Treatment of Tears of the Superior Labrum Anterior and Posterior: A Review

Luke W. Bulthuis, MD

Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center

Abstract

Tears to the superior labrum anterior and posterior (SLAP) are common injuries of the shoulder, and patients with these types of lesions are treated regularly by both general and sports-specialized orthopaedic surgeons. The causes, diagnosis, and effective treatment of these wounds have been examined extensively in the past several decades, owing partially to the development of arthroscopic techniques. Because clinical understanding has thus undergone frequent and notable changes, no standard method exists for current treatment. To help identify effective techniques for treating isolated SLAP tears, I reviewed the anatomy of the labrum and associated range of motion and stability of the complex, including pertinent locations such as the glenohumeral joint and long head of the biceps tendon; common mechanisms of injury (ie, inline, peel back, compression, and traction forces); past and current classification systems; results of physical examinations and imaging tests in diagnosing the injury; and nonoperative, operative, and current treatment methods (eg, tenodesis, debridement, and use of mattress sutures or knotless anchors). Although knowledge of the causes and long-term results of treating SLAP tears are limited, conservative techniques can be considered first to successfully treat the tear, with careful progression to operative treatment.

Introduction

Shoulder pain resulting from lesions of the superior labrum anterior and posterior (SLAP) presents a challenging problem for surgeons. A study in 1985 by Andrews et al[1] first described detachment of the superior labrum in a group of baseball pitchers. Five years later, the abbreviated term of "SLAP" tear was used.[2] As arthroscopic techniques develop, associated lesions have been noted more frequently. Currently, patients with isolated SLAP tears are seen often by both general and sports-specialty orthopaedic surgeons.

Because studies in the past several decades have extensively examined SLAP tears, clinical understanding has undergone frequent changes. Clavert[3] discussed a wide range of possible pathological features associated with the tears, including the locations of six sextants in the glenoid. I reviewed SLAP tears that occurred in the first sextant to focus on a specific area of the injury, at 60° of the glenoid labrum centered about the insertion of the long head of the biceps tendon (LHBT) on the glenoid labrum. To help shed light on effective treatment, I outlined the notable anatomical locations of the superior labrum and LHBT complex; possible mechanisms of SLAP injuries; classification systems; and standard methods of diagnosing the wound. Additionally, I examined past and recent studies to evaluate any change in techniques used for successfully treating tears to the SLAP.

Anatomy of the Labrum

The labrum, which lines and reinforces the ball and socket joints of the shoulder, consists of a fibrocartilage attached to the glenoid. It is circular, curved like a dish, and triangular shaped in a cross-sectional area.[4] As such, labral anatomy can be described by three parts: the superficial, articular, and peripheral sides.[4] The first part is the "surface," which directly contacts the humeral head; the second contains attachments to the glenoid and a free-standing edge between the humeral head and the glenoid; and the last attaches to the joint capsule.

Range of Motion and Stability of Shoulder

Dynamic stabilization is essential in allowing control of the shoulder because bony contacts apply minimal strain and provide a wide range of motion to the glenohumeral joint. The humeral head articulates on the glenoid cavity, with three to four times more articular surface than the glenoid.[5] During the normal range of motion of the glenohumeral joint, only 25% to 30% of the humeral head contacts with the glenoid.[6] These ligaments of the glenohumeral joint and capsule provide dynamic stability within the shoulder, which relax on motion and tighten in response to unstable positions of the shoulder.[7] Additionally, the muscle of the rotator cuff generates the compressive force that holds the humeral head within the glenohumeral joint. This restrictive force shields the joint from direct pressure when active motion occurs.[8-9]

Additionally, the labrum plays an enormous role in stabilizing the shoulder. A small area of the humeral head touches the joint of the glenoid, and compression of the humeral head to this small area occurs through a series of dynamically working cross-linked cables. The labrum helps impart the forces from the humeral head to the glenoid and stabilizing structures.[10] In this way, the labrum acts as a gasket.

Glenohumeral Joint

The labrum has three major roles in the anatomy of the glenohumeral joint. First, it serves as an attachment point for stabilizing structures and thereby acts as a force conduit, spreading tension from the glenohumeral displacement to the capsule and ligaments that prevent displacement.[10] Second, the labrum provides a larger, concave surface upon which the humeral head can articulate. Subsequently, the contact area to the humeral head is increased by 2mm in the anterior-to-posterior direction and 4.5 mm in the superior-to-inferior direction.[3] Third, the uniform surface and synovial fluid provides a negative viscoelastic pressure between the humeral head and glenoid, imparting additional stability.[11]

Long Head of the Biceps Tendon

The role of the LHBT is diverse and only partially understood. The complex typically inserts partially on the superior labrum and supraglenoid tubercle, a firm bony attachment, and the structure prevents multidirectional displacement of the humeral head.[12,13] Furthermore, the function of the long head can prevent humeral head translation when viscoelastic forces of the joint have been diminished.[14] Additionally, the role of the long head may be connected to the deceleration phase of throwing mechanics, as Andrews et al[1] originally noted.

