Nikhil N. Verma
Eric J. Strauss *Editors*

The Biceps and Superior Labrum Complex

A Clinical Casebook

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ISBN 978-3-319-54932-3   ISBN 978-3-319-54934-7 (eBook)
DOI 10.1007/978-3-319-54934-7

Library of Congress Control Number: 2017948395

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Pathologic conditions of the biceps and superior labral complex have received considerable attention recently. The spectrum of pathology remains complex, and decision-making regarding diagnosis and treatment options can be challenging, even for the most experienced clinician. Further, outcomes following surgery remain variable, and return to sports, particularly for the overhead throwing athlete, is inconsistent.

This book utilizes an easy-to-read, case-based format to present common clinical scenarios demonstrating pathology involving the long head biceps and superior labral complex. We have assembled an expert panel, each of whom have authored case vignettes, providing real case examples including presenting symptoms, physical exam, treatment decisions, and patient outcomes. Each chapter uses an evidence-based approach to review treatment options and indications for surgery.

This format presents information to the reader in a real-world translation format. The cases represent common clinical scenarios that may present to the surgeon on any given day. In addition, we have highlighted controversial topics, such as indications for SLAP repair versus biceps tenodesis, and patients presenting with persistent pain following prior superior labral repair.

I would be remiss without thanking my coeditor, Eric Strauss, MD, as well as all the authors who have provided their knowledge and expertise on this topic. Without their hard work and time commitment, we would not have been able to complete this work. We hope that this book provides some level of clarity on this complex topic to the practicing surgeon and stimulates further study of this topic to improve outcomes for our patients in the future.

Chicago, IL, USA Nikhil N. Verma, MD

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About the Editors

Eric J. Strauss, MD is a sports medicine specialist with a clinical focus on the arthroscopic treatment of orthopedic pathology affecting the knee and shoulder. After graduating AOA with honors in research from the Weill Medical College of Cornell University, Dr. Strauss completed his orthopedic surgery residency at the NYU Hospital for Joint Diseases where he received numerous awards for both basic science and clinical orthopedic research. He completed his sports medicine fellowship training at Rush University Medical Center in Chicago, gaining experience treating athletes at all levels of competition. As a clinician-scientist, Dr. Strauss is an active contributor to the orthopedic surgery literature, publishing more than 150 journal articles and book chapters to help advance the field of sports medicine.

Nikhil N. Verma, MD is a sports medicine fellowship trained orthopedic surgeon with a special interest in shoulder surgery. He has completed multiple clinical and biomechanical studies to evaluate the function of the biceps labrum complex and evaluate clinical outcomes following surgery.

A graduate of the University of Pennsylvania School of Medicine, Dr. Verma completed his orthopedic residency at Rush-Presbyterian-St. Luke's Medical Center. He then completed a fellowship at the Hospital for Special Surgery in sports medicine and shoulder surgery. Currently he is the Director of the Division of Sports Medicine at Rush University Medical Center and Fellowship Director for sports medicine and shoulder. In addition, he serves as head team physician for the Chicago White Sox baseball organization.

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Chapter 1
Acute Rupture of the Proximal Biceps Tendon in a 55-Year-Old Female

Matthew J. Kraeutler, Lionel J. Gottschalk IV, and Eric C. McCarty

Case Presentation

A 55-year-old female secretary presented with the acute onset of anterior right shoulder pain which began while throwing away a heavy trash bag. She felt a pop immediately followed by a sudden, sharp pain in the anterior aspect of her shoulder. The patient has a past medical history notable for mild right shoulder osteoarthritis and anterior shoulder pain that has been treated with intra-articular corticosteroid injections, most recently 1 week ago. On physical examination, she has significant ecchymosis over the anterior arm and a bulging of the biceps muscle on the right side. In addition, a distinct indentation is noted on inspection of the bicipital

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groove. Strength is noted to be four out of five with elbow flexion and supination. Initially, the patient noticed an acute pain. Now the pain has resolved, and her chronic anterior shoulder pain that was present prior to the acute episode is no longer present. The patient is neurovascularly intact and her physical examination is otherwise normal.

Diagnosis/Assessment

In some cases, the diagnosis of a long head of the biceps (LHB) rupture will be straightforward. Patients are typically between the ages of 40 and 60 years with chronic degeneration of the proximal biceps tendon. The patient's history typically involves weight lifting or a rapid stress upon the proximal biceps tendon [1] which causes rupture of the degenerated tendon. Although much less common, there have been case reports of younger patients (with presumably healthy biceps tendons) suffering a rupture of the LHB during biceps curls [2] and arm wrestling [3]. Most cases involve a single traumatic event in which a heavy object is lifted or a force is applied on the forearm with the elbow at 90° of flexion, although the force required to cause a tendon rupture differs significantly between middle-aged versus younger patients.

The case above is classic, with the sudden onset of a sharp anterior shoulder pain after hearing a pop and the presence of a bulging biceps muscle ("Popeye" sign) on exam (Fig. 1.1) [4]. Furthermore, the patient's history of intra-articular corticosteroid injections should also raise suspicion, as these injections may increase the risk of proximal biceps tendon rupture [5, 6]. Although this case relates to an acute rupture of the LHB, patients with chronic ruptures may present with paresthesias and burning pain in the lateral forearm due to compression of the lateral antebrachial cutaneous nerve by the biceps muscle [7, 8].

To further raise suspicion for the diagnosis, the Ludington's test may be performed. This test is performed by having the

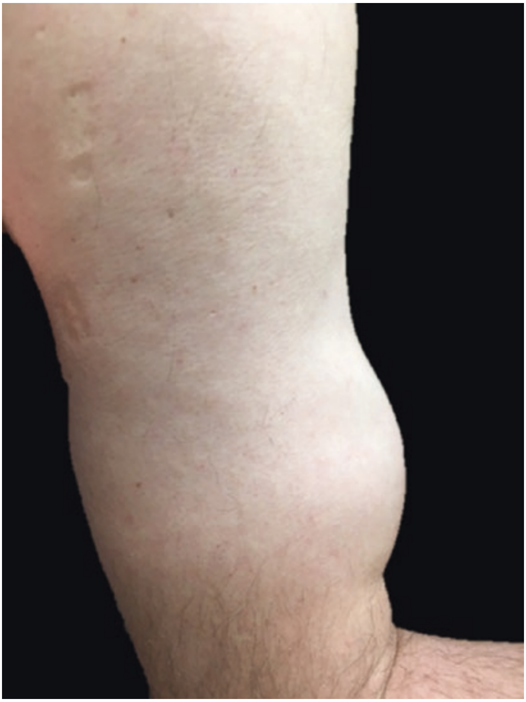

Figure 1.1 A bulging biceps muscle in the upper arm is known as the "Popeye" sign and is indicative of a biceps tendon rupture

patient put both hands behind the head and contracting and relaxing the biceps muscles of both arms. The test is considered positive if significant bulging of the affected biceps muscle is present or if the examiner cannot palpate the long head of the biceps tendon on the affected side. The Speed test is typically performed to diagnose bicipital tendinitis, though may also point to a ruptured biceps tendon. This test is considered positive with pain during resisted shoulder forward flexion in the scapular plane with the arm supinated.

Imaging should be performed in all cases of suspected LHB ruptures in order to confirm the diagnosis as well as to rule out concomitant pathologies such as a superior labral

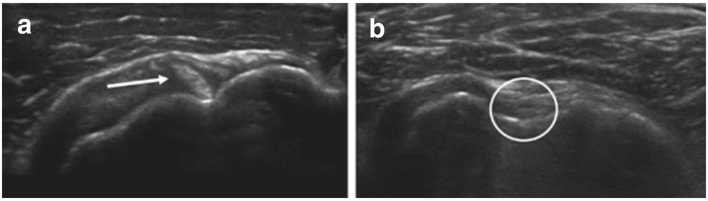

FIGURE 1.2 (**a**) Short axis ultrasound (US) showing the long head of the biceps tendon in the bicipital groove (*arrow*). (**b**) Short axis US in a different patient showing the absence of the LHB tendon in the bicipital groove (*circle*), indicating a complete tear of the tendon with distal retraction

tear or a rotator cuff tear. On plain radiographs, the bicipital groove may rarely demonstrate spurring. Magnetic resonance imaging (MRI) or ultrasound (US) may demonstrate an intra-articular split, fraying, or partial rupture of the LHB tendon. Absence of the LHB tendon in the bicipital groove on MRI or US indicates a complete rupture (Fig. 1.2). However, the sensitivity of MRI for detecting LHB tendon ruptures is limited, with a sensitivity of 28% for partial tears and 56% for complete tears [9]. The specificity of this imaging modality is significantly higher: 84% for partial tears and 98% for complete tears.

Management

Management of LHB ruptures may consist of conservative or surgical treatment depending on the patient's age, activity level, and occupation [1]. For middle-aged or older patients who do not require significant strength in supination or elbow flexion, a conservative approach is appropriate for isolated ruptures. Conservative management may include the use of nonsteroidal anti-inflammatory drugs (NSAIDs) and physical therapy. A conservative approach allows for earlier return to work and does not affect activities of daily living [1]. In patients over 40 years of age, no differences in outcomes have been shown between those treated operatively versus nonoperatively at long-term follow-up, including no differences in supination or elbow flexion strength [10]. However, long-term cramping pain may be present in patients who elect not to have surgery, particularly in those with repetitive biceps use [11, 12]. If a concomitant rotator cuff tear is present, then surgical intervention should be considered with possible biceps tenodesis.

For younger, more active patients and particularly those with concomitant pathology such as compression of the lateral antebrachial cutaneous nerve, SLAP tears, or rotator cuff tears, a surgical approach should be employed. Manual laborers who require full supination and arm strength should also undergo surgery. Finally, patients who are overly concerned about the cosmetic defect of the Popeye sign may also undergo surgical repair.

Surgical intervention consists of a biceps tenodesis. We typically perform a mini-open subpectoral biceps tenodesis, as described previously [13]. Briefly, the patient is placed in the beach chair position with the arm positioned in slight external rotation and abduction and the elbow positioned at 90° of flexion. An incision is made in the axillary crease with the superior third over the inferior margin of the pectoralis major muscle. Blunt dissection is performed down to the pectoralis major muscle and tendon and superolaterally over the lateral margin of the humerus. The short head of the biceps tendon is delicately retracted. Once the distal portion of the ruptured LHB tendon is visualized, the bicipital groove is curetted approximately 1–2 cm from the musculotendinous junction, if possible depending on the site of rupture. A suture anchor is placed in the curetted area, with sutures placed into the tendon in a lasso fashion. The biceps is re-tensioned and tenodesed. The proximal biceps tendon is then debrided intra-articularly.

Outcome

Given the classic physical examination findings in this 55-year-old female, the index of suspicion was high for a rupture of the long head of the biceps tendon. An MRI was obtained which demonstrated the absence of the biceps tendon in the bicipital groove, but no concomitant pathology was appreciated. Given the age and low physical demands of the patient's occupation (secretary), conservative treatment was offered. However, the patient requested to undergo surgery due to concern regarding the cosmetic deformity of the Popeye sign. A mini-open subpectoral biceps tenodesis was performed as described above. Postoperatively, the patient was placed in a sling for 4 weeks and began physical therapy shortly after surgery with passive and gentle active assisted range of motion (ROM) exercises for the shoulder. At 4 weeks, use of a sling was discontinued, and active elbow flexion was gradually progressed. Full ROM was restored by 10 weeks postoperatively. At 14 weeks, the patient was advised to gradually improve muscular strength and initiate functional activities. At 6-month follow-up, the patient's elbow flexion strength was noted to be approximately 80% of the contralateral side. At 9-month follow-up, the patient had regained full strength in the affected arm.

Clinical Pearls and Pitfalls

- Acute rupture of the long head of the biceps tendon most often occurs as a result of a single traumatic event, such as lifting a heavy object with the elbow at 90° of flexion.
- Classic findings on physical examination include the Popeye sign (bulging of the biceps muscle in the upper arm), sharp anterior shoulder pain, and a visible indentation present in the bicipital groove.
- Imaging with plain radiographs and MRI should be performed to confirm the diagnosis and evaluate for any concomitant pathology such as a SLAP tear or rotator cuff tear.

