by the torsion of the long head of the biceps brachii, particularly during arm deceleration, tear the labrum away from the glenoid. This has been termed the "weed-puller" mechanism of a superior labral injury.[33]

Finally, the scapula plays an important role in normal shoulder function, and altered scapular mechanics contribute to inefficient shoulder kinematics, resulting in secondary pain and dysfunction. The scapula must maintain a synchronized relationship with the humerus to maintain a stable center of rotation for the glenohumeral joint.[52] Movement of the scapula keeps the glenohumeral articulation within the "safe zone" of optimal and efficient activity of the rotator cuff musculature. The activity of these intrinsic muscles enhances glenohumeral stability through the concavity-compression mechanism.[52] As a result, the scapula is an integral part of the kinetic chain in the throwing shoulder and serves to transfer energy from the body to the arm. When the role of the scapula is not properly performed, there is scapular malposition and a decrease in normal shoulder function. This is termed "scapulothoracic dyskinesis."[52] During pitching, a lack of scapular retraction decreases shoulder stability in the cocking phase, while too much protraction during the acceleration phase can lead to a loss of concavity compression and impingement as the scapula rotates down and forward. Similarly, if the acromion does not properly elevate during the cocking and follow-through phases, dynamic impingement may occur. Burkhart and colleagues[18] used the acronym "SICK" (scapular malposition, inferior medial border prominence, coracoid pain and malposition, and dyskinesis of scapular movement) to describe a pattern of scapular abnormality in the disabled throwing shoulder. In particular, a SICK scapula with an internal rotation deficit causes the thrower to abduct in extension and hyperangulate in external rotation during the late cocking phase, further increasing strain in the posterosuperior rotator cuff and increasing torsional load of the inferior glenohumeral ligament. In addition, hyper–external rotation can worsen the peel-back mechanism and allow for internal impingement of the rotator

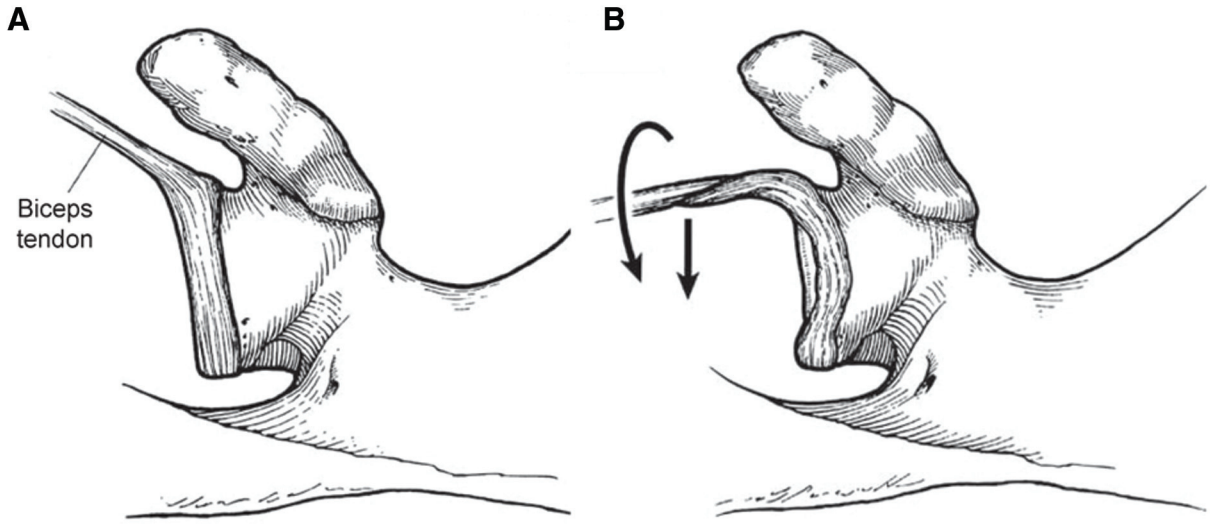


Figure 5. The ''peel-back'' mechanism. (A) Superior view in resting position of the biceps and labral complex. (B) In the abducted and externally rotated position, the biceps tendon moves posteriorly and twists at its base, resulting in a ''peel back'' of the labrum (arrows). From Burkhart et al.[16] ©2003 Elsevier. Reprinted with permission.

cuff with the posterosuperior glenoid.[18,52] Hyperangulation, described by Jobe,[48] causes internal impingement by direct abutment of the superior glenoid against the undersurface of the cuff, essentially a direct-contact cause of injury rather than a torsional cause, as described by the "weed-puller" and "peel-back" mechanisms.

PHYSICAL EXAMINATION

The clinical assessment of patients with SLAP lesions is often difficult given the frequently nonspecific history and physical examination findings and the high incidence of false-positive results on imaging studies. Athletes with shoulder injuries frequently have multiple coexisting lesions with similar clinical presentations and symptoms. In the throwing athlete, the clinician must ascertain the duration of symptoms. Throwing athletes with SLAP lesions often have anterior shoulder pain in their dominant arm followed by gradual loss of function and difficulty with overhead motions, including an inability to throw at preinjury velocity.[6,7] There are often mechanical symptoms such as clicking or popping during the cocking phase of throwing.[6] Complaints of night pain, weakness, and instability may be caused by a variety of associated findings, including partial-thickness rotator cuff tears, capsulolabral injuries, biceps tendinopathy, and internal impingement.[5] Mileski and Snyder[64] reported that 29% of patients in their series had concomitant partial-thickness rotator cuff tears and 22% had Bankart lesions. Kim and colleagues[56] also reported that type II SLAP lesions often present with other lesions depending on age, with younger patients more likely to have instability and older patients more likely to present with a rotator cuff injury.