The superior portion of the labrum about the attachment of the LHBT displays a notable amount of anatomic variance. In particular, the action between the superior labrum and biceps muscle-tendon unit has been examined. A study by Clavert et al[15] identified three types of labral variants to the glenoid (type 1, flat or adherent; type 2, rounded with a recess before attachment; and type 3, meniscal or mobile) in 100 patients treated with shoulder arthroscopy. In patients older than 30 years, the authors noted an increased number of types 2 and 3 labrums compared to patients younger than 30 years, suggesting a normal change in anatomy with aging. Furthermore, Williams et al[16] found 12% and 1.5% of superior labrums with sublabral foramen and Buford complex (normal variant to anatomy), respectively.

Mechanisms and Classification of Injury

The lesion that Andrews et al[1] initially discussed was observed in overhead-throwing athletes, mostly baseball pitchers. The wound was suggested to be caused by a wear-and-tear process, involving an inline pull on the labrum created by the biceps tendon during deceleration of the throwing motion. In the study,[1] the biceps-muscle belly was electrostimulated during arthroscopy for treating SLAP tears, and the contraction of the biceps displaced the labrum. Results of later studies have indicated that the causes of the lesion are more complex than one simple mechanism, with multiple classifications.

Inline and Peel-Back Mechanisms of Injury

Burkhart and Morgan[17] discussed the tear as a repetitive process of trauma owing to traction applied at the LHBT insertion, which can be observed during deceleration or late-cocking phases of throwing. Subsequently, two proposed mechanisms of injury gained acceptance, relating to repeated stress applied to the superior labrum gained acceptance: "inline" for noting the eccentric contraction of the biceps in line with the tendon (ie, deceleration phase); and "peel back" for describing the twisting and traction forces on the labrum created by the biceps, with the shoulder in maximum flexion, abduction, and external rotations (ie, late-cocking phase).

In a rather interesting study performed by Shepard et al,[18] the exposed biceps tendon of eight matched pairs of cadaveric shoulders were tested for maximum strength before tearing or rupturing when loaded with peel-back and inline mechanisms of force. Because the tendons in the peel-back group withstood significantly more force, the attachment of the LHBT may be more robust, with a force vector of equivalent value to the inline mechanism. Additionally, Pradhan et al[19] noted greater strain placed on the posterior labral attachment in a cadaveric study, with the arm positioned in the late-cocking phase.

The peel-back and inline mechanisms are possibly related to the appearance of lesions because, in terms of use-related tears, the shoulders of overhead-throwing athletes experience both types of stress during sports-related activity. However, one mechanism may not be more likely than the other to cause SLAP tears. Current thought is that both patterns contribute to the wound's appearance.[20] Continual stress at the superior-labral and LHBT insertions could lead to displacement of a microlesion. Further studies on displacement of pre-existing lesions by using both mechanisms may help reveal the role of each movement in causing SLAP tears.

Compression and Traction Forces

Acute lesions can also occur at the superior labrum. Snyder et al[2] noted injury to the glenohumeral joint resulting from a single instance of compression, often a fall onto outstretched hands, with the shoulder adducted and in slight flexion. On the other hand, Morgan et al[21] reported acute lesions related to a single traction-based injury. Although similar in location to compression-based wounds, traction-type lesions are treated operatively more often.

Classification

SLAP tears were originally classified into types I through IV. Type I tears involve fraying of the superior labrum; type II, tearing of the superior labrum, with the LHBT attached to the torn portion of labrum; type III, tearing of the labrum from its attachments and the LHBT attachments; and type IV, tearing of the superior labrum to the LHBT, with the tendon-to-glenoid anchor intact. In a study by Maffet et al,[22] fifty-five percent of tears were type II, and types III and IV wounds accounted for 8%. Difficulty in categorizing the tears may be reflected in the fact that 38% of the observed wounds were considered non-classifiable.