- Management of LHB ruptures may proceed through a conservative or a surgical approach. Middle-aged or older patients without significant physical demands may elect for conservative management without any long-term decrease in supination or elbow flexion strength.
- Surgical management of LHB ruptures is reserved for younger, more active patients or manual laborers who require high supination and arm strength. Surgery is performed through an open or mini-open subpectoral biceps tenodesis.
- Surgery may be considered for patients concerned about the cosmetic appearance of a LHB rupture (the Popeye deformity).

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Chapter 2
Chronic Rupture of the Proximal Biceps Tendon in a 63-Year-Old Male with Popeye Deformity and Persistent Cramping

J. Christoph Katthagen, Dimitri S. Tahal, and Peter J. Millett

Case Presentation

The patient is a 63-year-old male, who works as an emergency room nurse, as well as a member of the ski patrol. He presents with progressively worsening right shoulder pain over the last 18 months. He reported that although he had some intermittent symptoms with respect to his right shoulder for a number of years, it has become significantly more painful when he was pulling a sled during ski patrol early last spring. He attempted to whip it around and felt a painful pulling sensation in the anterior aspect of his shoulder. Since that time, he has performed physical therapy and rehabilitation, which initially helped, but over the last 2 months or so, he has had

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_2,

significantly more anterior shoulder pain and has noticed a development of a biceps Popeye deformity. In the past few weeks, the patient noticed considerable pain concentrated in the anterior aspect of the shoulder and also noticed an increase in the cosmetic deformity of the anterior shoulder. Additionally, he reports pain and cramping sensations in his right upper arm as well as some elbow weakness. The patient still participates in skiing, in which he is somewhat limited secondary to his shoulder pain. At rest, he has approximately 2/10 pain and, at its worse, can be approximately 10/10 pain. It does not wake him at night. He continues to work despite this pain. The patient states that rest seems to make it better, and any type of activity seems to make it worse.

Diagnosis/Assessment

The patient reported a history of smoking, but otherwise no significant past medical history.

Physical Examination

Examination of his left shoulder demonstrated no tenderness to palpation and a full range of motion of 170° of forward flexion, 170° of abduction, 80° of external rotation with the arm at the side, 95° of external rotation at 90° of abduction, and 80° of internal rotation. He was able to reach T8 with posterior reach. The rotator cuff appeared strong to internal rotation, external rotation, and scaption testing. He had a negative O'Brien sign and no impingement signs. The Speed and Yergason tests were negative. He remained neurovascularly intact distally in medial, ulnar, radial, and axillary nerve distributions with brisk capillary refill.

Examination of his right shoulder, again, demonstrated no swelling, erythema, or drainage concerning for infection. The patient presented with full range of motion of his right shoulder of 170° of forward flexion and abduction. He had 95° of external rotation at 90° of abduction, 80° of internal rotation, and approximately 80° of external rotation with his arm at his side. He reached to approximately T8 with some discomfort. The patient did have tenderness to palpation along the anterior bicipital groove, as well as at distal biceps tendon. The biceps muscle showed an obvious Popeye sign. The patient had no impingement sign and no AC joint tenderness to palpation. There was a negative crossover sign and a mildly positive O'Brien sign. Speed and Yergason tests caused him some discomfort. His rotator cuff strength was 5/5 to all distributions. He remained neurovascularly intact distally at the medial, ulnar, radial, and axillary nerve distributions. He had brisk capillary refill distally.

Radiographs

Plain films were reviewed in the clinic, and they showed no fractures or dislocations, with maintenance of joint space. There was no elevation of the humeral head or obvious arthritic change.

MRI

MRI demonstrated a partial-thickness subscapularis tear. Additionally, he had a significant amount of tendinosis throughout the superior rotator cuff. He also had some mild tendinosis of the supraspinatus tendon and it appeared that he had a proximal biceps tendon rupture. The tendon was absent from the groove. There was a small residual stump that remained in the joint near the bicipital attachment. The articular cartilage appeared intact.

Management

This patient is a 63-year-old male with a proximal biceps tendon rupture, as well as a partial-thickness subscapularis tear. We discussed a number of treatment options, and as he continues to work as a nurse in the emergency room, often times he has to be rather physical while working. He felt that it would have been in his best interest to have a right shoulder arthroscopy performed with likely subscapularis tear repair, removal of the stump of the biceps tendon, and subpectoral biceps tenodesis. The surgery was scheduled and performed 10 days later. The postoperative diagnoses were:

1. Right chronic proximal long head of the biceps rupture (Fig. 2.1)
2. Partial-thickness upper third subscapularis tear with an intrasubstance split (Fig. 2.2)
3. Degenerative type 2 SLAP tear (Fig. 2.3)
4. Subacromial impingement

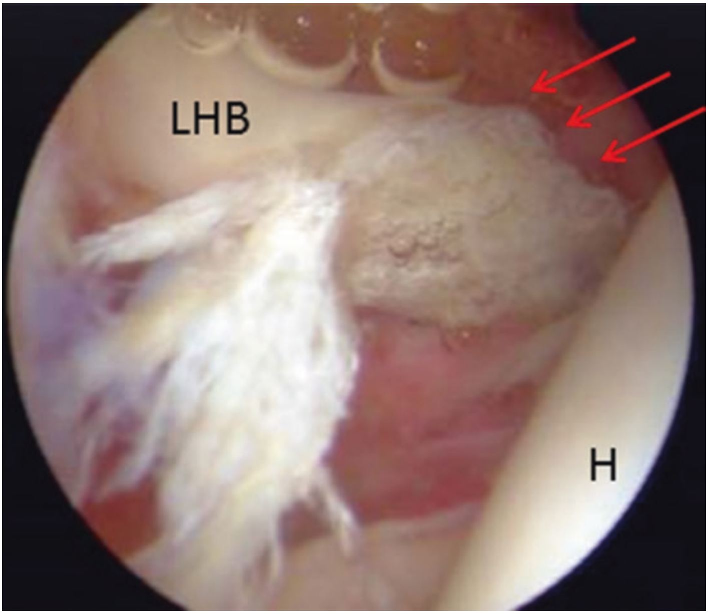

FIGURE 2.1 Right shoulder arthroscopy, 63-year-old patient, posterior viewing portal: rupture of the long head of the biceps [LHB] with remaining stump intra-articular (*red arrows*); H = humeral head

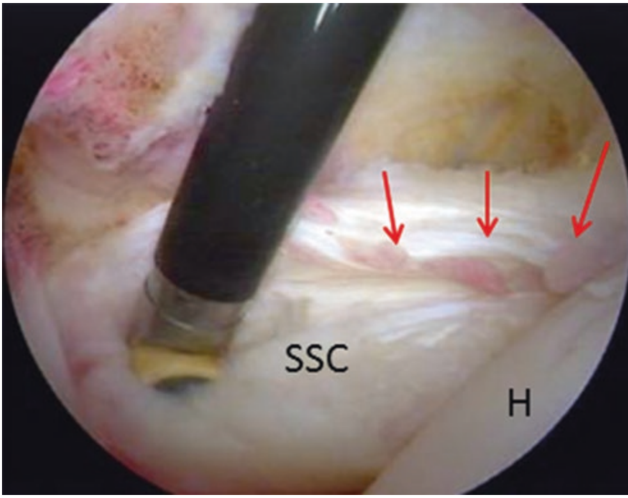

Figure 2.2 Right shoulder arthroscopy, 63-year-old patient, posterior viewing portal: partial-thickness upper third subscapularis (SSC) tear with an intrasubstance split (*red arrows*); H = humeral head

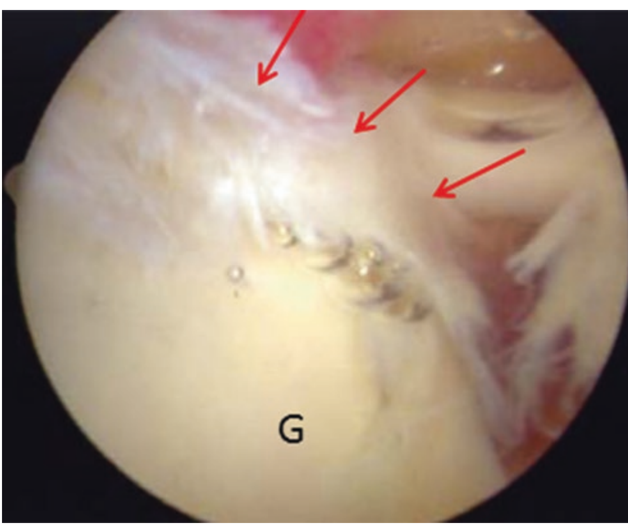

Figure 2.3 Right shoulder arthroscopy, 63-year-old patient, posterior viewing portal: degenerative type 2 SLAP tear (*red arrows*); G = glenoid

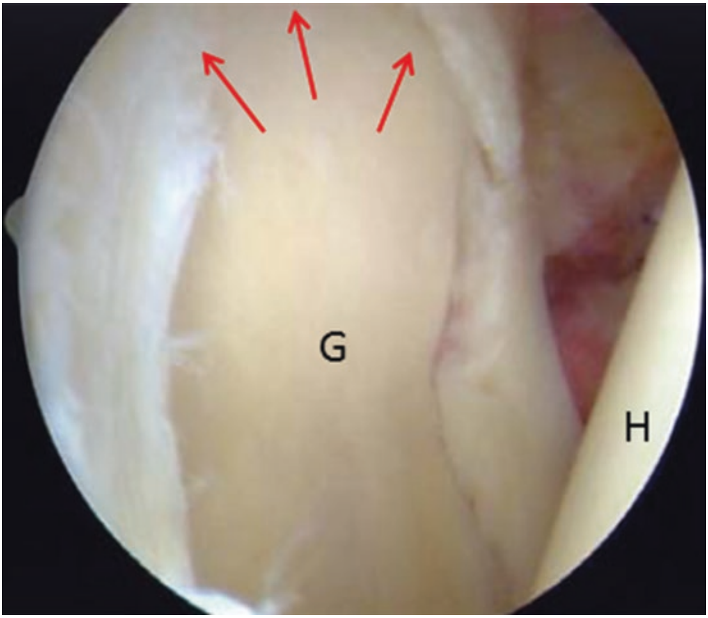

FIGURE 2.4 Right shoulder arthroscopy, 63-year-old patient, posterior viewing portal: after debridement of degenerative type 2 SLAP tear and resection of remaining long head of the biceps tendon stump (*red arrows*); G = glenoid, H = humeral head

The following procedures were performed:

1. Right shoulder arthroscopy and extensive glenohumeral debridement with excision of intra-articular biceps stump (Fig. 2.4)
2. Debridement of the degenerative SLAP tear (Fig. 2.4)
3. Arthroscopic subscapularis repair, side to side with a no. 1 PDS suture, securing it back to its anatomic location (Fig. 2.5)
4. Arthroscopic subacromial decompression with acromioplasty
5. Open subpectoral tenodesis of chronic long head of the biceps rupture (Figs. 2.6 and 2.7) (the detailed surgical procedure is described further below)

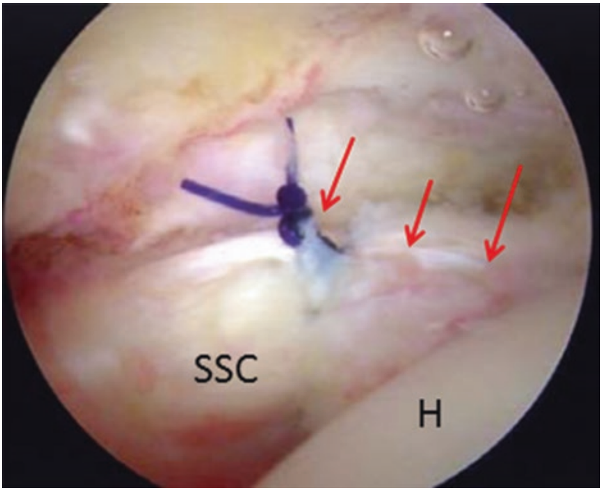

FIGURE 2.5 Right shoulder arthroscopy, 63-year-old patient, posterior viewing portal: after arthroscopic subscapularis (SSC) repair, side to side with a no. 1 PDS suture, securing it back to its anatomic location (*red arrows*)

