Superior Labrum Anterior to Posterior (SLAP) lesions of the shoulder

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Abstract
Superior Labrum Anterior to Posterior (SLAP) lesions are an abnormality of the superior glenoid labrum and are a significant cause of shoulder pain and instability.

Pathology of the superior labrum can pose a significant diagnostic challenge, and therefore a sound knowledge of the relevant anatomy and associated variants is essential in diagnosing and treating these patients. In this article the capsulolabral anatomy and pathomechanics of SLAP lesions are revised. We then review current concepts in the clinical and radiological diagnosis of SLAP lesions and discuss approaches to operative management.

Keywords: glenoid labrum; shoulder arthroscopy; SLAP

Introduction
Tears of the superior glenoid labrum account for a significant burden of shoulder pain and instability. In 1985, Andrews et al first described lesions of the glenoid labrum in their series of 73 throwing athletes, mostly occurring in the anterior-superior labrum.1

In 1990, Snyder et al. proposed the term SLAP (Superior Labrum Anterior to Posterior) for lesions involving the superior aspect of the glenoid labrum.2 In these injuries labral separation from the glenoid begins posteriorly and extends anteriorly to include the origin of the long head of the biceps.

The reported incidence of SLAP lesions varies from 1.2% to 11.8%.3–5 Warner et al analyzed 585 consecutive shoulder clinic patients over a period of 3 years and found an incidence of 1.2%. In Snyder’s series of 700 shoulder arthroscopies, SLAP lesions were found in 3.9%. Maffet et al. reported a much higher incidence, with SLAP lesions accounting for 11.8% of the 712 consecutive shoulder arthroscopies performed. However, the incidence of SLAP lesions is much higher in patients with chronic shoulder instability and can occur in addition to other capsulolabral pathologies.6

Anatomy
The glenoid labrum is a fibrocartilaginous rim around the glenoid fossa. It is triangular in profile, with the base attached to the margin of the fossa. The inner free edge projects into, and continues the curve of, the glenoid, thus deepening the cavity. This helps contain the relatively large humeral head, which outsizes the glenoid fossa by a ratio of four to one. The blood supply to the peripheral labrum includes branches from the suprascapular artery, circumflex branch of subscapular artery and posterior humeral circumflex artery. The inner zone of the labrum is avascular. The superior and anterosuperior labrum is relatively less vascular than the posterior and inferior regions.

The fibrous capsule envelopes the joint and is supported by the tendon of supraspinatus superiorly, infraspinatus and teres minor posteriorly, subscapularis anteriorly and the long head of triceps inferiorly. The rotator interval is a triangular unsupported area of capsule medially, between the superior edge of subscapularis and the anterior edge of supraspinatus.

The three glenohumeral ligaments — superior, middle and inferior, reinforce the joint capsule anteriorly and inferiorly. The superior glenohumeral ligament (SGHL) passes from the superior glenoid tubercle just anterior to the long head of biceps to the humerus on the medial ridge of the intertubercular (bicipital) groove. Along with the coraco-humeral ligament the SGHL suspends the humeral head and provides stabilization to inferior translation. The middle glenohumeral ligament (MGHL) arises from the anterior, middle and posterior margins of the glenoid labrum and passes inferolaterally to attach to the lesser tubercle deep to the tendon of subscapularis. It acts as an important secondary stabilizer of the shoulder, providing anterior stability from 45 to 60° of abduction. The inferior glenohumeral ligament (IGHL) complex arises from the anterior, middle and posterior margins of the glenoid labrum and passes anteroinferiorly to the neck of the humerus. It comprises a superior band, an anterior band and an axillary pouch. The anterior band is the primary anterior stabilizer of the shoulder beyond 60° of abduction.

The long head of biceps arises from the supraglenoid tubercle and superior labrum and passes through the joint, to exit by the bicipital groove. Studies have shown that the biceps contributes to stability in patients with a damaged rotator cuff or glenohumeral ligaments.7–9

There are several important anatomical variations, which must be appreciated when reviewing radiological investigations and at arthroscopy to avoid misinterpretation as pathological features.

Anatomical variants
Buford complex
A Buford complex is a large anterosuperior labral foramen occurring with a thickened, cord-like MGHL and is found in 1.5–10.2% of individuals.10–13 This can resemble an anterior labral avulsion or a superior labral tear on Magnetic Resonance Imaging (MRI), but is readily identifiable at arthroscopy. The presence of a Buford complex alone does not require surgical intervention, but if mistakenly repaired can lead to pain and restricted shoulder rotation and elevation.
Sub-labral foramen
A sub-labral foramen is typically located in the anterosuperior quadrant and has an incidence of 11.9–18.5% in patients undergoing shoulder arthroscopy. Rao et al. and Ilahi et al. concluded that a sub-labral foramen should not be repaired, particularly when found in isolation, as they do not contribute significantly to shoulder stability.