Classification of SLAP tears has been expanded to types V though VII,[3] which consider pathological features extending to other areas of shoulder stability. Type V tears involve instability; type VI, biceps detachment; and type VII, middle and inferior tears of the glenohumeral ligament (implying instability). These categories encompass additional causes of SLAP tears to the original five classifications.

Diagnosis

Results of physical examinations are commonly obtained yet unreliable in diagnosing SLAP tears, and most tests involve a simple stimulation of the biceps attachment. For example, Synder et al[2] noted the presence of shoulder pain with SLAP tears in patients who, while in the overhead position, snapped their fingers. However, despite suspicious findings of physical examinations, arthroscopic or direct visualization remains the gold standard for diagnosing SLAP tears.

Physical Examinations

Many studies have examined the reliability of provocative maneuvers used to identify SLAP tears.[23-25] A well-known maneuver, the O'Brien test,[25] was originally dubbed the "active compression test" and requires the shoulder to be in a position of flexion to 90°, maximum internal rotation, and adduction of 15°. Pain in resisted extension, with relief when the patient resists in external rotation, indicates positive test results for the injury.

In a review of all findings of physical examinations of patients with SLAP tears, Cook et al[23] noted that results of the Biceps Load II test were effective indicators of SLAP tears, with a 1.7 positive likelihood ratio and 0.39 negative likelihood ratio for the wound. In this test, the patient and forearm are in a supine position, with the shoulder in 120° of abduction and maximum external rotation. Positive results for a SLAP tear are indicated by re-creation of pain with resisted elbow flexion. Ultimately, some retrospective reviews have found no definitive findings of physical examinations, whereas other research has highlighted a handful.[23]

Imaging Procedures

Results of imaging procedures have indicated reliable rates of accurately diagnosing SLAP tears. High-resolution magnetic resonance imaging (MRI) is not readily available or practiced, yet one study noted that findings from a computed tomography arthrogram proved to be 94% to 98% sensitive and 73% to 88% specific in noting SLAP tears.[26] In the same study, results of an MRI arthrogram were similar, with 91% to 98% specificity and 82% to 89% sensitivity. Although these data are not uniform, an older study[27] reported similar MRI findings of 98% and 89% sensitivity and specificity, respectively, in 104 patients.

Treatment

Operative and nonoperative treatment methods for SLAP tears exist. When operative treatment is recommended, the decision is usually guided by two possible procedures: repair of the tear from the SLAP to glenoid, and tenotomy or tenodesis of the LHBT. These methods may be performed in tandem and are not mutually exclusive. Typically, nonoperative procedures are preferred and performed before the suggestion of surgical treatment.

Nonoperative

Nonoperative treatment of SLAP wounds has focused on the mechanisms proposed to cause the tear. Tension in the LHBT caused by peel-back motions, inline movements, and other mechanisms can result in stress along the superior labrum. For instance, internal impingement owing to tightening of the posterior capsule may place additional pressure on this superior labrum-biceps complex. Often, this outcome has been seen in overhead-throwing athlete-patients who have possibly reduced internal rotation of the shoulder and display signs of hypermobile external rotation in the later cocking phase of throwing. As such, therapy treatment has included stabilizing the scapula and performing stretches to relieve tension in the posterior capsule.[28] Additional stress placed on the biceps-labral complex may be caused by stabilizing the scapula in high external rotation and deceleration. Subsequently, techniques used in therapy have emphasized proper throwing mechanics, strengthening of the rotator cuff, and scapular stabilization.

Operative

Several decades ago, operative treatment of superior labral tears focused more on repairing the SLAP lesion-to-glenoid tear rather than releasing the LHBT. These repairs were typically unsuccessful in treating overhead-throwing patient-athletes. Furthermore, performing biceps tenodesis may not reliably result in a full return to high-level competitive sports for athletes.

A case series by Denard et al[29] reported the difference in outcomes between 22 SLAP repairs and 15 tenodesis procedures of the LHBT. About 77% and 100% of patients in the former and latter groups, respectively, reported satisfaction with the treatment outcomes. One study[30] in Korea examined 34 patients with type II isolated SLAP tears, in which 90% reported satisfactory results after undergoing treatment. However, results of the University of California-Los Angeles Shoulder Scale test were lower in overhead-throwing athletes, indicating poorer treatment outcomes. In a case series of 25 overhand-throwing athletes in France, Boileau et al[31] noted that 40% of patients who underwent repair (n = 10) were satisfied with treatment. Return to pre-injury level of play was noted in 20% and 87% of patient-athletes treated with direct repairs and LHBT tenodesis, respectively.