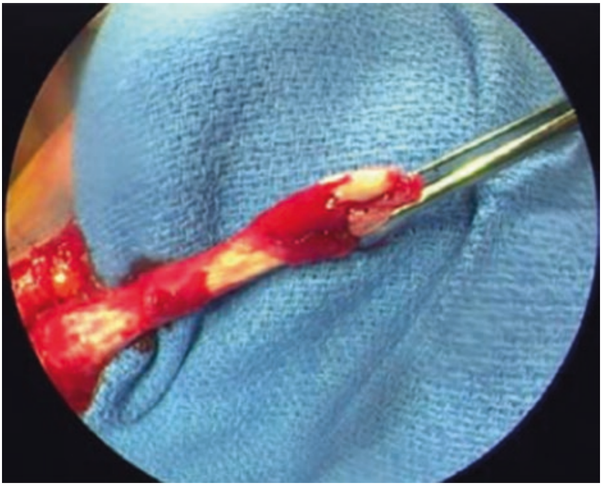

FIGURE 2.6 Open retrieval of retracted and scarred long head of the biceps stump

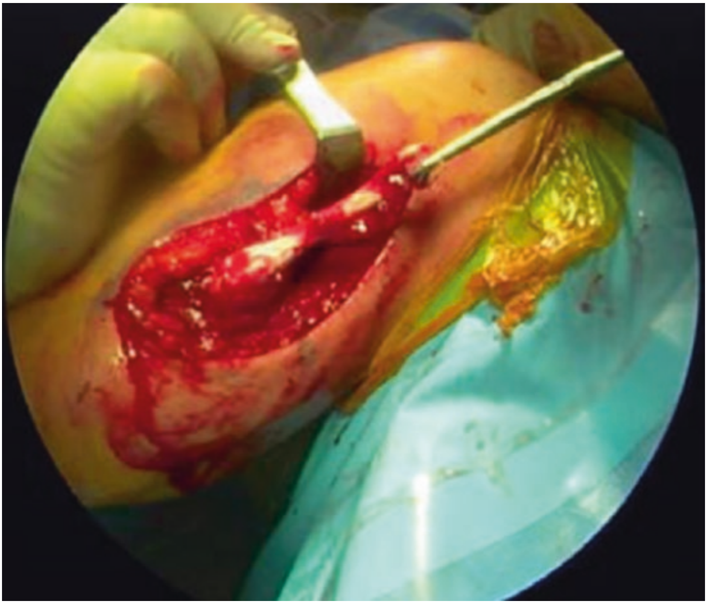

FIGURE 2.7 In case of a severely retracted ruptured long head of the biceps tendon, the skin incision can be extended distally until the tendon can be retrieved

Postoperative Rehabilitation

The patient began immediate pendulums and passive range of motion. He progressed to active and active-assisted motion as tolerated on his shoulder. He was instructed to avoid resisted elbow flexion for the first 6 weeks. Active elbow flexion was allowed after approximately 3–5 days once swelling subsided.

Outcome

The postoperative outcome of this patient was excellent. Three years postoperatively, the patient reported an improved ASES score (preoperative 66.7, postoperative 96.6) as well as

Table 2.1 The "subjective proximal biceps score" (SPBS) used for the evaluation of preoperative and postoperative symptoms related to the biceps muscle (from [1]; Copyright Springer)

	0	1	2	3
Pain	None	Mild	Moderate	Severe
Strength (flexion and supination)	Unrestricted	Activity-related weakness (mild)	Weak with activities of daily living (moderate)	Weak with all activities (severe)
Appearance/ cosmesis	Normal	Mild deformity, asymptomatic	Asymptomatic Popeye or mild deformity that is bothersome	Symptomatic Popeye deformity
Cramping	None	Mild	Moderate	Continuous

Interpretation: total score 0–2 = excellent; 3–4 = good; 5–8 = moderate; 9–12 = poor

an improved "subjective proximal biceps score" (preoperative 8, postoperative 2; Table 2.1). The postoperative QuickDASH score was 4.5 and the satisfaction was 10 out of 10.

Surgical technique for subpectoral LHB tenodesis in cases with chronic, symptomatic rupture (modified from [1]):

The procedure begins with an initial diagnostic arthroscopy in the modified beach-chair position to address any intra-articular pathology. After the administration of a regional interscalene block and the induction of general anesthesia, the operative extremity is draped free under sterile conditions with the arm secured in a pneumatic arm holder. A standard posterior portal is established, and, under direct visualization, an anterosuperior portal is also created. Diagnostic arthroscopy is then performed to identify and address any coexistent intra-articular pathology. The proximal stump of the LHB tendon is removed from the joint when present (Fig. 2.1). When access to the subacromial space is required, an accessory lateral portal is established to address concomitant subacromial and/or rotator cuff pathologies. When necessary, rotator cuff repair is performed at this time (Fig. 2.5).

Following the conclusion of diagnostic arthroscopy, open subpectoral biceps tenodesis is performed [2]. With the arm abducted and slightly internally rotated, the inferior margin of the pectoralis major tendon is palpated. An incision is then made extending from 1 cm superior to 3 cm inferior to the inferior border of the pectoralis major tendon. The short head of the biceps and the pectoralis major tendons are next identified and the LHB tendon can typically be retrieved within this interval. The ruptured LHB tendon is then isolated and its quality is assessed. In chronic cases, there is often a pseudotendon present in the inferior aspect of the bicipital groove. When the LHB tendon is absent proximally at the level of the pectoralis major, dissection can be carried distally until the proximal end of the ruptured LHB tendon is discovered (Fig. 2.7). When a pseudotendon is present, the proximal end of the LHB tendon must be excised in order to restore the appropriate length-tension relationship of the biceps muscle by visualizing the Popeye deformity and when it is eliminated. The remaining proximal 15–20 mm of the LHB tendon is then whipstitched using no. 2 nonabsorbable high-strength suture (FiberWire, Arthrex, Naples, FL). When the LHB stump is short or of poor quality, no. 2 sutures should be passed into the myotendinous junction [3].

Tenodesis with Interference Screw

LHB tenodesis using an interference screw can be performed when tendon quality is adequate. Briefly, subperiosteal dissection is performed approximately 1 cm proximal to the inferior border of the pectoralis major tendon corresponding to the inferior one-third of the bicipital groove. A 7- or 8-mm reamer is used to create a unicortical bone tunnel to a depth of approximately 15 mm. One suture limb from the whipstitched tendon is next threaded through a specially designed driver and an appropriately sized PEEK tenodesis screw (Arthrex, Inc., Naples, FL). The screw which has the same

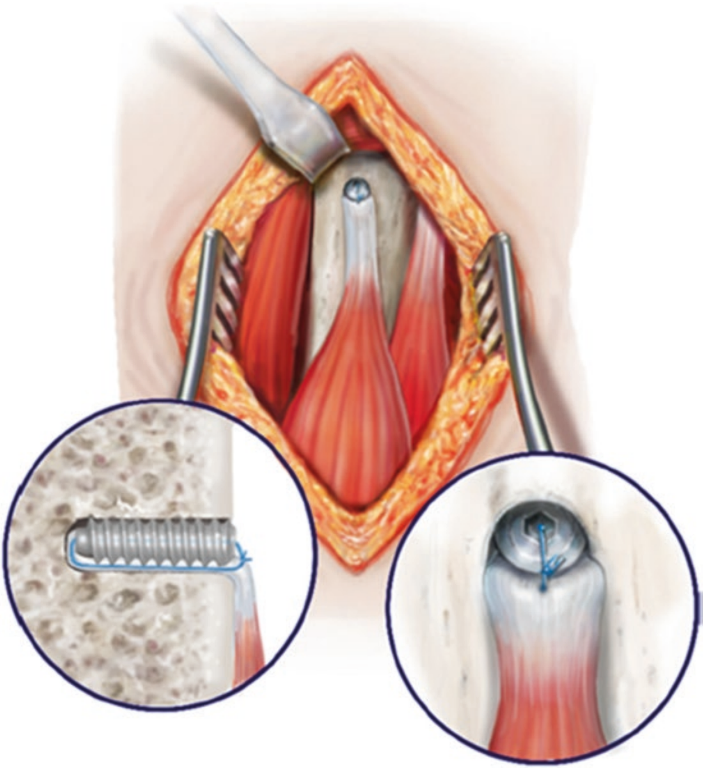

Figure 2.8 LHB tenodesis with an interference screw (from [1]; Copyright Springer)

diameter as the socket (7- or 8-mm) is placed into the bone and advanced until the screw is flush with the anterior cortex of the humerus. The remaining suture limb is then tied to the suture limb that was passed through the screw to enhance the fixation and prevent tendon slippage (Fig. 2.8, from [1]). When there is a lot of tension or when the tendon quality is poor, additional fixation can be achieved using multiple no. 1 absorbable sutures from the LHB tendon to the inferior border of the pectoralis major laterally.

Tenodesis with Suture Anchors

Suture anchor tenodesis can be performed in cases of tendon shortening or poor tendon quality. The periosteum along the anterior humeral shaft near the site of tenodesis is roughened to enhance healing of the biceps tendon stump and the musculotendinous junction to the humerus. Permanent no. 2 Krackow-type interlocking sutures are then woven into the musculotendinous junction and the overlying myofascia of the biceps muscle. Prior to the insertion of suture anchors, muscle tension is assessed qualitatively by pulling upward on the biceps tendon with the elbow in 90° of flexion. The goal of this maneuver is to determine an appropriate location for the tenodesis/myodesis that would restore normal resting tension and cosmesis. Typically, two appropriately sized unicortical bone tunnels are drilled in the proposed tenodesis site, and two knotless push-lock suture anchors (Arthrex, Inc., Naples, FL) are inserted and tightened, thus completing the tenodesis (Fig. 2.9, from [1]).

Postoperative Rehabilitation

Following isolated LHB tenodesis, patients are restricted from performing resisted elbow flexion maneuvers for at least 6 weeks after surgery. When the quality of the LHB tendon is poor, active elbow flexion is restricted for approximately 4 weeks. Overhead strengthening and heavy lifting are also delayed for approximately 3 months. Otherwise, full active and passive range of motion are allowed immediately postoperatively. When concomitant rotator cuff repair is performed, additional rehabilitation is implemented. Specific rehabilitation protocols following rotator cuff repair have been described elsewhere [4].

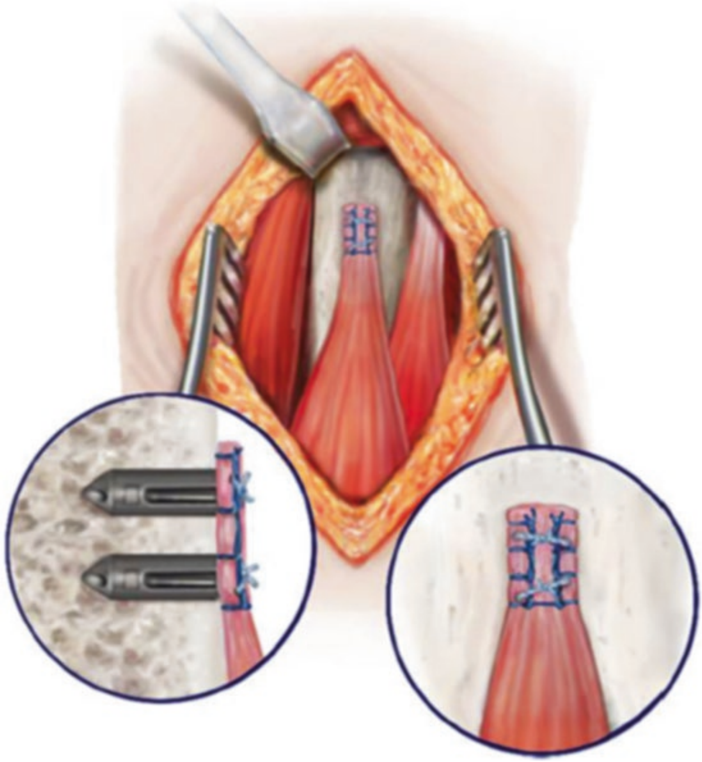

FIGURE 2.9 LHB tenodesis with suture anchors (from [1]; Copyright Springer)

Literature Review

Chronic rupture of the LHB tendon usually occurs due to ongoing degeneration of the tendon with tendinopathy leading first to partial and finally to complete ruptures. These changes are frequently observed in the context of rotator cuff tears [5, 6]. Chen et al. recently found that 7% of patients undergoing surgery for full-thickness rotator cuff tears had a complete biceps rupture [7]. The distal bicipital groove was found to be the predilection site for complete ruptures of the LHB tendon in this context [8]. Less commonly, traumatic proximal biceps rupture without underlying degeneration may occur in young athletes [9–11]. Furthermore, iatrogenic LHB tenotomy may become symptomatic, and postsurgical rupture of a prior LHB tenodesis can lead to recurrent symptoms that may require revision tenodesis [1].