Physical examination of the throwing athlete with shoulder pain and a potential SLAP tear should always begin with a careful assessment of glenohumeral and scapulothoracic range of motion. Glenohumeral range of motion is measured in both shoulders in adduction and 90° of abduction. Many high-level athletes exhibit increased external rotation and decreased internal rotation of the throwing shoulder. Assessment of range of motion should be performed in the supine position. The scapula is stabilized to measure active and passive glenohumeral range of motion in the scapular plane. If 2 examiners are available, one person can stabilize the scapula, while the other measures motion using a goniometer. GIRD is defined as a deficit in internal rotation of at least 20° when compared with the contralateral side.[16] In addition, strength testing, particularly of the rotator cuff muscles, is essential during examination of the overhead athlete. Evaluation of shoulder stability is important to document during assessment of the overhead athlete with shoulder pain. Concomitant anterior capsulolabral injuries with SLAP tears are not uncommon and should be assessed with load shift and apprehension relocation testing. Inferior instability is also assessed through the sulcus sign and posterior instability with the posterior apprehension sign, or jerk test. Beighton et al's[8] criteria assessing various joints should also be determined to identify occult hyperlaxity and multidirectional instability.

Numerous physical examination tests have been described to detect a superior labral injury, although most are sensitive but lack specificity. These include the O'Brien active compression test, anterior slide test, compression rotation test, resisted supination external rotation test, the Speed test, crank test, biceps load test II, and major shear test (Table 2).[54,59-61,77,86] Various investigators have examined the sensitivity and specificity of these tests both individually and in combination; there are no convincing data for accurate detection of a superior labral

TABLE 2
Summary of Clinical Tests to Diagnose SLAP Lesions With Reported Test Performance[a]

Test	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Active compression test	47-100	11.1-98.5	10-94.6	14.3-100
Anterior slide test	8-78.4	81.5-91.5	5-66.7	67.6-90
Biceps load test I	90.9	96.9	83	98
Biceps load test II	89.7	96.9	92.1	95.5
Crank test	12.5-91	56-100	41-100	29-90
Pain provocation test	15-100	90-90.2	40-95	70.9-100
Resisted supination external rotation test	82.8	81.8	92.3	64.3
Rotation compression test	24-25	76-100	9-100	58-90
Forced abduction test	67	67	62	71

[a]Some values are expressed as ranges. PPV, positive predictive value; NPV, negative predictive value. Adapted from Jones and Galluch.[49]

injury.[25,54,60,77] In addition, a meta-analysis by Meserve and colleagues[63] evaluated the sensitivity and specificity of different tests for the detection of SLAP lesions. Their findings suggest that the active compression test is the most sensitive and most predictive for ruling out labral tears, followed by the crank test and the Speed test. Most recently, Cook and colleagues[25] performed a prospective case-control study to test the diagnostic accuracy of 5 tests (O'Brien active compression test, Speed test, biceps load II test, O'Driscoll/dynamic labral shear test, labral tension test) for the diagnosis of SLAP tears under the strict control of bias. The authors concluded that each of the 5 tests, either as a stand-alone test or clustered together, provided minimal to no value for the diagnosis of SLAP lesions, either in isolation or combined with other shoulder pathological abnormalities, further illustrating the challenge in the clinical diagnosis of superior labral lesions.

Evaluation of scapular kinematics is an integral part of physical examination. Inspection of the scapula begins in the resting position to detect the presence of scapular asymmetry between the dominant and nondominant shoulders.[61] The shoulders are then evaluated through active range of motion, including forward flexion to observe for winging. Although a protracted scapular position may be a normal adaptation for throwing, this alteration may contribute to other shoulder injuries, increasing the risk for dynamic outlet impingement, and rotator cuff tears.[73] Similarly, a combination of scapular depression, anterior tilt, and protraction is implicated in the pathological cascade of dysfunction in the painful throwing shoulder.[1] Scapular dyskinesis is described as alterations in scapular position and motion relative to the thoracic cage and can be assessed by observing the arm during both the elevating and lowering phases of motion.[53] If significant scapular winging or periscapular muscle atrophy is noted, the clinician must ensure there is no associated cervical spine injury and institute an appropriate rehabilitation and strengthening program. GIRD is measured with the patient lying supine on the examination table and the arm positioned at 90° of shoulder abduction and elbow flexion, respectively, while the scapula is stabilized to eliminate scapulothoracic motion. Any side-to-side difference in glenohumeral motion is then assessed by internally and externally rotating the arm.

IMAGING

Initial evaluation of the painful thrower's shoulder should begin with plain radiographs, including anteroposterior, Grashey, outlet, and axillary views. While no specific radiographic findings are pathognomonic for SLAP lesions, other coexisting conditions such as Bennett lesions (mineralization of the posterior band of the inferior glenohumeral ligament), outlet impingement, or acromioclavicular pathological abnormalities may be detected. Currently, MRI remains the gold standard for the detection of labral injuries, in particular, MR arthrography.[20,29,45,85] The improved ability of MR arthrography to detect labral lesions is related to controlled distention of the glenohumeral joint from injection of the intra-articular contrast medium, providing a more clear delineation of the anatomic structures and SLAP lesions from anatomic variants such as a sublabral recess or sublabral foramen; sensitivity and specificity of MR arthrography for the detection of SLAP tears are reported near 90% in several studies.[29,45,85] SLAP tears are best appreciated on coronal oblique sequences where joint fluid or contrast medium fills deep clefts between the superior labrum and glenoid (Figure 6).[7] The presence of a spinoglenoid cyst is also detectable with MRI, and MR arthrography is helpful to differentiate between type II SLAP tears and a sublabral recess.[47] A recent study by Borrero and colleagues[11] assessed the magnetic resonance appearance of posterosuperior labral peel back. To improve the preoperative assessment of superior labral peel back in young throwing athletes, the authors retrospectively reviewed MR arthrography scans in the ABER position and compared the findings with those of a subgroup of overhead athletes who underwent arthroscopic examination. Their report suggests that MR arthrography in the ABER position can reliably detect posterosuperior labral peel back, which will assist the clinician in preoperative planning for superior labral lesions during arthroscopic surgery.

