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INJURIES IN OVERHEAD ATHLETES (J DINES AND C CAMP, SECTION EDITORS)

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Injuries of the Biceps and Superior Labral Complex in Overhead Athletes

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Abstract
Purpose of Review To summarize the current anatomy, biomechanics, presentation, treatment, and outcomes of injuries to the biceps and superior labral complex in overhead athletes.
Recent Findings The biceps and superior labral complex is composed of anatomically distinct zones. The inability to accurately diagnose biceps lesions contributes to continued morbidity especially as arthroscopy and advanced imaging fail to fully evaluate the entire course of the biceps tendon. Superior labrum anterior and posterior (SLAP) repair, long head of biceps tenodesis, and tenotomy are the most common operative techniques for surgical treatment of biceps-labral complex (BLC) pathology. Labral repair in overhead athletes has resulted in mixed outcomes for athletes and is best indicated for patients under age 40 years old.
Summary Injuries to the BLC are potentially challenging injuries to diagnose and treat, particularly in the overhead athlete. SLAP repair remains the treatment of choice for high-level overhead athletes and patients younger than 40 years of age, while biceps tenodesis and tenotomy are preferred for older patients.

Keywords Long head of biceps tendon · SLAP · Superior labral complex · Overhead athletes · Tenodesis · Tenotomy

Introduction

In 1985, Andrews et al. [1] reported a series of 120 patients undergoing shoulder arthroscopy, 73 of which were athletes. The authors evaluated the position of the long head of the biceps tendon (LHBT) relative to its insertion on the glenoid labrum and noted associated tearing of the labrum [1]. Subsequently, Snyder et al. [2•] described their classification system for superior labrum anterior and posterior (SLAP) lesions. Injuries to the biceps and superior labral complex commonly affect overhead athletes and can have devastating consequences to performance and play. The failure to identify and adequately address these injuries can lead to both loss of performance and a potential inability to return to play.

This article is part of the Topical Collection on *Injuries in Overhead Athletes*

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Anatomy

Recent literature focuses on the importance of the LHBT's entire course, from the musculotendinous junction to its insertion on the glenoid labrum [3, 4•, 5]. The biceps-labral complex is formed by the LHBT and the glenoid labrum. It is further divided into three distinct zones: inside, junction, and the bicipital tunnel [5]. The first zone includes the biceps anchor, which is the point of attachment of the LHBT onto the superior labrum and supraglenoid tubercle [5]. Junction refers to the intra-articular portion of the tendon and its stabilizing pulley, which is a capsuloligamentous structure that stabilizes the tendon within the proximal portion of the bicipital groove [5]. The junctional zone can be viewed arthroscopically within the glenohumeral joint. Lastly, the bicipital tunnel is the extra-articular portion of the LHBT that is fully enclosed by a fibro-osseous sheath and extends from the articular border to the subpectoralis region [5].

Taylor et al. [4•] further identified three anatomically and histologically distinct zones of the bicipital tunnel. The first is the traditional bony groove of the bicipital tunnel extending inferiorly from the articular margin to the distal margin of the subscapularis (DMSS) muscle. The second zone extends from the DMSS to the proximal margin of the pectoralis major tendon (PMPM) and cannot be viewed either arthroscopically or from exposure beneath the pectoralis [4•]. The third zone is the subpectoralis region.

The recognition that the biceps is a pain generator has many important implications [6]. The failure to properly diagnose and address the biceps during arthroscopic surgery may lead to persistent post-operative pain, and this may frequently affect overhead athletes. Within a single organization, Camp et al. [7••] found that biceps tendonitis was the most commonly occurring shoulder injury in baseball players.

Biomechanics of the Biceps Labrum Complex and Throwing

In conjunction with the static stabilizers of the shoulder and the rotator cuff, the biceps is thought to contribute to shoulder stability, although its exact role has not been fully elucidated.

Pagnani et al. [8] demonstrated that force applied along the LHBT reduced superior-inferior and anterior-posterior humeral head translation and stabilized the glenohumeral joint anteriorly during internal rotation and posteriorly during external rotation, especially at elevation levels below 45° [8]. In addition, multiple studies reveal increases in glenohumeral translation when a type 2 SLAP tear is created [9, 10]. Furthermore, Mihata et al. [11] demonstrated the importance of the anterior capsular ligaments in preventing excessive humeral head translation.