An isolated rupture of the proximal biceps is associated with little functional impairment as the range of elbow and shoulder motion usually remains unaffected, and the elbow flexion, supination strength, and the muscle endurance are reduced by "only" 8–25% [12–14]. Therefore, the vast majority of LHB ruptures are asymptomatic and can be treated nonoperatively. However, up to 25% of the patients develop long-term cramping and discomfort with repetitive biceps activities [15]. In these cases, LHB tenodesis may be beneficial. It has been suggested that the ruptured LHB tendon undergoes a process of "auto-tenodesis" to the bicipital sulcus, the brachialis muscle, short head of biceps, or humeral shaft in asymptomatic patients, whereas this mechanism fails in symptomatic patients [16]. MRI is helpful to detect and analyze biceps tendon lesions; however, MRI currently fails to fully evaluate the biceps-labrum complex and the biceps tunnel [17]. Full-thickness ruptures of the biceps tendon are best diagnosed clinically since they usually manifest with:

- Distalization of the LHB muscle belly presenting with the "Popeye sign"
- Complaints of LHB muscle pain and cramping
- Discomfort with repetitive biceps use
- Weakness of elbow flexion and supination

Often patients recall a traumatic incident involving eccentric contraction of the biceps, even in the context of degenerative rotator cuff tears [16].

Only a few studies have investigated outcomes after tenodesis of the LHB tendon in the context of chronic ruptures and reported the results in the literature (Table 2.2) [1, 16,

Table 2.2 Summary of studies published in the literature reporting outcomes after tenodesis in case of chronic rupture of the long head of the biceps tendon

Study	Number and gender of patients	Mean age of patients	Mean time interval between LHB rupture and surgery	Mean follow-up	Percentage of improved pain, strength, and cosmesis	Percentage of LHB tenodesis considered as failure	Mean outcome scores	Complications (i.e., infection, neurovascular injury, adhesive capsulitis, or humeral fracture)
Ng and Funk, Int J Shoulder Surg 2012 [16]	$n = 11$ (10 males, 1 female)	41 years (range 23–65)	29 months (range 6–60)	N/A	90.9%	9.1% ($n = 1/11$)	N/A	0%
Euler et al., Arch Orthop Trauma Surg 2015 [1]	$n = 27$ (22 males, 5 females)	61 years (range, 40–76)	9.0 months (range, 6 weeks to 7.5 years)	3.8 years (range, 2–6.1)	87.9%	8% ($n = 2$ patients in revision group)	ASES score = 90.3; SF-12 PCS = 52.6; median postoperative SPBS = 1	0%

(continued)

Table 2.2 (continued)

Study	Number and gender of patients	Mean age of patients	Mean time interval between LHB rupture and surgery	Mean follow-up	Percentage of improved pain, strength, and cosmesis	Percentage of LHB tenodesis considered as failure	Mean outcome scores	Complications (i.e., infection, neurovascular injury, adhesive capsulitis, or humeral fracture)
Anthony et al., J Shoulder Elbow Surg 2015 [18]	$n = 11$ (11 males)	43.3 years (range, 33–56)	8 months (range, 0.5–22 months)	2.6 years (range, 1.6–4.2 years)	90%	10%	SANE score = 84.2; WORC score = 86	0%
McMahon and Speziali World J Orthop 2016 [19]	$n = 11$ (10 males, 1 female)	56.9 years (range, 42–73)	30.1 (range, 3.5–240) months	19.1 months	71.8%	18.2% ($n = 2$ with recurrent rupture)	DASH 11.2; Mayo performance score 86	0%

18–20]. Currently, the objective "long head of the biceps score" and the "'subjective proximal biceps score" (SPBS) have been introduced to better assess the clinical situation related to the LHB tendon [1, 21]. Both scores include information on pain, cramping, strength, and cosmesis. Although there does not seem to be a consensus in the literature, ruptures of the LHB tendon are considered chronic if the patient presents at least 6 weeks after the rupture [1, 16, 19, 22]. All patients that finally received a LHB tenodesis failed a course of nonoperative treatment including anti-inflammatories and physiotherapy [1, 16, 18–20].

Ng and Funk (2012) and McMahon and Speziali (2016) each included 11 patients that received biceps tenodesis for chronic tears of the LHB tendon more than 3 months after the initial rupture [16, 19]. In over 90% of patients, pain, strength, and subjective cosmesis of the biceps improved postoperatively [16]. One tenodesis in a patient >60 years of age with interval between LHB rupture and surgery of 96 months failed without improvement of pain, strength, and cosmesis [16]. Younger patients seem to tolerate cramping and discomfort due to a ruptured LHB tendon less and seek surgical intervention earlier [16]. Euler et al. (2015) reported the outcomes of 25 patients with primary LHB tenodesis for chronic ruptures (n = 18; 72%) and revision repairs (n = 7; 28%) at a minimum of 2 years postoperatively [1]. Each of the subitems of the SPBS, pain, strength, cosmesis, and cramping significantly improved postoperatively. The authors concluded that an open subpectoral biceps tenodesis for chronic symptomatic rupture of the LHB tendon and for a failed prior LHB tenodesis was a safe and effective treatment modality that decreased pain and improved function in this patient cohort. Anthony et al. (2015) presented outcomes of ten symptomatic patients with LHB tenodesis for auto-rupture or after LHB tenotomy, with most of the patients receiving the surgery in the chronic state [18]. Overall, outcomes seem to be similar between results of acute and chronic biceps rupture as well as between primary and revision tenodesis for chronic ruptures [1, 19].

Different techniques using interference screws and anchor fixation of the LHB have been described [1, 16]. The surgical techniques described here use one incision which is extended in case of severe biceps retraction. In some cases, a two-incision technique may be necessary to retrieve the LHB tendon distally and fix it to the humeral diaphysis or metaphysis more proximally [19]. The overall complication rate after open subpectoral LHB tenodesis with interference screw fixation is low [23].

Clinical Pearls and Pitfalls

- If tendon quality and length is sufficient to perform a "regular" subpectoral tenodesis, intraosseous fixation with an interference screw is recommended.
- In cases with poor tendon quality, severe scarring, or retraction of the LHB tendon, an extraosseous fixation with the use of suture anchors may be more appropriate to keep an appropriate length-tension relationship. Furthermore, the sutures should be passed into the myotendinous junction.
- If an interosseous technique with interference screw fixation is used, the drill hole should be placed at the center of the humeral shaft to minimize the risk of humeral shaft fractures.

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Chapter 3
Persistent Anterior Shoulder Pain Following Rotator Cuff Repair in a 51-Year-Old Male

Michael J. Collins, Timothy J. Luchetti, Justin W. Griffin, and Scott Trenhaile

Case Presentation: Part 1

The patient is a 51-year-old right-hand-dominant retired male who complained of right shoulder pain of 5 months duration. The pain was rated at 8/10 in severity, both with activity and at rest. The pain was located in the anterior, posterior, and superior shoulder. Physical exam revealed 4/5 supraspinatus strength. Provocative testing revealed positive Neer's test, positive Hawkins' impingement test, positive Speed's test, and positive Yergason's test. There was tenderness to

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_3,

palpation at the bicipital groove. X-rays revealed a type III acromion, as well as mild degenerative changes of the AC joint and the greater tuberosity of the humeral head (Fig. 3.1a–c). MRI again showed degenerative changes in the greater tuberosity and AC joint. It also revealed a full-thickness tear of the supraspinatus tendon and partial thickness tearing of the infraspinatus and teres minor tendons

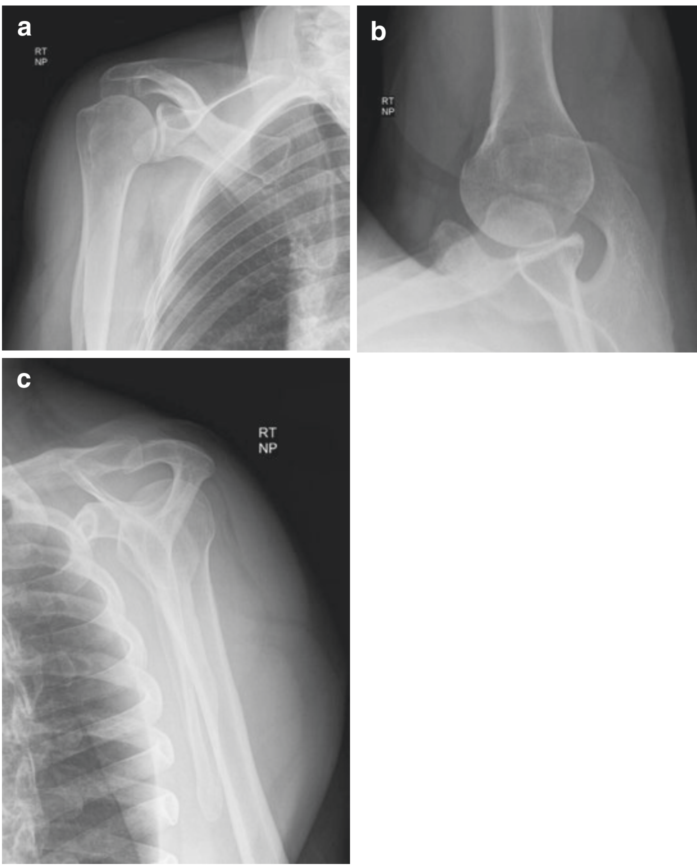

FIGURE 3.1 (**a–c**) Right shoulder AP, axillary, and scapular Y views which show a type III acromion, as well as mild degenerative changes of the AC joint and the greater tuberosity of the humeral head

but was otherwise normal. There was no evidence of biceps tendonitis on advanced imaging. The patient underwent arthroscopic rotator cuff repair and subacromial decompression. Intraoperative findings included a healthy appearing long head of the biceps tendon, evidence of subacromial impingement, full-thickness supraspinatus tear, and partial thickness infraspinatus and teres minor tears (Fig. 3.2a–f).

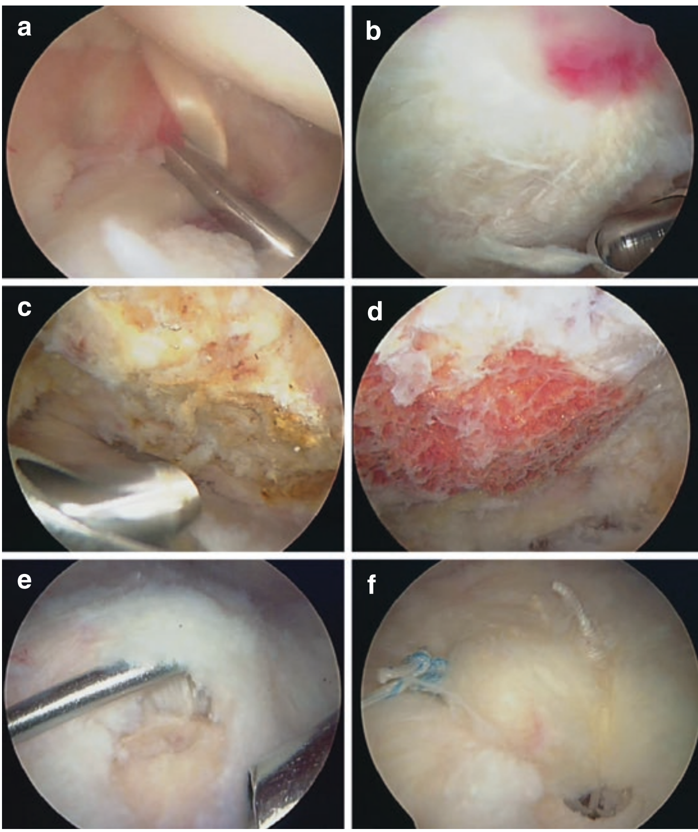

FIGURE 3.2 Intraoperative arthroscopic images of the shoulder, which reveal (**a**) a healthy appearing long head of the biceps tendon, (**b**) evidence of subacromial impingement, and (**e**) full-thickness supraspinatus tear. (**c** and **d**) Subacromial decompression. (**f**) Rotator cuff repair construct

There were no complications during surgery, and the patient underwent routine postoperative care with physical therapy beginning at 2 weeks. Follow-up examinations were unremarkable with the patient tolerating physical therapy well with mild shoulder discomfort. Unfortunately, the patient returned for the 4-month follow-up visit complaining of continued anterior and superior shoulder pain 5/10 with activity, improving only with rest. There was no pain-free interval after surgery. The patient denied any interval trauma after the index procedure.