Despite excellent sensitivity and specificity for the detection of pathological shoulder lesions, not all abnormalities are clinically significant. Connor and colleagues[24] conducted a prospective study of 20 young, asymptomatic elite overhead athletes with MRI to detect the incidence of imaging abnormalities. The authors reported a high

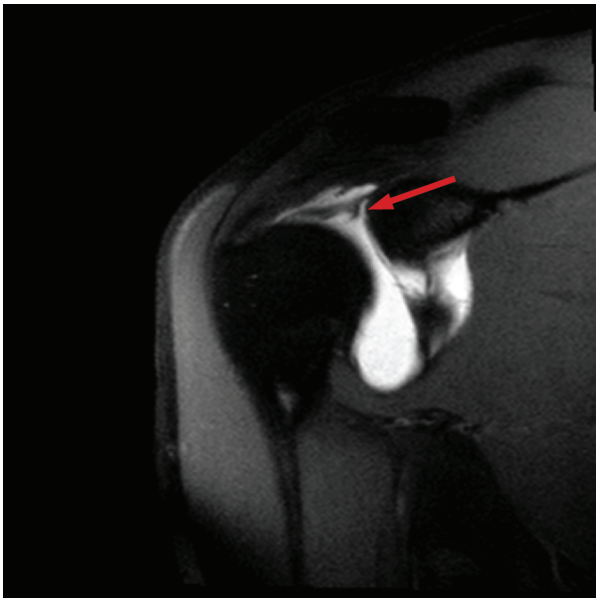


Figure 6. Coronal T2-weighted magnetic resonance imaging scan demonstrating a SLAP lesion with extension of contrast material between the glenoid and superior labral complex (arrow).

incidence of clinically false-positive MRI findings in the dominant shoulder, including 40% with partial- or full-thickness rotator cuff tearing, 20% with Bennett lesions, and 7.5% with partial tears of the anteroinferior or superior glenoid labrum. Similarly, in a study of elite handball players, Jost and colleagues[50] reported MRI abnormalities in 93% of throwing shoulders; however, just 37% of these shoulders were symptomatic. While advanced imaging studies have significantly improved the reliable detection of SLAP lesions, the high prevalence of associated pathological findings and clinically asymptomatic MRI findings warrants careful correlation with physical examination and clinical history to ensure that the SLAP tear is responsible for the presenting symptoms in the overhead athlete.

NONOPERATIVE MANAGEMENT

Shoulder injuries in throwers are initially managed with a trial of nonoperative treatment, including rest from provocative activities. Edwards and colleagues[31] showed that 10 of 15 (66.7%) overhead-throwing athletes treated with a nonoperative regimen for a SLAP tear were able to return to play at the same or better level than before the injury. Exercises to improve strength and endurance are not initiated until the pain has resolved. The goals of rehabilitation include restoration of muscle strength, endurance, and normal glenohumeral/scapulothoracic motion. In addition, proprioception, stability, and neuromuscular control must be emphasized. Nonsteroidal anti-inflammatory drugs, massage therapy, and passive- or active-assisted range of motion exercises can be incorporated.[12] In the setting of GIRD, various stretches involving the posterior-inferior

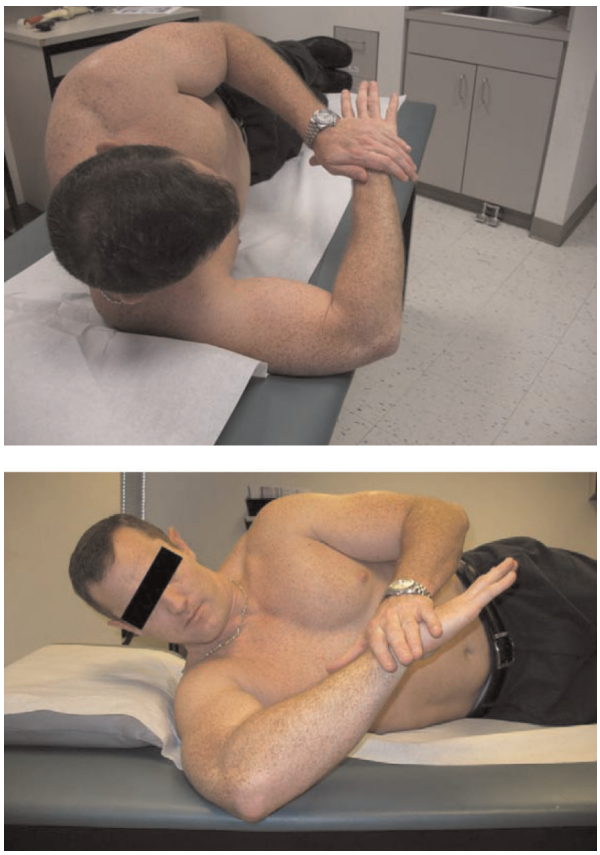


Figure 7. Demonstration of the ''sleeper stretch'' for posterior capsular contracture from Seroyer et al.[79]

capsule are utilized and are reported to be successful in approximately 90% of athletes.[16] The "sleeper stretch" is performed with the patient lying on his or her side, flexing both the elbow and shoulder to 90° while the shoulder is passively internally rotated (Figure 7).[18] Rehabilitation of the SICK scapula requires strengthening of the stabilizing musculature with the goal of eventual "re-education" of normal muscle kinetics. Closed kinetic chain exercises are performed followed by open kinetic chain exercises. While nonoperative treatment may be the definitive treatment for nonthrowers, overhead-throwing athletes may require operative treatment to return to a high level of function.[31]