Current Methods

A variety of treatment algorithms have been proposed, although no definitive standard exists. Results from a comprehensive literature review and professional recommendation suggest that clinical expertise is essential in deciding treatment of SLAP tears.[32] The author recommended tenodesis and debridement for treating type IV and degenerative or type I tears, respectively. For type II tears, repair of the labrum was only suggested for treating patients with acute trauma-related injuries, suspicious findings of physical examination, SLAP tears or paralabral cysts shown in an MRI arthrogram, and absence of injury to the biceps.

Furthermore, the effectiveness of techniques used to repair the superior labrum has been debated.[33] In a cadaveric study, DiRaimondo et al[34] showed that mattress sutures used for repairing superior labral tears could withstand more force than simple stitches or absorbable tacks. Similarly, Yoo et al[35] found that a horizontal mattress stitch had greater resistance to pullout forces than one or two simple stitches. Domb et al[36] also performed a cadaveric study, in which mean force until rupture or tear of the tendon was greater with use of two sutures, particularly horizontal mattress stitches.

The use of knotless anchors in repairing SLAP tears has also been examined. Yang et al[37] prospectively noted the outcomes of 46 patients treated with repair using knotless anchors, in which improved range of motion of the shoulder was noted postoperatively (in comparison to using traditional anchors). Another study[38] reported that a knotless repair possibly resulted in a meniscoid-shape appearance of the tear in the superior labrum.

Conclusion

SLAP tears are common injuries, frequently seen by general and sports-specialized orthopaedic surgeons. Abnormal appearances of labral tears may be a normal variant of the injury, sequel of aging, result of repetitive instances of microtrauma, or caused by an acute injury. Findings of physical examinations, although unreliable, can be helpful in deciding the next type of preoperative evaluation (ie, MRI) to confirm the diagnosis of a SLAP tear.

Treatment should be performed conservatively, with use of nonoperative methods and careful progression to surgical intervention. Operative procedures can be considered for patients with acute trauma-related tears of the labrum, tears with resultant instability of the shoulder, or tears involving chondral damage. Furthermore, patients with a paralabral cyst should be treated with decompression of the cyst, and labral repair may be considered. Biceps tenodesis or tenotomy and debridement of the superior labrum can be recommended for treating patients who underwent unsuccessful nonoperative treatment for chronic tears of the SLAP. Type II SLAP tears, in which the biceps tendon remains attached to a glenoid-detached labrum, can be treated when no obvious presence of injury to the biceps is noted. If performing a repair procedure, surgeons should consider use of more than one suture and horizontal mattress stitch.

Knowledge of the mechanisms behind and standard treatment for SLAP tears are limited. Additionally, long-term sequela of tenotomy and tenodesis for treating the LHBT remains uncertain. Clinical understanding of the injury may continue to increase as further studies are published on diagnosing and treating SLAP tears.

Funding

The author received no financial support for the research, authorship, and publication of this article.

Conflict of Interest

The author reports no conflict of interest.