The biomechanics of the baseball pitch have been extensively studied in the literature and consist of six phases: wind-up, stride, arm cocking, arm acceleration, arm deceleration, and follow-through. Furthermore, the cocking phase has been divided into early and late cocking based upon loads placed upon the shoulder and elbow. During each of these phases, energy is transferred from the lower limbs and trunk to the arm creating large angular velocities. This transfer of energy is referred to as the kinetic chain [12].

The late cocking, early acceleration, and deceleration phases have been implicated in injuries to the shoulder and elbow during throwing [13]. During the cocking phase, elbow flexion and shoulder external rotation rapidly increase as shoulder abduction reaches its maximum. Potential energy is generated as the arm and hand lag behind the continuously rotating trunk and shoulder. Rapid horizontal shoulder abduction and external rotation lead to a large rotational velocity at the glenohumeral joint. During the acceleration phase, the arm internally rotates from maximum external rotation. After the ball is released, arm deceleration occurs to dissipate the tremendous amount of energy created in the previous phases. The shoulder reaches maximum internal rotation and the elbow flexors eccentrically contract resulting in elbow flexion. Finally, during follow-through, the biceps contracts to decelerate the elbow and forearm [12].

Adaptations of the Overhead Athlete and Pathoanatomy

Several anatomic adaptations occur in throwers with repetitive overhead motion. At 90° of shoulder abduction, there is a shift in the total arc of rotation toward increased external rotation and subsequent decreased internal rotation compared to the contralateral side [7••, 14]. This may lead to pathologic loss of rotation, as overhead athletes may develop decreased internal rotation in their throwing shoulder due to a tight posterior-inferior capsule [13, 15]. Glenohumeral internal rotation deficit (GIRD) is defined as an internal rotation deficit of at least 20° compared to the contralateral side in addition to a loss of total arc of motion [7••, 14, 15]. In recent studies, however, GIRD may not be the only predisposing factor leading to shoulder injury [7••, 14]. Rather, an external rotation deficit of more than 5° compared to the contralateral side may be a predisposing factor to shoulder injury [7••, 14]. High-level overhead athletes must also maintain a unique balance between capsular laxity to allow for sufficient external rotation yet maintain enough stability to prevent glenohumeral subluxation [15]. Excessive capsular laxity and muscle weakness can lead to glenohumeral instability and ultimately biceps-labral complex (BLC) lesions [15].

Lesions affecting the LHBT are localized based upon the zones of the BLC. Inside lesions consist of SLAP tears, anterior labrum tears, posterior labrum tears, and entrapment of the LHBT within the glenohumeral joint [3, 16, 17]. Junctional lesions include subscapularis insufficiency which may result in LHBT instability, biceps pulley lesions, partial tears of the LHBT, and repeated wear of the humeral head as a result of abnormal tracking of the LHBT, referred to as biceps chondromalacia [3, 6, 16, 17]. Lastly, the extra-articular lesions of the bicipital tunnel can include scarring, stenosis, LHBT instability, loose bodies, and partial tearing of the LHBT [3, 16, 17].

Repetitive overhead motion is primarily indicated as the cause of SLAP tears, and several mechanisms have been proposed [15]. Traumatic events leading to SLAP tears are also described in the literature [2•, 18]. Andrews et al. [1] initially reported that these injuries occur during arm deceleration as the biceps contracts and transmits tension to the anterior superior portion of the labrum, pulling at the insertion site. Burkhart and Morgan [18] theorized that repeated vertical and posterior shifts in the angle of the LHBT during the cocking phase of throwing transmit torsion to the labrum and peel it back, commonly referred to as the "peel back" mechanism. In addition, disruptions of the kinetic chain, throwing motion, or technique can also have downstream effects as other joints compensate for increased forces [7••, 12, 15].

Presentation and Evaluation

The identification of BLC pathology presents a diagnostic challenge to clinicians, and a variety of physical exam maneuvers and imaging modalities have been utilized with varying success. One of the challenges that clinicians face during the identification of these lesions is the high incidence of concomitant shoulder injuries.

Evaluation of the athlete should begin with a thorough history. The athlete should be asked to describe their pain in detail with emphasis toward location and painful movements. Common symptoms localized to the BLC include anterior shoulder pain and a painful clicking or popping sensation during the cocking phase [15]. In addition, the athlete may report a gradual loss of throwing function, overhead motion, and loss of throwing velocity [6, 15].