OPERATIVE MANAGEMENT

Operative intervention in the management of SLAP tears in the overhead athlete is indicated after a failure of nonoperative treatment modalities to allow the athlete to return to play at the previous level of competition and a strong clinical suspicion that it is indeed the SLAP that is responsible for the symptoms. There have been many operative techniques described for surgical fixation of SLAP lesions, including transosseous sutures, staples, screws, arthroscopic sutures, and bioabsorbable tacks. These surgeries are performed arthroscopically with the patient in either the

beach-chair or lateral decubitus position. Three portals are often described for SLAP repair: a standard posterior viewing portal, an anterior portal superior to the upper border of the subscapularis tendon, and an anterosuperior rotator interval portal approximately 1 cm off the anterolateral tip of the acromion.[17] Trans–rotator cuff portals have also been described and are commonly utilized by many surgeons.[68] The superior labrum presents unique difficulties for accurate and safe anchor placement, requiring the surgeon to consider all portal options to avoid damaging the articular cartilage of the superior glenoid.

The surgeon has many different options available to surgically repair a SLAP lesion. This includes the use of anchors with nonabsorbable sutures or bioabsorbable tacks. Many concerns have been raised, however, regarding the use of tacks, largely resulting in an abandonment of their use. Sassmannshausen and colleagues[75] reported on 6 patients with persistent postoperative pain and disability following the use of bioabsorbable polyglycolide lactic acid (PLLA) tacks. Three of the patients had reported an identifiable injury at an average of 4 months from the original procedure. In these cases, MRI revealed broken or dislodged tacks. Repeat arthroscopic surgery in 2 patients also demonstrated a chondral injury. In addition, Wilkerson et al[92] and Freehill et al[35] have both reported complications after PLLA tack use, including foreign body synovitis and full-thickness humeral head chondral injury. At present, the use of knotless anchors for SLAP repairs is becoming more widespread. Dines and ElAttrache[30] have suggested that in a thrower's shoulder with limited glenohumeral joint space, the bulky suture knot used to secure the labrum may be a source of pain. Caution should be exercised with placement of the anchors anterior to the biceps tendon to avoid inadvertent tightening of the middle glenohumeral ligament or closure of a sublabral foramen, which could cause a loss of external rotation.[95] To avoid these potential complications, it is the preference of some senior authors (D.W.A. and J.S.D.) to place horizontal mattress sutures in a knotless configuration.

Biceps tenodesis also represents a method to successfully treat superior labral lesions. Boileau and colleagues[10] compared SLAP repair with suture anchor fixation to biceps tenodesis between 2 groups of patients, 60% of which were involved in an overhead sport. Patients who underwent arthroscopic treatment for isolated type II SLAP lesions were prospectively enrolled into the study. Ten patients, with an average age of 37 years, underwent SLAP repair using resorbable suture anchors placed at 11- and 1-o'clock positions on the glenoid. Fifteen patients, with an average age of 52 years, underwent biceps tenodesis utilizing a previously described technique by the senior author with interference screw fixation at the top of the bicipital groove. Postoperatively, both groups were treated with the same rehabilitation protocol. The treatment option was chosen by the surgeon based on patient age, with the treating surgeon trending toward biceps tenodesis in older patients, particularly over the age of 30 years. Comparative results were obtained between the groups, with statistically significant differences in the activity subscore, which was much better in the tenodesis group, as well as return to play, with 2 of 10 (20%) returning to the previous sport in the SLAP repair cohort compared with 13 of 15 (86%) in the tenodesis group. Similarly, 93% of patients in the tenodesis group were satisfied or very satisfied with their operation compared with 40% of those patients undergoing SLAP repair. The authors concluded that arthroscopic biceps tenodesis is an effective surgical alternative to SLAP repair in an older patient population and that subjective patient satisfaction and rate of return to the previous level of sport are better with biceps tenodesis. Limitations discussed include the nonrandomized design and relatively small sample size.[10]

Alpert et al[3] retrospectively reviewed a group of patients, stratified to those younger than 40 years (21 patients) and those older than 40 years (31 patients), who underwent repair of type II SLAP lesions. The mechanism of injury was not specified for all patients; however, the authors reported variable causes from throwing injuries, traction injuries, and unknown causes. Surgical treatment of the SLAP lesion was performed with the utilization of 2 suture anchors placed posterior to the biceps footprint. When comparing the clinical outcomes for patients younger and older than 40 years, the results were very similar. Patient satisfaction was reported at 84% (26 of 31) in the group of patients older than 40 years in comparison with 95% (20 of 21) in the younger patient group. Similarly, 90% (28 of 31) of the patients older than 40 years reported that they would have the surgical treatment performed again, while 86% (18 of 21) of those younger than 40 years stated they would elect to have the treatment again. When comparing results of the shoulder test scores, there was no significant difference between the 2 groups, specifically American Shoulder and Elbow Surgeons (ASES) average scores of 86.0 for the above-40 group and 93.1 for the below-40 group. The authors concluded that although some surgeons may be reluctant to repair type II SLAP lesions in older patients because of risks of stiffness postoperatively and delayed return to previous activities, patients over 40 years of age can have good to excellent results when undergoing repair with suture anchors. However, this study did not specify how many of the patients were involved in overhead sports, and thus, it may be difficult to generalize these outcomes to patients involved in significant overhead activities.