Diagnosis/Assessment

There is a broad differential diagnosis for anterior shoulder pain following rotator cuff repair including biceps tendinitis, labral tear, acromioclavicular (AC) joint arthrosis, glenohumeral arthritis, adhesive capsulitis, subacromial and subcoracoid impingement, rotator cuff pathology, and cervical radiculopathy, among others. The close anatomic proximity to these structures makes it difficult to accurately diagnose the cause of shoulder pain.

One of the most common complications following rotator cuff repair is stiffness, occurring between 2.7% and 15% of cases [1]. Stiffness may be due to incomplete physical therapy or non-compliance with therapy. Alternatively, adhesive capsulitis may have developed. These patients will present with insidious onset shoulder pain and stiffness in both active and passive range of motion. Pain is typically more pronounced at extremes of motion. Physical examination does not reveal specific tenderness although the biceps may be tender due to its synovium being confluent with the glenohumeral joint [2]. Adhesive capsulitis has been described as occurring in three stages. The first stage is deemed the "freezing" or painful stage, which generally lasts between 3 and 9 months. The second stage, known as the "frozen" or transitional stage, has the hallmark of pain accompanied with muscular disuse and stiffness. Typically, the frozen stage lasts between 4 and 12 months and is followed by the final "thawing" stage of gradual symptom improvement that may last many years. The diagnosis of adhesive capsulitis, at the beginning stages, may mimic orther pathologies that should be ruled out initially.

When considering lesions in the long head of the biceps tendon, the clinician should have a keen eye for a history of anterior shoulder pain of insidious onset. Typically, there is no history of trauma with biceps tendinitis or instability. Occasionally patients will report a history of popping during shoulder motion. Physical exam findings can be nonspecific but include tenderness of the bicipital groove as well as provocative testing. The Yergason, Speed, and O'Brien active compression test all test for biceps tendon pathology. The reported sensitivities and specificities vary widely with these tests, and often further assessment must be performed. X-rays are usually normal. MRI is particularly helpful to assess the biceps tendon with T2 imaging showing fluid collection around the tendon sheath or tendon displacement in instability. MRA is superior for assessment of the intra-articular tendon segment, though increased cost, wait time, and invasiveness limit its use. In addition to imaging, corticosteroid injection into the biceps sheath is often utilized in both diagnosing pathology of the biceps and also as an initial treatment modality.

Unrecognized glenohumeral arthritis should be considered as a possible cause of pain after rotator cuff surgery. Glenohumeral arthritis also becomes more common later in life. Patients similarly present with pain at night and painful range of motion. Patients can sometimes exhibit tenderness at the glenohumeral joint. Typically a decrease in external rotation is noticed. Physical exam findings should be correlated with radiographic findings including subchondral sclerosis, cyst formation, joint space narrowing, and osteophyte formation. Typically, posterior glenoid wear is seen.

Patients with arthritic changes of the glenohumeral or AC joint typically present with activity-related pain that increases in frequency over a period of months to years. Patients may note a history of weight lifting, nighttime pain, overhead activities, or crepitus of the AC or glenohumeral joints. Physical exam findings may include tenderness on palpation of the AC joint or a positive cross body adduction test. This may be seen following rotator cuff repair in patients where preoperative arthritis was unrecognized or underappreciated.

Rotator cuff arthropathy is a specific type of shoulder arthritis that occurs only after a rotator cuff tear and needs to be considered. Physical exam findings will be very similar to those seen with glenohumeral arthritis. In patients recently treated with rotator cuff repair, it is unlikely that the classic exam findings of a positive Hornblower's sign or external rotation lag sign will be present. Radiographic findings include superior migration of the humeral head and superior glenoid wear. Likewise, an "acetabularization" of the acromion is sometimes seen in severe cases.

Unrecognized subcoracoid impingement may also cause persistent shoulder pain following rotator cuff repair. One review of 216 cases of rotator cuff repairs describes an incidence of subcoracoid impingement in 11 (5.1%) [3]. Classic findings of subcoracoid impingement include pain of the anterior shoulder and localized tenderness over the coracoid process. Pain can typically be elicited with the arm internally rotated at 120° of flexion. Impingement test may be positive but is nonspecific. The test is performed by placing the patient's arm in cross body adduction, forward flexion, and internal rotation. Pain with the patient's arm passively in this position is positive. However, labral pathology and subacromial impingement may also cause positive findings. Plain radiographs may show a decreased coracohumeral distance or a lateral projecting coracoid. On CT or MRI, a decreased coracohumeral distance can be better appreciated. It has been suggested that there should be a minimum distance of 6.8 mm between the tip of the coracoid and closest part of the proximal humerus; in asymptomatic individuals the average coracohumeral interval is 11 mm [4].

Recurrent subacromial impingement after rotator cuff repair and subacromial decompression is a well-known entity. Risk factors for recurrent subacromial impingement include worker's compensation claims, current smokers, and operative error. Patients complain of night pain and an insidious onset of pain aggravated by overhead activities. Exam findings are similar to those seen in isolated subacromial impingement syndrome. Provocative testing would include a positive Neer impingement sign, a positive Hawkins impingement test, and a positive Jobe test. Diagnostic imaging in patients with recurrent subacromial impingement after subacromial decompression will likely show evidence of prior subacromial decompression and may be normal. MRI is useful to assess the subcoracoid space and subacromial space and to assess for any re-tears or new tears.

It is also important to consider extrinsic causes of ongoing shoulder pain. Cervical radiculopathy may be caused by compression of nerve root, often due to cervical disk herniation or degenerative spondylosis. A history of neck pain, pain radiating down the arm, and numbness or tingling distal to the shoulder all suggest underlying neck pathology. Physical exam findings can be variable and may depend on which nerve is involved. A positive Spurling's exam maneuver is suggestive of cervical radiculopathy. The cervical spine should be evaluated on any shoulder radiographs. Any suspicion on exam or shoulder imaging warrants dedicated cervical spine x-rays, as well as a cervical MRI.

Case Presentation: Part 2

The patient followed up 4 months following his rotator cuff repair and subacromial decompression complaining of worsening anterior and superior shoulder pain. The severity of pain was 5/10 with activity and 2/10 with rest. The patients had a normal cervical spine exam. Significant physical exam findings of the shoulder included 5/5 strength testing with external rotation with the arm at the side, internal rotation with the arm at the side, external rotation with the arm at the horizontal, and with isolated supraspinatus strength testing. Range of motion testing showed forward flexion to 160°, abduction to 140°, IR with the arm at the side to T12, ER with the arm at the side to 45°, IR at the horizontal to 30°, and ER

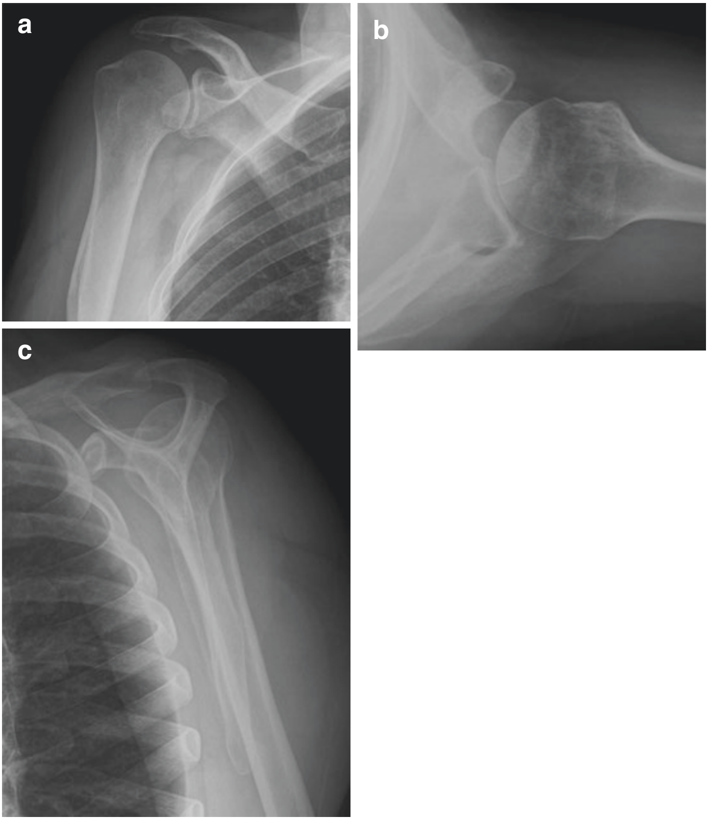

Figure 3.3 Plain radiographs of the shoulder revealed mild degenerative changes of the AC joint and preserved glenohumeral joint space. (**a**) Grashey view, (**b**) axillary view, (**c**) scapular Y view

at the horizontal to 70°. There was tenderness over the AC joint and bicipital groove as well as positive Hawkins impingement test and Neer's, Yergason's, and Speed's tests. Repeat plain radiographs of the shoulder revealed mild degenerative changes of the AC joint and preserved glenohumeral joint space. (Fig. 3.3a–c). MRI showed an intact rotator cuff with normal postoperative changes, AC degeneration with minimal mass effect exerted by the hypertrophied distal clavicle. It was decided to begin with an injection of lidocaine and corticosteroid into the biceps sheath to confirm physical exam findings and begin conservative management. One month later he returned to the office, stating the injection was beneficial for only 2 days and the pain had returned. Repeat examination was unchanged from the prior visit. Since the patient had failed conservative management, he was scheduled to undergo diagnostic arthroscopy and surgical treatment of his biceps tendinitis, AC joint arthrosis, and possible subacromial and subcoracoid decompression.

Management

When treating a pathologic condition of the biceps, it is important to consider the underlying cause and associated conditions. It has been estimated that primary tendinitis of the biceps tendon makes up 5% of all cases of biceps tendinitis [5]. In the elderly population, this most often includes rotator cuff pathology, although impingement, traction, narrowing of the bicipital groove, and arthritis can affect the tendon. Initial nonsurgical management is often the first line of treatment. Patients are counseled on cessation of provocative activities and given nonsteroidal anti-inflammatory drugs (NSAIDs). Additionally, patients undergo physical therapy. The use of corticosteroid injections may help aid in the diagnosing biceps pathology although the therapeutic capabilities are controversial as many causes of biceps pathology are mechanical and there is currently a paucity of clinical data on efficacy [6].

Surgical management begins with arthroscopic evaluation. A thorough evaluation should be performed paying special attention to the biceps, including checking stability of the tendon with a probe, thickening of intra-articular tendon portion resembling an hourglass, and examination of the distal aspect of the tendon which may reveal fraying or a hyperemic tenosynovium or lipstick lesion.

Two options for directly addressing the biceps tendon are tenotomy alone or with concomitant tenodesis. Tenotomy is performed arthroscopically using scissors or cautery to release the tendon from its origin at the labrum. Isolated tenotomy requires no postoperative immobilization or activity limitations. The cost is lower due to the lack of implants. There is shorter surgical time and technical ease associated with the procedure. Drawbacks include potential cramping and fatigue, decreased strength, and a potential for retraction of the biceps muscle distally which creates a cosmetic Popeye deformity. This deformity is less likely to develop in the setting of chronic inflammation due to the development of a thickened proximal end of the biceps that is too large to pass through the bicipital groove [7]. In a study of 40 patients aged 18–83 following biceps tenotomy, 70% reported a Popeye deformity, and 40% exhibited fatigue or soreness with resisted flexion. However, when compared to the contralateral arm, patients over 60 had no decrease in strength [8].