Next, glenohumeral and scapulothoracic range of motion should be assessed and recorded bilaterally in the supine position. With the scapula stabilized, internal and external rotations are measured with the shoulder abducted to 90° and the elbow flexed to 90°. Strength testing should focus on the biceps and rotator cuff muscles bilaterally.

O'Brien et al. [19] described the active compression test, which involves the patient standing with the arm fully extended at the elbow, forward flexed to 90° and adducted 10 to 15° medial to the sagittal plane with the arm internally rotated and forearm pronated. The clinician then applies a downward force to the arm. The forearm is subsequently supinated with the arm held in the same position and a force is again applied. The test is considered positive if pain is elicited during the first phase and either relieved or decreased following supination. The pain generated during this test is believed to be due to tensioning of the BLC as the LHBT displaces medially and inferiorly [19]. To decrease errors in patient positioning, Urch et al. [20] described a modification to the active compression in which both arms were adducted to 10–15° and the patient positions the dorsum of their hands so that they touch at the midline. A similar maneuver, as described by Verma et al. [21], can be performed arthroscopically and in the presence of a SLAP lesion, the torn labrum can be visualized displacing into the joint as the BLC becomes entrapped and compressed. With isolated biceps pathology, the LHBT is visualized displacing into the joint. As above, this entrapment is relieved with external rotation.

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of physical exam maneuvers to identify biceps and labral lesions have been studied in the literature with varying results [15]. To address the diagnostic shortcomings of singular examination findings and better localize lesions, combination tests have been developed. The "3-Pack" examination includes the active compression test, the throwing test, and bicipital tunnel palpation [22•]. The throwing test is performed with the shoulder abducted to 90°, the elbow flexed at 90°, and maximal external rotation to replicate the late cocking phase. The acceleration phase is then simulated as the patient steps forward with the contralateral leg while the clinician provides isometric resistance. Taylor et al. [22•] examined the ability of the "3-Pack" to diagnose inside lesions, junctional lesions, and bicipital tunnel lesions. The authors found that a negative active compression test and no pain elicited with bicipital tunnel palpation ruled out hidden extra-articular bicipital tunnel disease with a negative predictive value of 93 to 96%. In addition, the authors found that the active compression test had a sensitivity of 95.7% and tenderness to palpation had a sensitivity of 97.8% when detecting bicipital tunnel lesions [22•]. Rosas et al. [23] found the uppercut test combined with tenderness to palpation along the LHBT had a sensitivity of 88% to localize lesions to the proximal biceps.

Following the history and physical examination, standard anteroposterior, true anteroposterior (Grashey view), lateral, and axillary shoulder radiographs should be performed to rule out osseous pathology or joint incongruity [3, 15]. Additional imaging may include magnetic resonance imaging or magnetic resonance arthrography (Fig. 1) [15, 24]. Amin et al. [24] reported the sensitivity of MRA in the detection of SLAP lesions to be 90% with a specificity of 50%. MRI in particular has yielded variable results in detecting BLC lesions. As summarized by Gausden et al. [3], the sensitivity of MRI to detect LHBT pathology has ranged from 38 to 89% and 38 to 98% for SLAP tears. Additionally, MRI may fail to detect lesions in the various zones of the LHBT. Taylor et al. [16] found a sensitivity of 77.3%, specificity of 68.7%, PPV 57.3%, and NPV of 84.5% to detect inside lesions and 43.3%, 55.6%, 73.1%, and 26.0% for junctional lesions respectively. Lastly, to detect lesions in the bicipital tunnel, MRI was found to have a sensitivity of 50.4%, specificity of 61.4%, PPV of 48.7%, and NPV of 63.0%.