Despite these conflicting outcomes of surgical repair of type II SLAP lesions, recent studies have demonstrated increasing numbers of patients undergoing arthroscopic SLAP repair in the United States. Zhang et al[97] recently reported the highest incidence of SLAP repair among those aged 20 to 29 years (29.1 per 10,000) followed by those aged 40 to 49 years (27.8 per 10,000). Biceps pulley lesions, or disruption of the surrounding sheet of the long head of the biceps tendon, have also been described in conjunction with SLAP lesions. Whereas SLAP lesions are thought to be the result of primarily a traumatic injury, biceps pulley lesions are considered to be the result of more chronic degenerative factors. Although previously thought to coexist, recent studies demonstrate that concomitant SLAP and biceps pulley lesions are relatively rare, occurring in only 10% of patients with SLAP tears.[69] Patients with SLAP

lesions and concomitant signs of chronic irritation or pulley lesions may benefit from a primary double tenodesis, as described in a small cohort of overhead-reaching rock climbers, with 100% returning to their previous level of activity following surgical tenodesis.[78]

Patients with SLAP lesions in addition to other shoulder lesions, such as rotator cuff tears, can have both lesions addressed simultaneously. Voos and colleagues[83] retrospectively evaluated 30 patients with combined rotator cuff tears, SLAP tears, and Bankart lesions treated arthroscopically with a mean follow-up of 2.7 years. Twenty-seven patients (90%) reported satisfaction as "good" or "excellent," and 77% returned to their preinjury level of competition, although no professional overhead athletes were included in the study. Forsythe et al[34] compared clinical outcomes after isolated arthroscopic rotator cuff repair alone (28 patients) or arthroscopic SLAP repair with concomitant rotator cuff repair (34 patients). In both groups, all patients reported high satisfaction with the procedure. Despite the advantages of addressing both pathological lesions during the same arthroscopic procedure, authors have described a potential increased risk for postoperative stiffness and decreased range of motion following repair of concomitant SLAP lesions and rotator cuff tears, potentially attributable to the more prolonged restrictions in range of motion in the setting of a rotator cuff rehabilitation protocol. Conversely, however, several authors have shown restoration of motion after concomitant repair of both SLAP and rotator cuff lesions.[34,83] For this reason, the clinician must remain diligent and weigh the risks and benefits before surgical treatment of a shoulder with multiple pathological lesions.

Burkhart and colleagues[16] have suggested that refractory posterior capsular contractures that do not improve with stretching should be addressed at the time of SLAP repair with an arthroscopic selective posteroinferior capsulotomy. The issue lies in deciding which patients with limited internal rotation have a capsular contracture versus bony or muscular causes of limited motion. An arthroscopic capsular release can be performed in the posteroinferior quadrant from the 6-o'clock position to the 3- or 9-o'clock position. After capsulotomy, the muscle belly of external rotators should be clearly visualized. A more common associated condition is anterior-inferior capsular redundancy, allowing anterior subluxation of the humeral head. This is a notoriously difficult diagnosis to make and is based on historical symptoms, physical examination signs, examination under anesthesia, and visual inspection of the inferior glenohumeral ligament. If significant anterior capsular instability is also present, this can be treated through arthroscopic anterior capsular plication to restore appropriate tension in the anterior band of the inferior glenohumeral ligament. However, great caution must be exercised to avoid iatrogenic overtightening of the anterior capsule, as this can limit the increased external rotation that is often necessary in throwers to achieve their target velocity. Yoneda and colleagues[95] performed arthroscopic posterior capsular release in 16 overhead-throwing athletes and reported that throwing pain disappeared in 14 patients and decreased in 2 and that 11 throwers returned to their preinjury activity level.

OUTCOMES

There are numerous studies that report clinical outcomes after repair of SLAP lesions (Table 3).[32,36,37,65,74] The clinician must evaluate the merits of each study to ensure there is sufficient follow-up and that the patient population includes athletes who participate in overhead sports. Although several studies have shown a high level of successful outcomes after SLAP repair, more recent studies indicate that returning these elite athletes to their preinjury activity level may be difficult. Initial work by Morgan and colleagues[65] demonstrated excellent short-term outcomes in overhead athletes after SLAP repair, and in their evaluation of 53 overhead athletes at 1 year after surgery, 87% reported overall excellent results, with 84% of pitchers returning to preinjury activity levels. In another study by Friel and colleagues,[36] there was no difference between outcomes after SLAP repair in non–overhead athletes and recreational/collegiate overhead athletes, suggesting that successful surgery is independent of a patient's level of sport. Finally, Samani and colleagues[74] reviewed the results of 25 patients who underwent SLAP repair with a bioabsorbable tack. There were 3 overhead athletes in this study, including 1 professional thrower and 2 high school throwers. Postoperatively, the professional athlete returned to the National Football League as a quarterback, while the other athletes progressed to collegiate-level sports. In addition, outcomes in high-level athletes such as rugby players and in military cadets have been successful. Funk and Snow[37] retrospectively reviewed the clinical outcomes in professional rugby players after arthroscopic SLAP repair with suture anchors, with 95% returning to their preinjury level. A similar retrospective review of active-duty military personnel by Enad and colleagues[32] showed that of the 26 patients who participated in competitive recreational sports before being injured, 76.9% returned to the same activity level or higher. At final follow-up (mean, 30 mo), 96.2% remained in full active duty and reported satisfaction with their result.