MGHL variations
The MGHL is absent in 30–40% of shoulders. When present, it can arise from the anterosuperior labrum, the supraglenoid tubercle or the scapular neck. It can also vary in its appearance from a cord-like to a sheet-like structure. The cord-like variant presents with a foramen between MGHL and IGHL and the sheet-like variant presents as a sheet merging with the anterior band of IGHL.

Superior labral variations
Variations of the superior labrum occur due to its loose attachment to the glenoid and its association with the long head of the biceps. Firstly, extensive variations in the origin and insertion of the long head of the biceps have been described. Secondly, the presence of a synovial recess between the superior labrum and the biceps tendon can be misinterpreted as a SLAP lesion. Finally, a meniscoid superior labrum is a normal anatomical variant and does not require repair.

Pathophysiology
Several anatomical and biomechanical factors predispose to SLAP lesions. The strength of the superior labrum/biceps complex varies according to shoulder position. In the initial description of SLAP lesions, the pathophysiology was attributed to forces applied to the long head of biceps during the follow-through phase of throwing. However, subsequent studies have demonstrated that SLAP tears occur more commonly in the late cocking position of throwing. Kuhn et al. showed that tension in the biceps tendon was 20% less in the late cocking phase of throwing than in the early deceleration phase. This finding was confirmed by Shepard et al., who demonstrated that tension on the biceps anchor was almost doubled during the deceleration phase compared to the late cocking phase of throwing.

Overhead throwing athletes have been shown to have an increased range of movement in external rotation, with a corresponding reduction in internal rotation. This has been attributed to a number of factors, including posterior capsular contracture, anterior capsular laxity and increased proximal humeral retroversion. A tight posterior capsule results in increased posterosuperior migration of the humeral head. Anterior capsular laxity along with proximal humeral retroversion results in greater external rotation of the shoulder. This causes increased torsional loads across the superior labrum from the more posteriorly positioned biceps tendon. This results in displacement of the labrum and biceps tendon medially over the glenoid rim, producing a ‘peel-back’ injury to the labrum.

Another predisposing factor to increased labral injury is the presence of SICK (Scapula malposition/Inferior medial border prominence/Coracoid pain, dysKinesis) scapula. Scapular protraction and increased glenoid ante-tilting seen in SICK scapula cause increased glenohumeral angulation. This results in abnormal posterior compression and anterior tension, thereby increasing the risk of labral injury.

Classification
Snyder et al. initially classified SLAP lesions into four types based on arthroscopic findings in their study of 27 patients presenting with pain and/or clicking of the shoulder (Figures 1–4). Morgan et al.
further divided SLAP II lesions into three subtypes\textsuperscript{29} and in 1995, Maffet et al added three types to Snyder’s original classification.\textsuperscript{5} The classification system has continued to develop and there are now 10 types of SLAP lesion described in the literature (Table 1).

### Clinical features

The clinical diagnosis of SLAP lesions can be challenging, as the symptoms are often non-specific. Patients often present with a history of pain and associated locking, clicking or snapping. The pain is particularly associated with overhead or cross-body motion and patients may also complain of weakness or instability.

### Classification of SLAP lesions

<table>
<thead>
<tr>
<th>Type of lesion</th>
<th>Description</th>
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<tbody>
<tr>
<td>I</td>
<td>Marked fraying of the free edge of the superior labrum, with an intact biceps tendon. These lesions are associated with age-related degeneration (Figure 1).</td>
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<tr>
<td>II</td>
<td>Avulsion of the labral—bicipital complex from the superior glenoid. These are the most common type of SLAP lesions and are associated with repetitive microtrauma (Figure 2).</td>
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<tr>
<td>IIA</td>
<td>Anterosuperior labral lesion.</td>
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<tr>
<td>IIB</td>
<td>Posterosuperior labral lesion.</td>
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<tr>
<td>IIC</td>
<td>Superior labral lesion extending both anteriorly and posteriorly.</td>
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<tr>
<td>III</td>
<td>Displaced bucket handle tears of the superior labrum with a preserved biceps anchor. These are associated with a fall on an outstretched arm (Figure 3).</td>
</tr>
<tr>
<td>IV</td>
<td>Bucket handle tear of the superior labrum, with extension into the fibers of the biceps tendon. A partially torn biceps tendon may displace the superior labral flap into the joint (Figure 4).</td>
</tr>
<tr>
<td>V</td>
<td>Anteroinferior Bankart lesion that extends upward to include separation of the biceps tendon.</td>
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<tr>
<td>VI</td>
<td>Unstable radial or flap tears that are associated with separation of the biceps anchor.</td>
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<tr>
<td>VII</td>
<td>Extension of a type II or III SLAP lesion into the MGHL. However, extension into the MGHL can be difficult to ascertain on MRI due to the variable nature and redundant folding of MGHL.</td>
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<tr>
<td>VIII</td>
<td>A SLAP II or III lesion plus a posterior labral tear.</td>
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<tr>
<td>IX</td>
<td>Circumferential labral tears with anterior and posterior labral involvement.</td>
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<tr>
<td>X</td>
<td>Superior labral tears with extension into the rotator cuff interval through the SGHL.</td>
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The patients may give a history of trauma. The two most common mechanisms of injury leading to SLAP lesions are avulsion of the labrum by the long head of the biceps, usually resulting from repetitive overhead throwing, and compression forces applied to the shoulder, typically resulting from a fall on an outstretched arm. Other mechanisms of injury include forceful traction loads to the arm, impaction loading on the shoulder when it is forward flexed and direct traction injury to the biceps tendon.