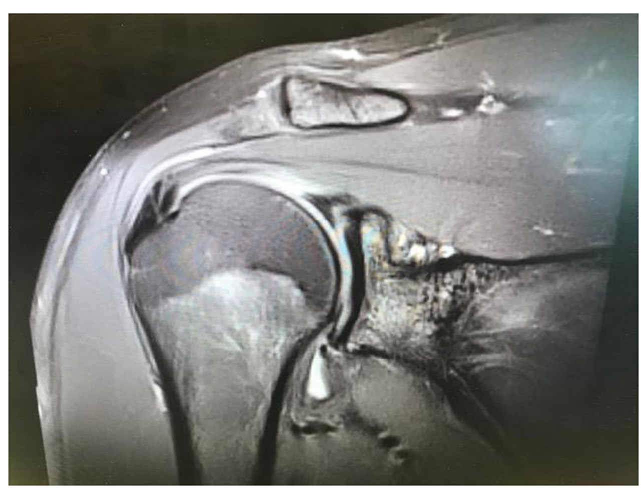

Fig. 1 Coronal view of a MRI showing a superior labrum consistent with a superior labrum anterior and posterior (SLAP) tear

In addition to MRI being unable to reliably detect junctional and bicipital groove lesions, arthroscopy is unable to fully evaluate BLC lesions. Festa et al. [25] found that following the arthroscopic pull test, only 30.8% of the extra-articular region could be visualized and only 48% of the tendon within the bicipital groove could be visualized [25]. Similarly in a cadaveric study, Taylor et al. [17] found that during arthroscopy, 56.3% of the total length of the LHBT relative to DMSS, 39.6% respective to the PMPM, and 33.0% relative to the MTJ was visualized at rest. When the tendon was pulled into the joint, this was improved to 78.4%, 55.0%, and 45.9% respectively. In a parallel clinical series, 277 patients were reviewed and 47% of these patients were found to have bicipital tunnel lesions that were not visualized during arthroscopy. Scarring, LHBT instability, and stenosis were the most commonly found lesions, and these extra-articular lesions may further limit the ability to evaluate the LHBT, as the tendon excursion is affected during the pull test [17]. In a series of patients undergoing subpectoral tenodesis, Moon et al. [26] found that all LHBT tears extended into the bicipital tunnel with 77.8% extending to the subpectoral zone. The authors also found that tenosynovitis was present in 77.8% and extended extra-articularly [26].

Classification

Numerous SLAP lesion classification systems exist. The most commonly used is the classification initially described by Snyder et al. [2•]. They described four injury patterns involving the peripheral labral edge and biceps anchor, with the most common pattern being the superior labrum and the biceps tendon are pulled off the underlying glenoid resulting in an unstable biceps anchor (type II, Fig. 2). Morgan et al. [27] later subclassified type II lesions: anterior, posterior, and combined anteroposterior.

Treatment

Following evaluation, treatment should first focus on non-operative rehabilitation [3, 15, 28]. Pain can be initially addressed with nonsteroidal anti-inflammatory drugs (NSAIDs). Physical therapy should focus on range of scapulothoracic and glenohumeral motion as well as improving muscle strength, balance, stability, and endurance [6, 15]. Pain refractory to NSAIDs can be addressed with an anesthetic and corticosteroid combination injection into the bicipital tunnel, which may be both diagnostic and therapeutic [3, 6, 29, 30]. In the setting of GIRD, focus should be paid to stretching the posteroinferior capsule, most commonly with the "sleeper stretch" [15].

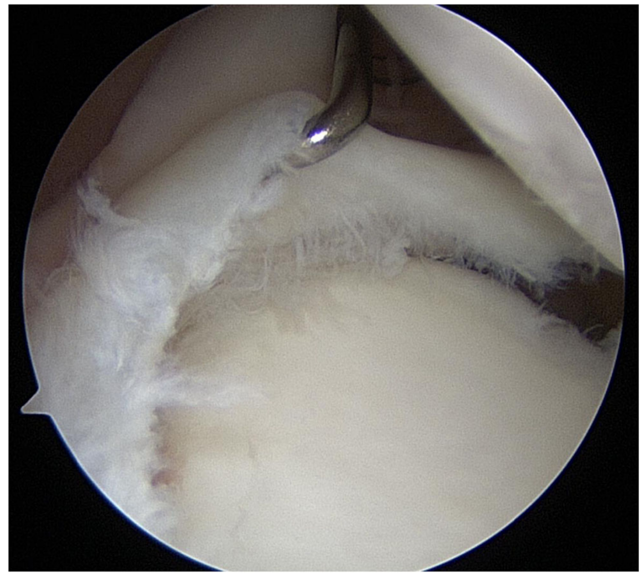

Fig. 2 Intraoperative arthroscopic photograph of a type II superior labrum anterior and posterior (SLAP) tear as viewed from the posterior portal to the shoulder joint

If symptoms persist despite a comprehensive course of non-operative management, operative management may be required to allow the athlete to return to play. Due to the inability to accurately diagnose lesions within the bicipital tunnel, treatments should be considered based on their ability to decompress the tunnel, especially if there is a high likelihood of a bicipital tunnel lesion. Given the likelihood of diagnostic uncertainty of identifying lesions within the bicipital tunnel, treatments should be organized into their ability to decompress the bicipital tunnel [3].