Alternatively, biceps tenodesis is a viable option. Biceps tenodesis may be performed either arthroscopically or via a mini-open approach. The potential benefits include restoration of strength and better cosmetic results. Disadvantages include increased cost, longer rehabilitation, and need for immobilization. In addition case reports of humeral fracture following open tenodesis have been reported, though the incidence remains rare and may be minimized with the use of smaller tenodesis screws. In our patient, who is active and able to undergo rehab, biceps tenodesis is the best option. This can be performed either arthroscopically or through an open approach. Multiple studies have sought to compare outcomes of open versus arthroscopic biceps tenodesis in patients undergoing rotator cuff repair. A recent review comparing outcomes of 271 open and 205 arthroscopic biceps tenodesis showed good to excellent outcomes in 98% of patients in both groups [9]. No specific study reporting on biceps tenodesis as a salvage procedure following rotator cuff repair was found during the writing of this paper. However, among patients with irreparable cuff tears, both biceps tenodesis and biceps tenotomy have shown to significantly improve symptoms [10].

Subacromial decompression is a very common procedure. It has been reported that persistent impingement syndrome is a common cause of continued shoulder pain after surgery for rotator cuff disease. This can be due to a failure to thoroughly decompress, regrowth of bone, anterior acromial spurring, inferiorly projecting acromioclavicular osteophytes, or subacromial calcification [11]. Results of revision acromioplasty in the literature have been mixed, although in patients with radiographic and physical exam findings, such as the positive Hawkins and Neer's test in this patient, revision acromioplasty may be necessary.

For patients with anterior shoulder pain worsened with activity, tenderness over the AC joint, and radiographic evidence of AC joint arthrosis who have failed conservative management, surgical treatment with a distal clavicle excision is indicated. This can be performed both arthroscopically and open with excellent results, although patients with arthroscopic repair were found to have significantly less pain at 2-year follow-up compared to the open cohort in a recent study [12]. Care must be taken not to remove more than 1–1.5 cm in order to prevent AC instability post-op. Distal clavicle excision is routinely performed in conjunction with subacromial decompression with excellent outcomes, though limited data is available of these procedures as salvage following rotator cuff repair.

Outcome

The patient underwent a diagnostic arthroscopy confirming a diagnosis of biceps tendinitis, AC joint arthritis, and impingement syndrome (Fig. 3.4a, b). The rotator cuff was examined showing no new tears or tendinosis. The patient subsequently underwent arthroscopic biceps tenodesis, subacromial decompression, and distal clavicle excision (Fig. 3.5a–c). There were no complications with surgery. The patient was seen 1 week postoperatively where his pain decreased from a 6/10 preoperatively to a 4/10 with activity and 2/10 at rest. The patient will require sling immobilization for 3–4 weeks with progression to full range of motion by 6 weeks.

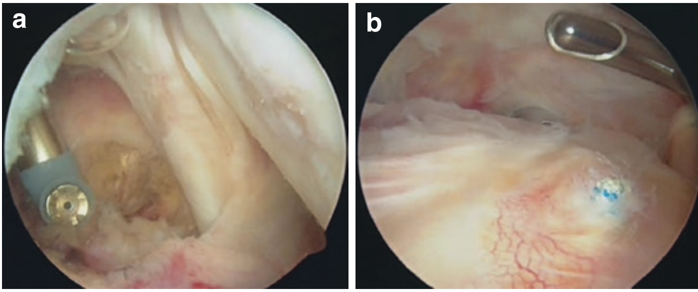

FIGURE 3.4 The patient underwent a diagnostic arthroscopy confirming a diagnosis of biceps tendinitis (**a**). AC joint arthritis and recurrent subacromial impingement were also observed (not shown). The rotator cuff repair construct was found to be intact (**b**)

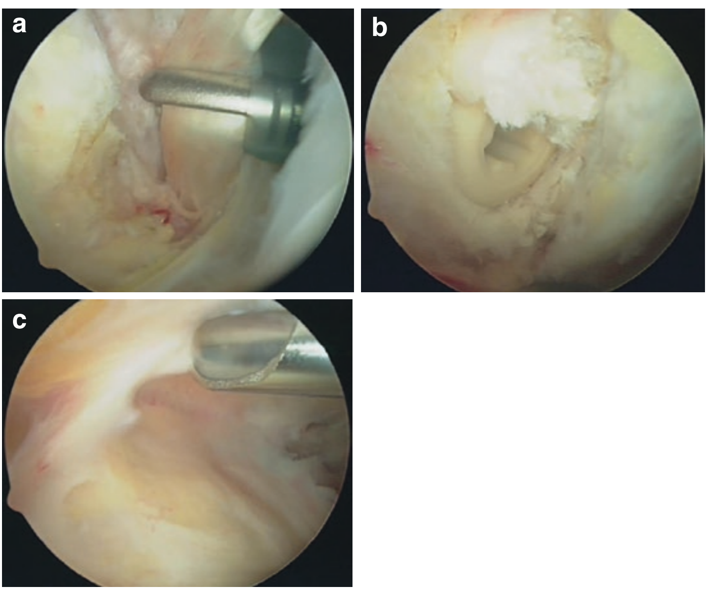

FIGURE 3.5 The patient subsequently underwent arthroscopic biceps tenotomy and tenodesis (**a** and **b**), subacromial decompression, (**c**) and distal clavicle excision (not shown)

Clinical Pearls and Pitfalls

- Anterior shoulder pain following rotator cuff repair may be due to causes both intrinsic and extrinsic to the shoulder. A careful examination must be performed, including examination of the cervical spine.
- Remember to consider the underlying cause of biceps tendinitis, as only 5% are considered primary tendinitis.
- Initial assessment of the LHBT should be assessed without fluid because pump pressure can compress peritendinous vessels, causing inflamed synovium to appear washed out.
- Removal of greater than 1–1.5 cm during distal clavicle excision may increase the risk of postoperative AC instability.

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Chapter 4
Anterior Shoulder Pain in a 23-Year-Old Overhead Throwing Athlete

Justin W. Griffin, John D. Higgins, Timothy S. Leroux, and Anthony A. Romeo

Case Presentation

The patient is a 23-year-old right hand-dominant male Division 1 tennis player who presented to our office complaining of right shoulder pain of 5 months duration. The pain was rated at 8/10 in severity, with overhead activity, especially during service. The pain was located in the anterior and superior aspect of the shoulder with some occasional radiating pain posteriorly. The patient felt a sensation of the shoulder occasionally catching when starting to throw. He attempted 3 months of no throwing. He was unable to exercise including weight training due to pain.

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_4,

Physical exam revealed full strength and range of motion. Provocative testing revealed positive Obrien's, positive labral shear test, negative Hawkin's test, and no apprehension. There was pain with resisted internal rotation with the arm in 90° external rotation and abduction to 90°. Importantly, there was no tenderness with palpation at the bicipital groove. X-rays revealed a Type I acromion, a normal AC joint, and no other bony abnormalities. MRI was obtained demonstrating a superior labral tear extending mostly anterior to the biceps tendon (Fig. 4.1). There was some mild insertional tendinosis of the rotator cuff tendon, a common finding in MRI's obtained in overhead athletes. Finally, the MRI did demonstrate a possible HAGL lesion as seen in Fig. 4.1b. Cartilage surfaces appeared well preserved. There was no evidence of biceps tendonitis in the groove on advanced imaging.

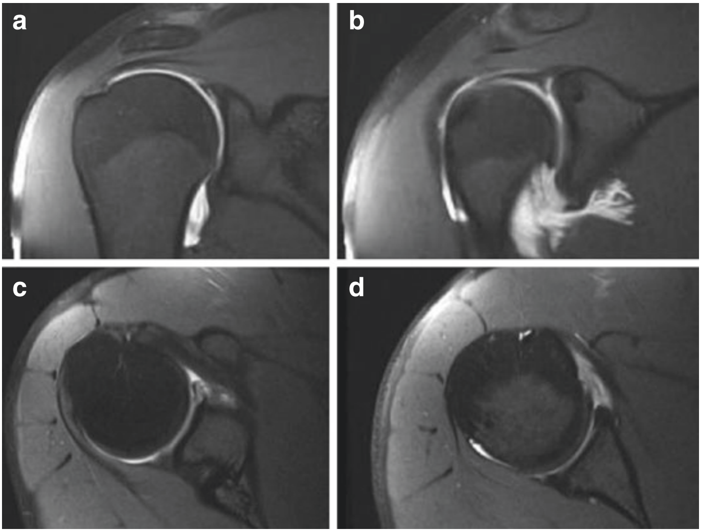

FIGURE 4.1 T2-weighted coronal image demonstrating a superior labral anterior posterior tear (**a** and **b**). Coronal images show the more anterior extent of this tear and the biceps remaining in the bicipital groove with concern for a HAGL lesion

Diagnosis/Assessment

Anterior shoulder pain in the overhead athlete carries a relatively broad differential diagnosis. Pathologies include global biceps tendinitis, anterior or posterior labral tear, SLAP tears, cartilage lesions of the humeral head, rotator cuff tendinitis, and subacromial and internal impingement. A detailed patient history is important to ensure an accurate diagnosis and proper treatment methods. Information about the patient and their activity can provide the physician with useful diagnostic information. Such information includes patient age, instability events, years of overhead activity, hand dominance, level of competition, comprehensive medical history review, previous shoulder injuries, and other orthopedic injuries [1]. A thorough history can help the physician narrow the diagnosis and identify which structures are injured. Age is a helpful indicator of possible pathologies and treatments as it can help determine if the patient's physes are open, if they are more likely develop a disease, and what their recovery period will be like [1, 2].

Physical examination becomes very important to differentiate the various pathologies. Initially, the examination should identify any obvious visual deformities, asymmetry compared to the contralateral side, swelling, ecchymosis, erythema, or scarring from previous surgeries. Recurrent instability events can provide the physician with a great deal of information regarding the pathology of the shoulder, i.e., glenoid labrum and/or humeral head lesions [3]. Palpating the shoulder can help determine which structures are injured and any presence of warmth or crepitus. Active and passive range of motion should be evaluated and compared to the unaffected side. It is diagnostically helpful to gauge the patient's pain during specific movements or tests. In our case, the patient possessed full range of motion in both arms with no previous instability events or evidence of joint swelling, crepitus, or tenderness to palpation.

In order to rule out rotator cuff pathology, an assessment of the rotator cuff strength is highly advised. The examiner can evaluate the supraspinatus by resisting the patient's abduction with the arm abducted to 30° and internally rotated so that the patient's thumbs are facing downward. The subscapularis can be assessed through the lift-off test or the belly-press test. Testing the patient's ability to lift the dorsum of their hand off the mid-lumbar region of their spine completes the lift-off test. The belly-press test asks the patient to apply pressure to their abdomen while internally rotating the shoulder. The infraspinatus and teres muscles can be evaluated during the external rotation test where the examiner resists the patient's external rotation while their arms are by their side and bent at 90°. Any pain or inability exhibited during the strength testing can help identify specific tendon injury [1]. Our patient had full strength during such tests eliminating suspicion for any significant rotator cuff pathology.

Overhead athletes often suffer from impingement syndrome, which is one of the possible causes of shoulder pain [4]. This impingement is categorized into two different pathological conditions: subacromial and internal impingement [5]. Overhead athletes are often vulnerable to internal impingement due to the abduction and extensive external rotation of their throwing arm [1, 5]. Posterior shoulder pain and a positive relocation test are common in such cases. Diagnostic imaging struggles to effectively diagnose impingement syndromes; furthermore, arthroscopy appears to be the most effective method of diagnosing and treating such pathologies [1]. Despite this statement, conservative treatment measures should be employed, emphasizing rotator cuff strengthening, anti-inflammatories, subacromial joint injections, and appropriate activity modifications [5].

Further provocative testing was completed to elucidate additional shoulder pathologies. To assess the integrity of the labrum, a number of clinical tests can be administered. Guanche and Jones found that the Jobe relocation, load and shift, O'Brien's, and anterior apprehension tests are all valuable options to determine if any labral lesions including superior labrum anterior and posterior (SLAP) or instability type symptoms are present [6]. Other tests to assess the labrum are bicipital groove tenderness, the crank test, Speed's test, and Yergason's test, as defined by Guanche and Jones [6].

Bicipital groove tenderness and Speed's and Yergason's tests can also help identify biceps tendon pathology [7]. Our patient exhibited a positive O'Brien's test and a positive labral shear test hinting at a SLAP tear and no evidence of biceps pathology or groove pain. However, studies have shown that in addition to clinical examination, appropriate radiographic imaging must be undertaken to ensure proper diagnosis of labrum pathology. An MRI of our patient was read and demonstrated a superior labral tear, which coincided with our positive provocative tests.