Recently, several authors have demonstrated that returning throwing athletes to preinjury levels may be more difficult than previously reported. Yung and colleagues[96] investigated the effectiveness of SLAP repair in 16 patients at 28 months postoperatively. Of the 13 patients who were involved in overhead sports before surgery, 4 took an average of 11 months to return to the same activity level, and 1 never returned to competitive play. The authors concluded that preinjury activity level is an important factor to consider when treating SLAP lesions and that elite overhead athletes may take longer to rehabilitate before returning to sport. More recently, Sayde et al[76] published a systematic review on the outcomes of type II SLAP repair in athletes. A total of 506 patients with type II SLAP tears were reviewed from 14 studies; of these, 327 had SLAP lesions repaired by anchors, 169 by tacks, and 10 by staples. Of the 506 patients, 198 were overhead athletes with a pooled subset of 81 identified baseball players. For the entire patient population, there was overall very high "good-to-excellent" patient satisfaction and return to play (73% returned to their previous

TABLE 3
Outcomes After Repair of SLAP Tears[a]

Study	Study Design	No. of Patients	Repair Techniques	Outcomes Summary
Morgan et al[65]	Retrospective	102	Type II repair, suture anchor	83% excellent results in entire group; 87% excellent results in 53 overhead athletes (44 pitchers)
Friel et al[36]	Prospective cohort	48 (small no. with concomitant procedures)	Suture anchor fixation	54% return to previous level of sport
Samani et al[74]	Retrospective	25	Bioabsorbable tacks	17 return to previous level of play (including NFL quarterback)
Sayde et al[76]	Systematic review	506	Suture anchor, bioabsorbable tacks, staples	63% return to previous level of play
Neuman et al[67]	Retrospective	30	Suture anchor fixation	93.3% satisfaction rate; subjectively reported 84.1% of preinjury level
Synder et al[80]	Retrospective	140	Type I debridement, 56% type II debridement, 44% suture fixation	—
Cohen et al[22]	Retrospective	39	Biodegradable tacks	27/39 G-E results; 14/29 return to play at preinjury level at 3.7-y follow-up
Funk and Snow[37]	Retrospective	18	Suture anchor fixation	89% satisfaction rate; 95% return to play at preinjury level
Enad et al[32]	Retrospective	27	Suture anchor fixation	24/27 G-E results
Coleman et al[23]	Retrospective	±50 acromioplasties	Biodegradable tacks	65% G-E results at 3.4-y follow-up
Yung et al[96]	Retrospective	16	Suture anchor fixation	87.5% G-E results
Boileau et al[10]	Prospective cohort	25 (2 groups)	Suture anchor fixation (biceps tenodesis vs SLAP repair)	4/10 satisfied in SLAP repair group; 13/15 satisfied in tenodesis group
Brockmeier et al[13]	Prospective cohort	47	Suture anchor fixation	41/47 G-E results at 2.7-y follow-up
Galano et al[38]	Retrospective	22	Suture anchor fixation	90% return to play at preinjury level
Combined rotator cuff and SLAP lesions				
Voos et al[83]	Retrospective	30 (16 Bankart and 14 with SLAP)	Suture anchor fixation for RCR and SLAP	90% G-E results; 77% return to play at preinjury level
Forsythe et al[34]	Retrospective	34 SLAP + RCR and 28 RCR alone	Suture anchor fixation for RCR and SLAP	All patients in both cohorts were satisfied and would undergo procedure again

[a]NFL, National Football League; G-E, good to excellent; RCR, rotator cuff repair.

level of play). However, in overhead athletes, only 63% were able to return to their previous level of play. The authors comment that there may be a high incidence of concomitant pathological abnormalities (ie, rotator cuff tear, instability) in the thrower's shoulder that affected the final results. Nevertheless, the conclusions from their analysis suggest that further research is required to improve outcomes and our understanding of the pathological lesions involved in the thrower's shoulder.[76] Neuman and colleagues[67] also recently performed a retrospective review of 30 overhead athletes who underwent arthroscopic repair of symptomatic type II SLAP lesions with bioabsorbable suture anchors. Overall, 93% of athletes reported being satisfied or very satisfied with their surgery at an average of 3.5 years postoperatively. Brockmeier and colleagues[13] prospectively evaluated the outcomes of arthroscopic type II SLAP repair with suture anchors in 34 patients, including 3 professional athletes, 5 collegiate-level athletes, and 26 recreational athletes. Twenty-eight patients were involved in overhead sports at a recreational level or higher. Although the ASES scores increased from 62 to 97 postoperatively, and the L'Insalata score increased from 65 to 93, at an average of 2.7 years postoperatively, of those patients involved in overhead sports, only 71% were able to return to their preinjury level. In addition, O'Brien and colleagues[68] presented outcomes on 31 patients treated arthroscopically for a SLAP tear with a trans–rotator cuff approach. At a mean follow-up of 3.7 years, only 44% of patients returned to their preinjury level of sports. Finally, Cohen and colleagues[22] reported on clinical outcomes after arthroscopic repair of isolated type II SLAP lesions with bioabsorbable