Non-decompressing techniques include SLAP repair, proximal tenodesis, and tenotomy. SLAP repair is well described in the literature and consists of repairing the biceps anchor and labrum with the use of suture anchors [15, 28]. Multiple techniques have been described for anchor and suture technique; however, the use of a knotless anchor system (Fig. 3) may be beneficial to use in the athlete as the knots do not interfere with the glenohumeral joint space [15, 31]. In addition, a horizontal mattress pattern can be utilized to prevent abrasion of the humeral head and recreate the anatomic meniscoid appearance of the labrum [15, 31]. Provencher et al. [32] prospectively followed 179 active duty military personnel, and while the investigators found an improvement in functional outcomes post-operatively, 36.8% (66/179) failed surgical treatment and 44 required revision surgery. When analyzing factors associated with failure, they found that age greater than 36 years was a significant risk factor for revision with a relative risk of 3.45 [33]. In a review of a national patient database, Taylor et al. [34] found age greater than 40 years old to be a risk factor for revision surgery with an odds ratio of 1.6 following SLAP repair. In addition, they found female sex (OR 1.5) and tobacco usage (OR 2.0) to be demographic risk

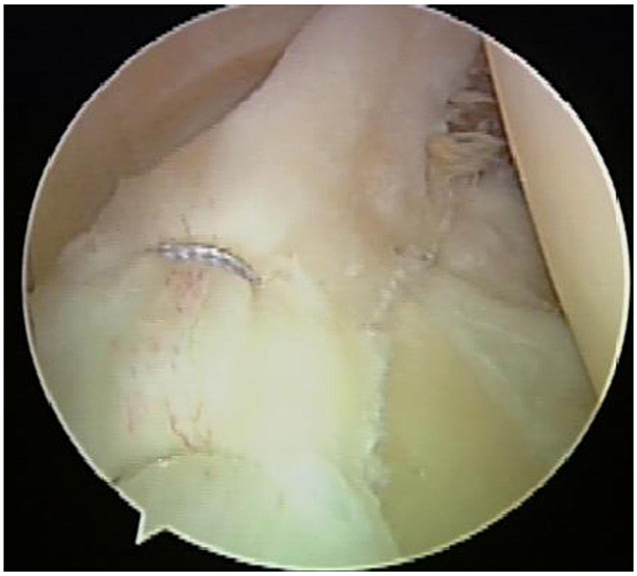

Fig. 3 Intraoperative arthroscopic photograph of prior patient with type II SLAP tear treated with a knotless suture anchor system

factors and concomitant diagnoses of biceps tendonitis or LHBT tear to be significant risk factors (OR 3.5, 5.1 respectively) [34]. The findings of biceps involvement as a significant risk factor for revision underscore both the importance of proper diagnosis of hidden biceps disease and the necessity to select procedures that will address biceps pathology.

Tenotomy involves release of the biceps tendon, which ultimately relieves pain by preventing further tension on the injured BLC [3, 29, 35]. Advantages of tenotomy include a quick procedural time, adequate relief of pain, and return to activity following surgery. While there is a reported high satisfaction rate following tenotomy in certain patient populations, there may be continued muscle soreness, fatigue, post-operative decreases in strength during elbow flexion and forearm supination, and cosmetic "Popeye sign" deformity [3, 29, 35, 36]. The potential loss of strength during elbow flexion and supination generally precludes tenotomy in the overhead athlete population. In a systematic review, Erickson et al. [37] recommended tenotomy or tenodesis over SLAP repair in patients over 40 with an associated rotator cuff injury. Biomechanics studies have also examined the effect of labral repair following tenotomy. Patzer et al. [9] found that following tenotomy, SLAP repair had no effect on glenohumeral translation and could not restore native motion.