Management

Management of SLAP lesions and anterior shoulder pain should initially be nonoperative. The most commonly utilized strategy includes physical therapy to focus on scapular mechanics and rotator cuff strengthening. Reported results in the literature are somewhat variable with many series suggesting that most cases resolve without surgery. Further, many professional athletes have SLAP tears which are asymptomatic.

Associated shoulder instability and significant glenohumeral dysfunction is not uncommon in athletes with lesions of the biceps-labral complex. In our case, the subtle anterior instability was dealt with at the time of surgery and exam under anesthesia was critical to the patient's management and outcome. Regarding SLAP lesions, in 1985 Andrews et al. first described SLAP tears in a series of 73 overhead athletes [8]. Later, Snyder et al. further classified these lesions into four types based upon the stability and location of the tear and coined the term SLAP as an acronym [9, 10]. Morgan et al. subclassified Type II lesions into three groups based on location including anterior, posterior and anterior, and posterior [11]. Type I lesions are typically managed nonoperatively. Type II lesions are the most commonly occurring and treated variant in throwing athletes as seen in our case (Fig. 4.2). Evaluation intraoperatively for a peel-back lesion by placing the arm in abduction, external rotation, as opposed to a sulcus of 1–2 mm, may confirm the presence of a Type II SLAP tear [11–13]. The direction of the tear propagation is often important to consider as well and in our case propagated anteriorly (Fig. 4.2).

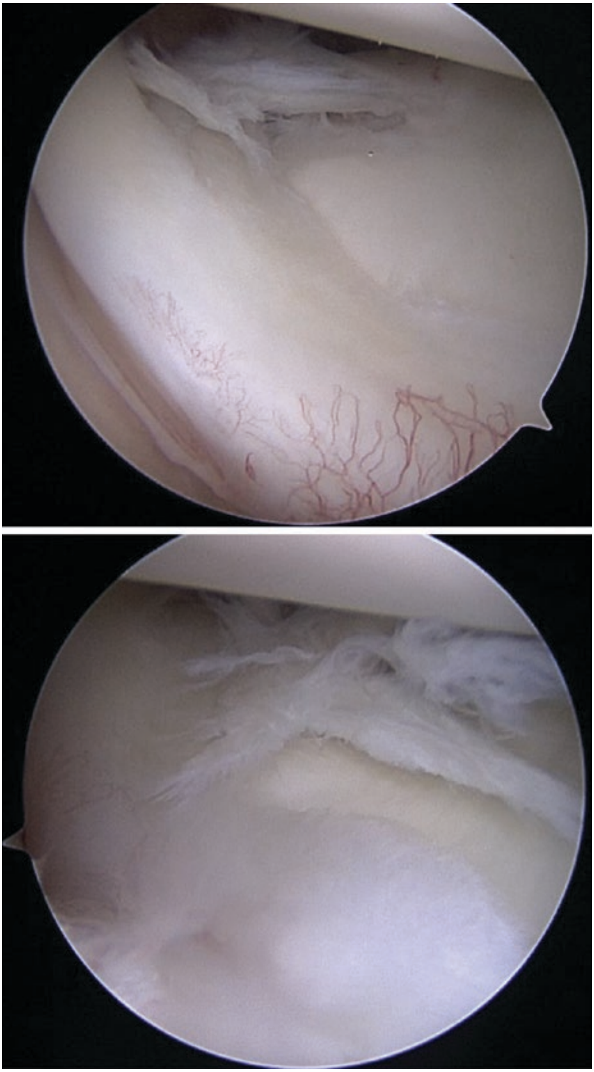

FIGURE 4.2 Intraoperative images of the SLAP lesion

Type III lesions include those with an intact biceps-labral complex but with a bucket handle tear of the superior labral complex with an intact biceps tendon, while a Type IV tear includes additional extension of the tear into the biceps tendon [9, 10]. Although various methods exist, SLAP repair most commonly consists of repairing the labrum and biceps anchor. Several prospective studies have demonstrated improved overall outcomes after Type II SLAP repair [14–19]. Other series have demonstrated less promising outcomes including dissatisfaction with persistent pain and inability to return to throwing [16, 20]. A recent systematic review reported that the percentage of patients who return to preinjury level of play was only 64% [21]. Overhead throwing athletes results were even worse with only 22–60% able to return to their previous level of play [21].

These less than ideal outcomes have led many surgeons treating overhead athletes with SLAP tears to ask what is the best single surgery for the SLAP tear in this population including revision for failed SLAP repair. Missed instability at the time of surgery as a result of tear propagation can cause recurrent pain. Our case emphasizes the importance of recognizing this and treating it appropriately.

Cartilage damage, anchor pullout, and knot prominence remain a concern in overhead throwing athletes who undergo SLAP repair. We prefer knotless technology for this reason and have seen cases of glenoid osteochondrosis from prominent hardware or prominent knots, which others have reported as well [22–27]. Prepping the glenoid edge to a bony surface may help with healing, which remains a significant concern [26, 28]. The intra-articular portion of the biceps tendon as well as the portion within the bicipital groove contains sensory fibers, which may lead to persistent pain and inflammation following SLAP repair [13, 29, 30]. Several studies have demonstrated this phenomenon leading some authors to perform primary biceps tenodesis in an attempt to avoid revision surgery [16, 29, 31–33]. When possible, we prefer to place anchors posterior to the biceps insertion as opposed to anterior to avoid stiffness as reported in the literature [19].

For older, non-overhead throwers, the SLAP repair has largely become less popular as a management option for Type II SLAP tears in many centers with many tears being debrided or undergoing biceps tenodesis [20]. Biceps tenodesis has been proposed as an alternative to SLAP repair in recent years especially in older individuals [13, 16]. Some authors have proposed biceps tenodesis for primary treatment of isolated SLAP tears concluding that arthroscopic biceps tenodesis was an effective alternative to the repair of a Type II SLAP lesion; however, this study was not isolated to overhead athletes with an average age of 52 in the tenodesis group [16]. Gupta et al. evaluated patients undergoing primary biceps tenodesis with 80% excellent outcomes based on improved shoulder outcome scores in select patients with SLAP tears including eight athletes, 88% of which were overhead athletes [20]. These studies suggest that primary biceps tenodesis may present an alternative with less failure rates in middle-aged patients as well as overhead athletes with SLAP tears though further specific studies are needed to focus on overhead athletes on a larger scale.

Our algorithm for SLAP lesions is evolving along with our understanding of this complex disease process. In young overhead throwers with Type II SLAP lesions, we favor performing an arthroscopic SLAP repair with knotless technology. In patients who are older recreational overhead athletes, we favor biceps tenodesis in the subpectoral region after diagnostic arthroscopy with biceps tenotomy with or without additional SLAP tear fixation depending on the stability of the biceps anchor. When revising a prior SLAP repair, the authors recommend revision to a biceps tenodesis utilizing our published technique [34, 35]. Rehabilitation postoperatively is critical as lack of return to play may be a result of poor throwing mechanics rather than surgical fixation technique.

Outcome

Following a period of nonoperative management including physical therapy, the patient underwent shoulder arthroscopy. The patient was administered a right interscalene block using ultrasound guidance. He was then brought back to the operating room, identified, and placed on the operating room table. He was then placed into a left lateral decubitus position. We prefer the lateral decubitus position for this procedure.

An examination under anesthesia demonstrated 2+ anterior translation with his elbow below 45° of abduction consistent with a problem related to the anterior part of his shoulder at the 3 o'clock position or superiorly. With abduction and external rotation, his shoulder was stable, which was inconsistent with the MRI diagnosis of the HAGL lesion. He had some mild crepitation in his shoulder on examination. Then, the arthroscope was placed into his shoulder through a posterior superior portal, and the arm was brought through range of motion. There was no evidence of a HAGL lesion that was seen from this arthroscopic evaluation (Fig. 4.3). A superior labral tear was confirmed (Fig. 4.2; Video 1). In addition, this superior labral tear extended anteriorly from the 1 o'clock to the 3 o'clock position. The rotator cuff was intact. The biceps tendon was intact.

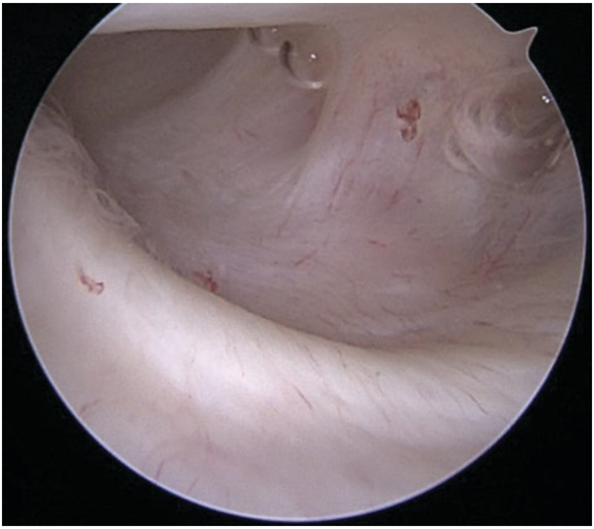

FIGURE 4.3 No evidence of HAGL lesion was seen on arthroscopy

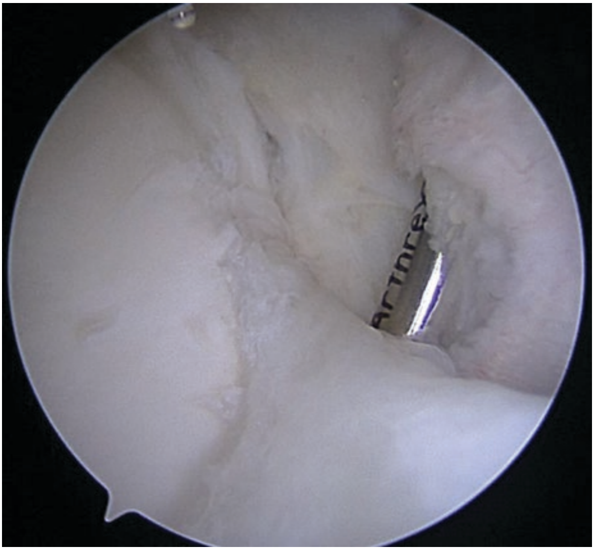

FIGURE 4.4 Intraoperative fixation of the SLAP and anterior labrum

The arthroscope was placed back into the posterior superior portal, and an anterior portal was established in the rotator interval. A debridement was carried out within the glenohumeral joint and confirmed the findings of the dynamic examination including an intact rotator cuff. The arthroscope was placed in the anterior portal, and while visualizing through this portal, the rim of the labrum was debrided down to a bleeding bony surface off the edge of the glenoid. Two 2.9 mm PushLock knotless anchors (Arthrex, Naples FL) were then used to fix the labrum using with labral tape (Arthrex, Naples FL). This was performed in a mattress-type configuration to minimize the amount of the synthetic materials that would come in contact with the arm in abduction and external rotation (Fig. 4.4). A secure and stable repair in an anatomic position was achieved regarding the superior labrum (Fig. 4.4).

The arthroscope was now placed back to the posterior portal, and while visualizing anteriorly including anterior to the biceps tendon, the rim of the glenoid was now debrided again. The area again from approximately the 3 o'clock position to the 1 o'clock position was clearly abnormal and did not represent a sublabral hole. This was consistent with his preoperative examination of the pathologic anterior laxity. Therefore, two additional PushLock anchors using labral tape were used to fix this area down to its anatomic position one with a simple stitch down the lower area to gather up the tissue with the proper labral bumper, and then the superior stitch at the corner of the glenoid from approximately the 12:30 to the 1:30 position was a mattress-type suture configuration applying this down into a normal position (Figs. 4.5, 4.6, and 4.7).