### Examination

A number of clinical tests have been described to determine the presence of SLAP lesions. These include O’Brien’s, the
compression rotation test, Speed’s, Clunk test, Crank test, Kibler’s, Kim’s Biceps Load Test I and II and Mimori’s test. However, no single test is diagnostic.

**O’Brien’s active compression test**: performed with the shoulder placed in 90° forward elevation and 30° horizontal adduction. The examiner then applies a downward force on the forearm, first while the forearm is pronated and then with the forearm supinated. The test is positive when pain is elicited with the forearm pronated (Figure 5) and relieved when the forearm is supinated (Figure 6). The sensitivity and specificity vary from 54 to 100% \(^{30,31}\) and 11 to 99.5% \(^{30,32}\) respectively.

**Compression rotation/grind test**\(^2\): with the patient in the supine position, the glenohumeral joint is compressed from the elbow through the long axis of the humerus as the shoulder is passively rotated. This attempts to grind the labrum between the glenoid and humeral head to elicit pain. The sensitivity and specificity vary from 24 to 73% \(^{33,35}\) and 54 to 100% \(^{33,35}\) respectively.

**Speed’s/Biceps tension test**\(^2\): performed with the shoulder placed in 90° forward elevation, the elbow extended and forearm supinated. The examiner applies downward force to the arm against resistance to reproduce pain in patients with SLAP lesions (Figure 7). The sensitivity and specificity vary from 32 to 90% \(^{36-38}\) and 13 to 81% \(^{36-39}\).

**Clunk test**\(^1\): performed with the patient supine. Anterior translation of the humeral head is performed using one hand, while externally rotating the shoulder at the elbow with the other hand. The presence of a clunk or grinding sound indicates a labral tear. The sensitivity and specificity are reported as 44% and 68% respectively.\(^{44}\)

**Crank test**: can be performed with the patient sitting or supine.\(^{40}\) With the shoulder elevated to 160° in the plane of the scapula, the examiner applies an axial load whilst internally and externally rotating the humerus. Typically, patients with SLAP lesions report pain on external rotation. The sensitivity and specificity vary from 39 to 91% \(^{31,41,42}\) and 56 to 93% \(^{31,41,42}\) respectively.

**Kibler’s anterior slide test**: is performed with the hand on the ipsilateral hip with the thumb positioned over the anterior superior iliac spine.\(^{43}\) The scapula is stabilized and an anteromesially directed axial load is applied to the humerus to reproduce pain. The sensitivity and specificity vary from 8 to 78% \(^{33,34,44}\) and 70 to 98% \(^{33,35,44}\) respectively.

**Kim’s Biceps Load Test I**: the biceps is contracted against resistance with the shoulder placed in 90° abduction, maximal external rotation and the forearm supinated.\(^{45}\) Deep shoulder pain on this manoeuvre indicates a SLAP lesion. Kim reported a sensitivity of 91% and a specificity of 97%.\(^{45}\) Further refinement of this test led to a description of Biceps Load Test II.\(^{46}\) This is performed in the same manner as the original test, with the shoulder abducted to 120°. The sensitivity and specificity vary from 30 to 90% \(^{35,46}\) and 78 to 97% \(^{35,46}\) respectively.

**Mimori’s pain provocation test**: the shoulder is abducted to 90° and externally rotated with forearm in full pronation.\(^{47}\) The presence of pain on pronation indicates the presence of a SLAP lesion. This has a reported sensitivity of 100% and a specificity of 90%.\(^{47}\)
Imaging

If a SLAP lesion is clinically suspected, radiological investigation needs to be considered prior to planning surgical intervention. The most frequently used imaging modalities are MRI and MR arthrography. A normal superior glenoid labrum has low intensity signal on all MRI sequences. The superior glenoid labrum is associated with a significant number of anatomical variations, including Buford complexes, sub-labral foramen and sub-labral

Figure 6 O’Brien’s active compression test — pain relieved when the forearm is supinated.