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. Clavert P. Glenoid labrum pathology. Orthop Traumatol Surg Res 2015;101(suppl 1):S19-S24.
4. 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.
5. Soslowsky LJ, Flatow EL, Bigliani LU, Pawluk RJ, Ateshian GA, Mow VC. Quantitation of in situ contact areas at the glenohumeral joint: a biomechanical study. J Orthop Res 1992;10(4):524-34.
6. 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.
7. Gohlke F, Essigkrug B, Schmitz F. The pattern of the collagen fiber bundles of the capsule of the glenohumeral joint. J Shoulder Elbow Surg 1994;3(3):111-28.
8. Wattanaprakornkul D, Cathers I, Halaki M, Ginn KA. The rotator cuff muscles have a direction specific recruitment pattern during shoulder flexion and extension exercises. J Sci Med Sport 2011;14(5):376-82.
9. Wattanaprakornkul D, Halaki M, Cathers I, Ginn KA. Direction-specific recruitment of rotator cuff muscles during bench press and row. J Electromyogr Kinesiol 2011;21(6):1041-9.
10. Terry GC, Hammon D, France P, Norwood LA. The stabilizing function of passive shoulder restraints. Am J Sports Med 1991;19(1):26-34.
11. Kumar VP, Satku K, Balasubramaniam P. The role of the long head of biceps brachii in the stabilization of the head of the humerus. Clin Orthop Relat Res 1989;(244):172-5.
12. Pagnani MJ, Deng XH, Warren RF, Torzilli PA, O'Brien SJ. Role of the long head of the biceps brachii in glenohumeral stability: a biomechanical study in cadavera. J Shoulder Elbow Surg 1996;5(4):255-62.
13. Pagnani MJ, Warren RF. Stabilizers of the glenohumeral joint. J Shoulder Elbow Surg 1994;3(3):173-90.
14. Alexander S, Southgate DF, Bull AM, Wallace AL. The role of negative intraarticular pressure and the long head of biceps tendon on passive stability of the glenohumeral joint. J Shoulder Elbow Surg 2013;22(1):94-101.
15. Clavert P, Kempf JF, Wolfram-Gabel R, Kahn JL. Are there age induced morphologic variations of the superior glenoid labrum? About 100 shoulder arthroscopies. Surg Radiol Anat 2005;27(5):385-8.
16. 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.
17. 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.
18. 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.
19. 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.
20. Dodson CC, Altchek DW. SLAP lesions: an update on recognition and treatment. J Orthop Sports Phys Ther 2009;39(2):71-80.
21. 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.
22. Maffet MW, Gartsman GM, Moseley B. Superior labrum-biceps tendon complex lesions of the shoulder. Am J Sports Med 1995;23(1):93-8.
23. Cook C, Beaty S, Kissenberth MJ, Siffri P, Pill SG, Hawkins RJ. Diagnostic accuracy of five orthopedic clinical tests for diagnosis of superior labrum anterior posterior (SLAP) lesions [published erratum in J Shoulder Elbow Surg 2012;21(5):707]. J Shoulder Elbow Surg 2012;21(1):13-22.
24. Munro W, Healy R. The validity and accuracy of clinical tests used to detect labral pathology of the shoulder — a systematic review. Man Ther 2009;14(2):119-30.
25. 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.
26. Chloros GD, Haar PJ, Loughran TP, Hayes CW. Imaging of glenoid labrum lesions. Clin Sports Med 2013;32(3):361-90.
27. Connell DA, Potter HG, Wickiewicz TL, Altchek DW, Warren RF. Noncontrast magnetic resonance imaging of superior labral lesions: 102 cases confirmed at arthroscopic surgery. Am J Sports Med 1999;27(2):208-13.

28. Edwards SL, Lee JA, Bell JE, Packer JD, Ahmad CS, Levine WN, Bigliani LU, Blaine TA. 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.
29. Denard PJ, Lädermann A, Parsley BK, Burkhart SS. Arthroscopic biceps tenodesis compared with repair of isolated type II SLAP lesions in patients older than 35 years. Orthopedics 2014;37(3):e292-e297.
30. Kim SH, Ha KI, Kim SH, Choi HJ. Results of arthroscopic treatment of superior labral lesions. J Bone Joint Surg Am 2002;84-A(6):981-5.
31. Boileau P, Parratte S, Chuinard C, Roussanne Y, Shia D, Bicknell R. Arthroscopic treatment of isolated type II SLAP lesions: biceps tenodesis as an alternative to reinsertion. Am J Sports Med 2009;37(5):929-36.
32. Burns JP, Bahk M, Snyder SJ. Superior labral tears: repair versus biceps tenodesis. J Shoulder Elbow Surg 2011;20(suppl 2):S2-S8.
33. Kibler WB, Sciascia A. Current practice for the surgical treatment of SLAP lesions: a systematic review [Epub ahead of print Nov 6, 2015]. Arthroscopy 2015.
34. DiRaimondo CA, Alexander JW, Noble PC, Lowe WR, Lintner DM. A biomechanical comparison of repair techniques for type II SLAP lesions. Am J Sports Med 2004;32(3):727-33.
35. Yoo JC, Ahn JH, Lee SH, et al. A biomechanical comparison of repair techniques in posterior type II superior labral anterior and posterior (SLAP) lesions. J Shoulder Elbow Surg 2008;17(1):144-9.
36. Domb BG, Ehteshami JR, Shindle MK, et al. Biomechanical comparison of 3 suture anchor configurations for repair of type II SLAP lesions. Arthroscopy 2007;23(2):135-40.
37. Yang HJ, Yoon K, Jin H, Song HS. Clinical outcome of arthroscopic SLAP repair: conventional vertical knot versus knotless horizontal mattress sutures. Knee Surg Sports Traumatol Arthrosc 2016;24(2):464-9.
38. Dines JS, Elattrache NS. Horizontal mattress with a knotless anchor to better recreate the normal superior labrum anatomy. Arthroscopy 2008;24(12):1422-5.