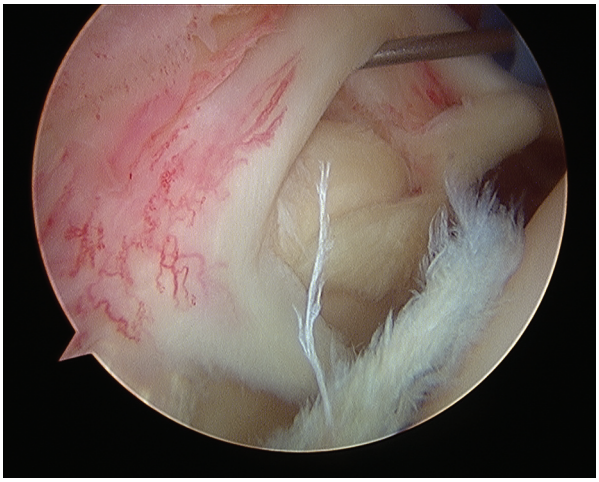


Figure 8. Arthroscopic view of a right shoulder from the posterior portal. The superior labrum–biceps complex injury is probed, demonstrating the unstable flap and exposure of bone proximal to the chondral margin.

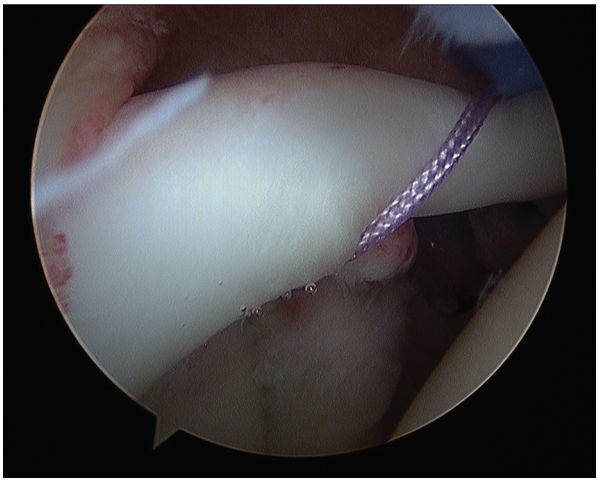


Figure 9. As viewed from the posterior portal, a suture is passed around the unstable superior labrum posterior to the biceps anchor. Care is taken to pass the suture to allow for an anatomic reduction and to avoid entrapment or incarceration of the biceps tendon.

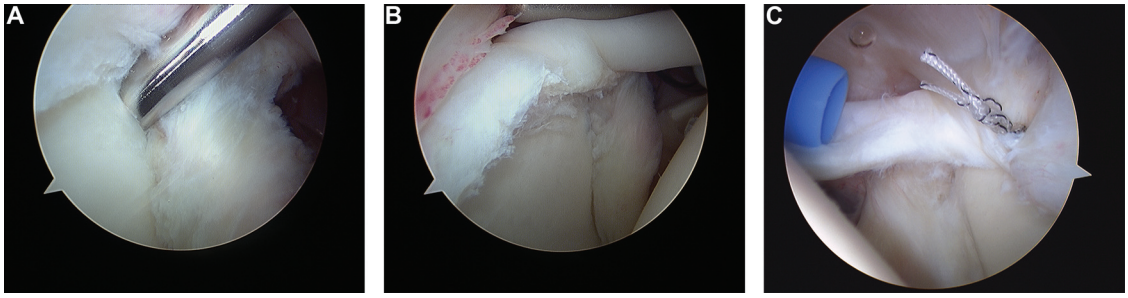


Figure 10. Arthroscopic view from the posterior portal. (A) A single knotless anchor is placed posterior to the biceps anchor. The glenoid bone was roughened with an arthroscopic shaver before securing the repair. (B) The final repair demonstrating anatomic reduction of the superior labrum without incarceration of the biceps tendon or prominent suture in the joint. (C) A standard suture anchor–based repair. While the location of the suture and repair is appropriate, there is a risk of overadvancement of the labrum and significant knot impingement in the throwing athlete.

tacks in 39 patients, including 8 throwing athletes. Only 14 patients (48%) were able to return to their preinjury level of sports, while only 3 of 8 throwers returned to their previous level of play. Overall satisfaction was reported as good to excellent in 69% (27 of 39) of patients.

AUTHORS' PREFERRED TECHNIQUE

1. Glenohumeral arthroscopic surgery is performed using a standard posterior portal in the beach-chair position. The lateral decubitus position is also appropriate and may be selected based on surgeon comfort and preference. The principles of portal placement and repair are valid independent of patient position.
2. A spinal needle–guided midglenoid anterior portal is established under direct visualization above the leading edge of the subscapularis and just lateral to the middle glenohumeral ligament. This confirms safe access and instrumentation of the superior and anteroinferior labrum as needed for a repair. A probe is introduced through this portal to evaluate the integrity of the superior labral complex (Figure 8). It is critical to examine and distinguish pathological labral detachment and peel back from a meniscoid superior labral variant or sublabral foramen. The presence and location of associated pathological lesions, including partial-thickness rotator cuff injuries, are critical to assess and may help to indicate the etiology and pain and guide the appropriate intraoperative treatment plan. Posterosuperior labral and cuff pathological abnormalities may be consistent with internal impingement, while anteroinferior chondral shear injury on the glenoid may be consistent with occult anterior instability of the glenohumeral joint. The biceps tendon should be carefully examined for tenosynovitis and partial-thickness tearing, taking care to pull the groove

portion of the tendon into the joint for examination. This constellation of findings may help the surgeon decide on the need for associated posterior capsular release, biceps tenodesis, and/or anterior capsular plication.