Proximal tenodesis is the transfer of the LHBT to a new fixation point [35]. Purported advantages include maintenance of strength and rotation, decreased post-operative cramping, preservation of the length-tendon relationship, and improved cosmetic results. Disadvantages include a more complex operation, and similar to SLAP repair, a longer period of post-operative immobilization and rehabilitation. Several complications also exist and include length-tension mismatch, loss of fixation, and stiffness [35]. Recent literature has focused on tenodesis for young, active patients [36]. Werner et al. [36] found a significant increase in the number of biceps tenodesis being performed in the USA over a 4-year period from 2008 to 2011, especially in patients aged 60–69 years old and 20–29 years old with commonly associated diagnoses being biceps tenosynovitis and SLAP lesions. Similarly, Erickson et al. [38] found an increase in the number of biceps tenodesis being performed for SLAP repair from 2004 to 2011; however, there was no change in average age over time at 49.33 years at a single institution.

Decompressing techniques include proximal tenodesis that releases zones 1 and 2 of the bicipital tunnel, open subpectoral tenodesis, and arthroscopic subdeltoid tenodesis [3, 30]. Open subpectoral tenodesis involves fixation of the LHBT to the humerus via drilling and screw or anchor fixation [3, 30, 39]. Disadvantages of this technique include an open incision, potential risk of humeral shaft fracture through formation of a stress riser, and neurovascular injuries given the proximity of the musculocutaneous nerve, radial artery, and brachial artery [3, 30]. In comparison with patients who underwent SLAP repair in the treatment of type 2 SLAP lesions, Ek et al. [39] found no difference in either clinical outcomes or return to sport for patients that underwent open subpectoral tenodesis; however, patients who underwent tenodesis were generally older than 35. In addition, patients were selected for either procedure depending on the quality of their superior labrum at the time of surgery, with those patients undergoing tenodesis having arthroscopic evidence of a degenerative labrum. Patients who underwent SLAP repair were judged to have a superior labrum without degeneration at the time of repair. Similarly, Gottschalk et al. [40] showed improved clinical outcomes in patients with type II and type IV SLAP tears after undergoing open subpectoral tenodesis in a single surgeon series. In a cadaveric study, Strauss et al. [10] found that open subpectoral tenodesis did not restore glenohumeral translation following a simulated type 2 SLAP lesion. Additionally, when the labrum was repaired following tenodesis, there was restoration of ABER translation in anterior and posterior SLAP lesions and a trend toward restoration in posterior translations for posterior lesions; however, anterior instability in anterior lesions remained [10].

Arthroscopic subdeltoid tenodesis involves LHBT tenotomy at the intra-articular origin and then transfer to the conjoint tendon using the subdeltoid space [3, 30, 41]. Taylor et al. [30] studied 56 shoulders and found improvements in American Shoulder and Elbow Surgeons (ASES) and L'Insalata scores and no differences in elbow flexion strength and endurance with a 10-lb weight following subdeltoid tenodesis. One patient had a Popeye sign and the rest had a normal appearing biceps contour [30]. Taylor et al. [42••] also conducted a literature review and compared functional outcomes following bicipital tunnel decompressing and non-decompressing surgical techniques and found not only a lack of literature comparing these two techniques but also possible significantly better constant scores in tunnel decompressing techniques, but this could be due to a lower age of surgery in this cohort. Revision rate was found to be 3.3% for decompressing techniques; however, this may be influence by publication bias as the authors note a large proportion of single cohort level IV studies [42••].

Outcomes in Overhead Athletes

The effectiveness of rehabilitation and repair of injuries to the biceps and superior labral complex in the overhead athlete has mixed results. Neuman et al. [43] conducted a retrospective chart review of 30 athletes who participated in overhead sports with 3.5 years of follow up following SLAP repair and measured clinical outcomes. They found an overall satisfaction rate of 93.3% with an average return to play (RTP) at 11.7 months post-operatively. Subjectively, the athletes rated their ability to return to their pre-injury level of play at 84.1%. They found the average ASES score to be 87.9 and average Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow (KJOC) score as 73.6. In a subgroup analysis of baseball players, there was no significant difference in pitchers and position players in ASES scores, KJOC scores, or subjective return to pre-injury performance [43].