Figure 7 Speed’s/Biceps tension test — the shoulder is positioned in 90° of forward flexion with the elbow extended and forearm supinated. Pain is elicited when a downward pressure is applied to the arm.
recesses, as discussed above. These can complicate the interpretation of MRI. Furthermore, MRI is unable to differentiate the different types of SLAP lesions. The use of a contrast medium is beneficial in distinguishing pathology from normal anatomical variants and in classifying the type of SLAP lesion. This can be achieved through either direct (intra-articular injection of contrast) or indirect (intravenous contrast) MR arthrography (Figures 8 and 9).

Studies comparing MR arthrography with standard MRI have shown superior sensitivity and accuracy in favour of arthrography, without influencing specificity.48,49 Furthermore, using arthroscopy as the gold standard, MR arthrography has shown a sensitivity ranging from 82 to 89% and a specificity of 91–98% for the detection of SLAP lesions.50,51

If a SLAP lesion is identified on MRI or MR arthrography, further characterization of the abnormality is necessary to plan operative intervention. This involves assessment of the lesion for the presence of a bucket handle tear or flap fragment, involvement of the biceps anchor and adjacent structures. Any associated abnormalities such as glenohumeral osteoarthritis, para-labral cysts and glenoid fractures must also be identified.

Treatment

The conservative management of symptomatic SLAP lesions is generally unsuccessful, particularly when associated with other pathologies such as rotator cuff tears and joint instability. At arthroscopy the superior labrum and the biceps anchor are evaluated with a hook probe to assess stability. Burkhart describes a ‘Peel-back’ sign, which is the detachment of the biceps–superior labral complex medially over the edge of the glenoid at 90° abduction and 90° external rotation.52 A positive ‘peel-back’ test indicates a posterior SLAP lesion. An anterior SLAP lesion is identified by a displaceable biceps root.

A combined anterior–posterior SLAP lesion demonstrates both a positive ‘peel-back’ test and a displaceable biceps root.

Type I lesions do not ordinarily necessitate treatment unless symptoms continue to progress or there is significant fraying. In such cases, the lesion is debrided back to a stable labrum.

When the labral ring is detached, as in a Type II lesion, arthroscopic repair involves re-attachment of the superior labrum to the glenoid and stabilizing the biceps anchor. Fixation techniques include bio-absorbable tacks, suture anchors and knotless fixation methods. Accurate portal placement is crucial in achieving good access for anchor placement, suture passing and knot-tying. A posterior portal is used for viewing while a high anterolateral portal is used for anchor placement. A further working portal is placed anteriorly through the rotator cuff interval. The suture anchor is inserted through the anterolateral portal below the biceps root. A suture-passer is used to pass the suture through the same portal to penetrate through the labrum and the sutures are then tied from anterior to posterior. Burkhart describes the ‘money stitch’, which is the suture placed just posterior to the biceps root. This is the most effective suture in resisting the ‘peel-back’ force.53

Type III, as for Type I lesions, should be debrided back to a stable labrum. The exemption to this is lesions involving a Buford complex which should be repaired using a method similar to that described above for a Type II tear.

The treatment for Type IV lesions depends on the extent of biceps anchor involvement. If the biceps tendon tear is greater than 25% of the entire tendon, a biceps tenodesis is performed. In older patients with a substantial tear the labrum is debrided and a biceps tenotomy performed.

Patients must also be assessed for concomitant rotator cuff pathology. Patients with SLAP tears may present with concurrent PASTA (Partial Articular Sided Tendon Avulsion) lesions. Treatment options include debridement of the PASTA lesion, typically when the tear is less than 6 mm of the thickness of the
rotator cuff, in-situ repair of the rotator cuff and completing the tear to full thickness and repairing it in the usual manner. Simultaneous repair of the SLAP and rotator cuff tears poses a high risk of post-operative stiffness. For this reason, it is the author’s preference to repair the rotator cuff combined with a biceps tenodesis.

For the first 3 post-operative weeks the patient’s shoulder is immobilized in internal rotation in a sling. Thereafter, physiotherapy is commenced to restore stability and improve mobility of the joint.

Outcome
The outcome following operative intervention for SLAP lesions depends on the method of treatment and the presence of co-existing pathology. Snyder et al. published a retrospective review of 140 patients who underwent arthroscopic SLAP repair. They found that repair with the suture anchor technique was successful in 80% of patients. In a recent prospective study by Brockmeier et al., excellent results were achieved in 74% of athletes undergoing arthroscopic suture anchor repair of Type II SLAP lesions.

Summary
SLAP lesions are a significant cause of pain and disability amongst those presenting to the shoulder clinic. Although the clinical diagnosis remains a challenge because of the lack of a single diagnostic test and the frequent presence of other lesions, advances in diagnostic imaging and arthroscopic techniques have led to a much improved outcome and restoration of function in this patient group.

REFERENCES