3. If a SLAP tear is identified, a high rotator interval portal is established under direct visualization. This is carefully localized by spinal needle guidance, taking care to enter the joint just posterior to the leading edge of the supraspinatus tendon and superior to the biceps tendon. This portal is usually directly lateral and approximately 2 to 3 cm away from the midglenoid anterior portal (see step 2). This portal is typically used to place the anchors with an ideal trajectory for SLAP repair and does not violate the rotator cuff tendons. In addition, visualization from this portal affords an *en face* view of the glenoid and anteroinferior capsulolabral complex to assess for injuries and sufficient mobilization of periosteal sleeve injuries when an associated repair of these structures is necessary.
4. Using a combination of an arthroscopic shaver and elevators through the anterior portals, devitalized tissue is debrided, and the superior labrum–glenoid interface is prepared. The bone is gently decorticated to expose bleeding cancellous bone before repair.
5. The anchor and suture configuration is individualized based on the tear pattern. Typically, anchors will be placed by way of the anterosuperior portal and positioned 2 to 3 mm medial to the glenoid articular cartilage. An appropriate trajectory is selected to obtain excellent purchase in the bone and to avoid the risk of slipping or drilling toward the spinoglenoid notch (Figure 9). The number of anchors depends on the tear size and propagation of the "peel-back" lesion.
6. Sutures can be passed and retrieved using a variety of techniques. Most commonly, the authors use a medium-sized crescent hook by way of the anterior portal to pass relay sutures through the labrum. Anchor suture shuttling is performed using the 2 anterior portals. Occasionally, the authors use spinal needles or a banana lasso (Arthrex Inc, Naples, Florida) through the Neviaser portal to facilitate suture passage through the superior labral tissue. These relay sutures must be passed carefully to avoid overtightening and advancement of the superior labral complex as well as to avoid incarceration of the biceps tendon between sutures.
7. Anchors may need to be placed both anterior and posterior to the biceps based on the severity and extent of the tear. Most surgeons recommend limiting the zone of repair to the region posterior to the biceps tendon to avoid inadvertent tightening of the middle glenohumeral ligament, which could cause loss of external rotation. Simple or mattress knot configurations can be used, taking care not to entrap the biceps tendon (Figure 10). Surgeons have noted that knot impingement is a distinct potential complication of traditional knotted anchors when utilized for superior labral repairs, particularly in overhead athletes. To avoid these potential complications, it is the preference of some senior authors (D.W.A. and J.S.D.) to place horizontal mattress sutures in a knotless configuration.[30]
8. The repair should be tested by way of traction applied on the biceps tendon with an arthroscopic probe. Secure attachment of the labrum to bone with the absence of gap formation confirms a stable repair.
9. Concomitant injuries should be addressed, including (in the overhead athlete) undersurface cuff lesions and, in rare circumstances, posterior capsular tightness. Subtle anterior instability with secondary internal impingement may benefit from anterior capsular plication.
10. Postoperatively, the patient is maintained in a sling for 4 weeks. Elbow and wrist range of motion exercises are commenced immediately. Overhead athletes are allowed to begin controlled range of motion exercises in the scapular plane, avoiding positions of extreme abduction or external rotation, 1 week after surgery. Scapular stabilizer exercises are initiated immediately. Resisted strengthening exercises are initiated at 3 months postoperatively. It is critical to avoid extreme positions of abduction and external rotation during the first 3 months postoperatively, as these positions increase the risk of disrupting the repair before complete healing. In overhead athletes, a formal throwing program is initiated at 4 months when full, painless range of motion has been achieved. Although return to preinjury function is variable, the authors typically observe a return to unrestricted, full throwing activity by 6 to 9 months postoperatively.

CONCLUSION

The repetitive demands of overhead athletes can result in significant injury to the biceps–superior labrum complex, resulting in throwing pain and dysfunction. Since Snyder et al[81] and Andrews et al[4] provided the original description of anterosuperior labral tears involving the biceps origin, there have been numerous theories and studies evaluating the pathogenesis of SLAP tears, helping to improve our understanding of this relatively common injury. Developments in imaging modalities, including MR arthrography, have proven to be a useful complement to the physical examination to accurately diagnose SLAP lesions. However, a careful correlation of history and physical examination with imaging findings is essential to avoid errant treatment of asymptomatic lesions or to neglect other associated pathological abnormalities. Nonoperative rehabilitation is the current mainstay of treatment, and a thoughtful treatment plan must be individualized for each athlete. Posterior capsular contracture and secondary GIRD are not uncommon and can significantly improve with appropriate stretching protocols. Athletes with continued pain despite treatment with nonoperative modalities may eventually require operative intervention, usually in the form of arthroscopic repair, for which favorable outcomes and return to competitive play have been reported; however, some more focused studies, such as those performed recently by Sayde et al,[76] have demonstrated poor return to sport rates after SLAP repair in the competitive overhead athlete. Alternatives, such as

nonoperative rehabilitation or surgical intervention such as primary biceps tenodesis, are being increasingly chosen as the treatment of choice rather than SLAP repair. This is in contrast to SLAP tears of a traumatic origin, where repair generally is associated with favorable outcomes. It should be noted that the senior authors do not believe that SLAP repair is reliably effective in relieving symptoms in patients over 40 years old, as Boileau and colleagues[10] have demonstrated that biceps tenodesis is the treatment of choice in this age group. Despite our improved understanding of the superior labrum and its treatment, the diagnosis and management of this disorder remain a unique challenge for the clinician.

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