Fedoriw et al. [44] showed that within a single professional baseball organization, surgical management of SLAP lesions in pitchers had a lower RTP than position players and that non-surgical management had relative success in rehabilitating players. A group of 68 patients with type II or type II variant SLAP lesions was selected from 119 major league and minor league baseball players with shoulder pain and included 45 pitchers and 23 position players. The players underwent non-operative management to treat GIRD, posterior capsular contracture, scapular dyskinesia, and any other associated injuries [44]. If non-operative management failed with persistent symptoms, players then underwent SLAP repair. The authors analyzed both RTP and return to prior performance (RTPP). They found that for pitchers following the non-operative rehabilitation program, 40% were able to return to play with a 22% RTPP [44]. Twenty-seven pitchers required SLAP repair and 48% returned to play with a 7% RTPP. Of the 23 position players studied, 39% returned following non-surgical management with a RTPP of 26% and following surgical treatment, there was an 85% RTP with 54% RTPP [44]. The overall RTP for pitchers was 62% with 26% RTPP and for position players 87% with a RTPP of 57%. Additionally, injuries that were associated with a rotator cuff tear had lower RTP and RTPP. Fedoriw and colleagues demonstrated a relatively poor return to play for these athletes following SLAP repair. Unlike Neuman et al. [43], the authors noted that the RTP and RTPP were better for position players compared to pitchers.

The EMG activity of both heads of the biceps and the effect of repair on throwing motion has been also been studied between uninjured pitchers and players following both subpectoral biceps tenodesis and type II SLAP repair [45]. Chalmers et al. [45] analyzed 18 pitchers, 5 of whom underwent biceps tenodesis, 6 who underwent SLAP repair, and 7 control subjects. Following SLAP repair and biceps tenodesis, most functional outcome scores were lower than controls. There was also a difference in ball velocity between groups with both the biceps tenodesis group and SLAP repair group having a lower ball velocity. Motion analysis was used to study throwing motion and found altered trunk rotation patterns following SLAP repair. The study found that both controls and those who underwent biceps tenodesis had peak thoracic rotation in the late cocking/early acceleration phase while pitchers following SLAP repair had peak thoracic rotation in the late acceleration phase. Lastly, compared to published norms, the cocking phase of the pitch was different for those who underwent biceps tenodesis than for controls and SLAP repair. Similarly, Laughlin et al. [46] noted changes in pitching biomechanics following SLAP repair. This study used motion analysis to compare pitching biomechanics between 13 pitchers who had previously undergone SLAP repair with a matched control group of 52 players and found that shoulder horizontal abduction at foot contact and maximum shoulder external rotation were significantly less for those who underwent SLAP repair [46]. The authors also found less forward trunk tilt at ball release following surgery [46].

Park et al. [47] found an improved ASES score of 87.1 from a pre-operative baseline of 55.8 and a RTP of 50% in a single surgeon series following arthroscopic repair of type II SLAP tears in overhead athletes from a variety of sports to include the following: baseball, badminton, volleyball, and javelin throwing. In addition to improvements in the ASES score, there was a decrease in the Visual Analog Pain Scale from 5.7 to 2.0. Smith et al. [48] identified 24 Major League Baseball (MLB) pitchers who underwent SLAP repair between 2003 and 2010. They found that 62.5% of players were able to return to pitch at least 1 entire season with an average career length following surgery of 3.67 ± 1.91 years [48]. Players spent an average of 315 days on the disabled list and following surgery, there were decreases in pitch count but no difference in earned run average (ERA) or walks and hits per innings pitched (WHIP) and there was an overall RTPP of 54.2%; however, those that did return to play, 86.7% were able to RTPP [48].

Conclusion

BLC injuries are common in overhead athletes and remain challenging to both diagnose and treat effectively to return athletes to high levels of competition. Current techniques including advanced imaging and arthroscopy do not fully evaluate the BLC. While further research is needed to fully compare treatment techniques, SLAP repair remains the treatment of choice for patients under 40 years old. For patients older than 40, tenodesis and tenotomy are the preferred treatments, with further research needed to better determine the efficacy between the varying tenodesis techniques.

Compliance with Ethical Standards

Conflict of Interest Kyle W. Morse, Jonathan-James Eno, and David W. Altchek each declare no potential conflicts of interest.

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•• Of major importance

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