There was no evidence of an anterior labral tear below the 3 o'clock position. There was no evidence despite the MRI findings that there had been a disruption of the capsule from the humerus in the form of a HAGL lesion. If this had in fact occurred, it had subsequently healed back in a normal anatomic appearing position. No additional surgery was indicated for the anterior aspect of the shoulder based on the arthroscopic visualization. Postoperatively, the patient's

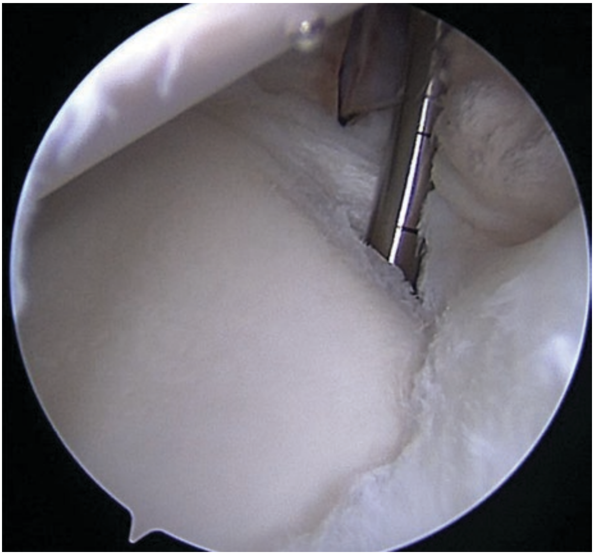

FIGURE 4.5 Intraoperative fixation of the anterior labrum with knotless technology

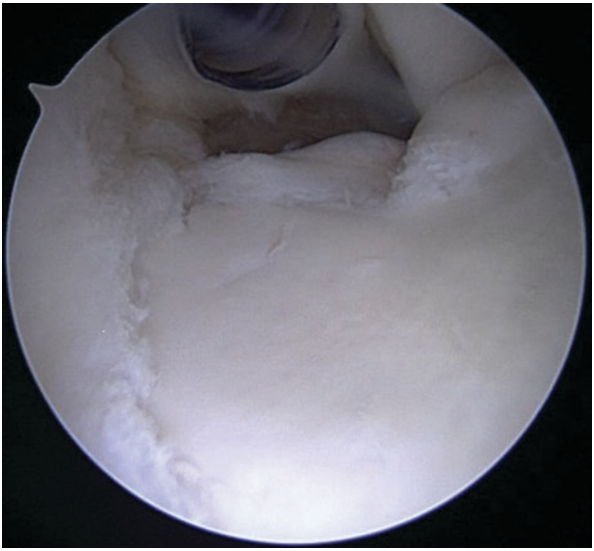

Figure 4.6 Demonstration of final fixation of the anterior labrum and SLAP with knotless technology

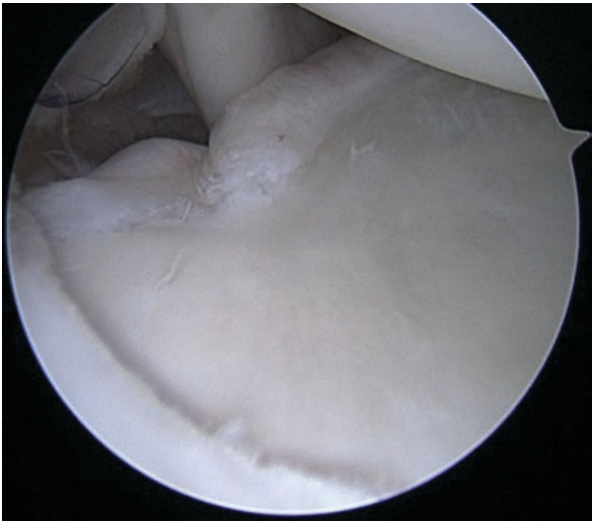

Figure 4.7 Demonstration of final fixation of the anterior labrum and SLAP with knotless technology

arm was placed into a shoulder abduction sling. Postoperative care included a sling for 4 weeks followed by progression of active and passive range of motion. He was able to return to play at 8 months after surgery without restrictions.

Clinical Pearls and Pitfalls

- Anterior shoulder pain in young athletes may be due to causes both intrinsic and extrinsic to the shoulder. Physical examination including evaluation of internal rotation deficit as well as bicipital groove pain is paramount to selecting the proper treatment.
- Assessment of the LHBT should be assessed within the groove for instability and inflammation.
- Exam under anesthesia is a critical portion of the procedure to evaluate for instability which may be addressed at the time of surgery.
- In young overhead athletes, we prefer primary SLAP repair though some severe or revision cases may warrant biceps tenodesis primarily.
- Use of a percutaneous port of Wilmington is often helpful to obtain the appropriate angle for anchor placement.
- Knots should always be kept off the articular surface, and knotless technology is preferred in our hands above the equator of the glenoid.

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Chapter 5
Anterior Shoulder Pain in a Windmill Softball Pitcher

L. Pearce McCarty III

Introduction

Participation in fast-pitch softball remains popular among female adolescents in the United States, estimated to be the fifth most popular high school sport for high school women in the 2014–2015 scholastic season as judged by number of individual participants, and the fourth most popular with respect to number of schools participating [1, 2]. Over 360,000 high school and over 16,000 collegiate athletes play competitive, fast-pitch softball on a seasonal basis, a number that has remained relatively stable at a high level over the past decade, producing a significant degree of athletic injury exposure due to repetitive forces encountered during this sport [1, 3]. With this popularity, authors have focused new attention on this athletic population and the potential risk of injury associated with various aspects of the sport, in particular with the windmill fast-pitch motion [3, 4, 5–9].

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_5,

Over 50% of musculoskeletal injuries sustained by fast-pitch softball athletes involve the upper extremity and relate primarily to pitching or throwing in the field [6, 7]. Specifically, Loosli et al. found that 45% of all time-loss injuries in collegiate, fast-pitch softball could be attributed to pathology involving the shoulder or elbow [4]. Volume and repetition play a significant role in generating these injuries and exceed levels observed in other overhead throwing sports such as baseball [9]. Elite-level softball teams carry fewer pitchers on their rosters than baseball teams, and an elite-level windmill softball pitcher can throw as many as 1500–2000 pitches over a 3-day tournament [9].

The mechanics of overhand baseball pitching and the resulting biomechanical stress imparted to the shoulder and elbow have garnered extensive interest and investigation in the orthopedic literature. Although significantly less studied, multiple authors have described significant biomechanical stress to a pitcher's shoulder with underhand, windmill technique, fast-pitch softball as well, challenging the historical notion that the underhand throwing mechanism produces negligible stress on the shoulder and that resulting injury is therefore rarely observed [1, 6, 9]. In particular, it is thought that the long head of the biceps tendon and associated superior labrum experience significant strain during certain phases of the windmill pitch cycle [6].

Case Presentation

An 18-year-old, right-hand dominant, female windmill softball pitcher with no history of shoulder or elbow injury presented, referred by her physical therapist, complaining of 3 months of progressive anteriorly based right shoulder pain while pitching. The patient denied acute onset of pain during any particular windmill pitch or overhand throw and instead described a gradual increase in anteriorly based pain to the point that it had begun to affect performance, with decreases in velocity and ability to locate pitches accurately. With further investigation the athlete was able to pinpoint the majority of her pain to the release phase of pitching, roughly at the 9 o'clock point of the cycle. Additionally, the athlete complained of occasional mechanical-type symptoms, with a sensation of "catching" in certain positions and a feeling of instability. The patient had been seen by an outside provider and had participated in 3 months of physical therapy focusing on periscapular and rotator cuff strengthening without improvement in her symptoms. Additionally, she had been held from throwing or batting during this period.

Diagnosis/Assessment

Investigation of anterior shoulder pain in any overhead athlete presents a diagnostic challenge as it involves an anatomic region rich with potential pain-generating structures. A differential should include intrinsic long head of the biceps tendon pathology, anterior supraspinatus pathology (e.g. partial articular-sided delamination), subscapularis pathology including lesser tuberosity avulsion in the skeletally immature overhead athlete, superior labral pathology, anterior labral pathology, and coracoid impingement.

On physical exam, the patient exhibited hypermobility in both shoulders with positive hyperabduction tests bilaterally, and no evidence of significant difference in total arc of rotation side to side [10]. Manual motor testing revealed full strength throughout both upper extremities. Focal tenderness to palpation was found anteriorly on the right shoulder in the region of the coracoid process and bicipital groove. O'Brien's active compression test, the compression–rotation test and the resisted supination external rotation tests were all positive, reproducing the patient's anteriorly based right shoulder pain [10]. While no single physical exam maneuver can be considered to be pathognomonic for superior labral pathology, the resisted supination external rotation test has been shown to have the highest sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of commonly performed special tests to detect superior labral pathology [11]. Apprehension and relocation tests were negative. The elbow exhibited normal range of motion with negative bounce and moving valgus stress tests.

Plain radiographs of the shoulder were obtained and observed to be normal. Although there is evidence that conventional, high-resolution (1.5 T and higher) MRI can yield diagnostic accuracy for superior labral pathology similar to that of MRI arthrography, we have found in our regional location that MRI arthrography provides more consistently accurate results. An MRI arthrogram was obtained and demonstrated a Type VI SLAP lesion using the Maffet extended classification, with detachment of the superior labrum from the supraglenoid tubercle and a small labral flap displaced into the glenohumeral joint [12] (Fig. 5.1).

FIGURE 5.1 Coronal, fat-suppressed image depicting gadolinium undercutting superior labrum consistent with unstable tearing from the supraglenoid tubercle

Management

After discussion of both continued nonoperative treatment, consisting of activity modification and physical therapy, and operative repair with the athlete and her family, the patient elected to proceed with arthroscopic debridement of the superior labral flap and repair of the portion of the superior labrum detached from the supraglenoid tubercle. Factors associated with failure of nonoperative treatment of SLAP lesions include participation in overhead sports, traumatic etiology, and a positive compression–rotation test [13]. The procedure was performed in a lateral decubitus position to facilitate access to the entire glenoid capsulolabral complex. Consistent with preoperative imaging, a small, displaced anterior labral flap was observed along with detachment of the superior labrum from the supraglenoid tubercle (Fig. 5.2). Repair was accomplished using two anchors placed posterior

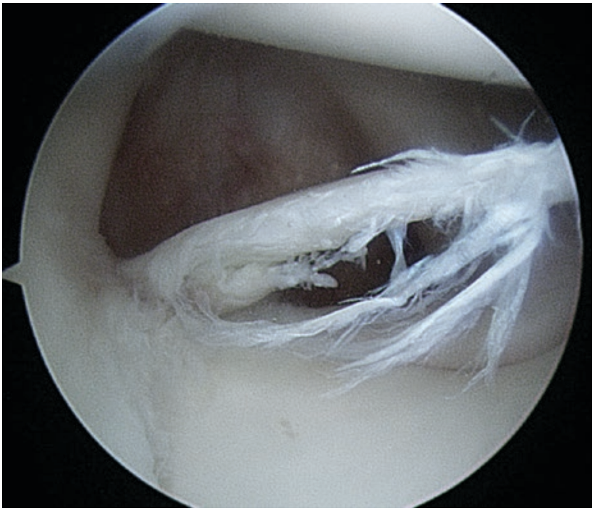

FIGURE 5.2 Arthroscopic image of Maffet Type VI SLAP lesion with anteriorly based unstable flap. The remaining superior labrum was unstable when probed

to the biceps anchor. Note that the author favors a knotless, “labral tape”-based technique with the theoretical intention of mitigating any risk of knot-based undersurface wear at the supraspinatus–infraspinatus junction during abduction–external rotation.

Postoperatively, sling immobilization was utilized for a period of 4 weeks. Pendulums and gentle passive range of motion were initiated at 2 weeks postoperatively and active-assisted range of motion begun once the sling had been discontinued. With our typical postoperative SLAP rehabilitation protocol, early focus is placed on activation of scapular stabilizers, including the middle and lower trapezius, which have been shown to involve low activation of the biceps brachii with surface EMG monitoring [14]. Gentle activation of the serratus anterior is also included in this early phase, although cautiously, as concomitant activation of the biceps brachii is more significant with this periscapular stabilizer than with the middle and lower trapezius. Strengthening progresses from periscapular stabilizers, to internal rotators, to external rotators, to forward flexion in the scapular plane following progressive involvement of the biceps brachii. A return to throw protocol is initiated 16–18 weeks postoperatively depending upon the progress of the patient with respect to active range of motion and muscle activation.

Outcome

Elite-level, fast-pitch, windmill-style softball pitchers experience significant distraction forces through the glenohumeral joint during the pitching motion, reaching up to 80% of body weight and achieving angular velocities of almost 2200 deg/s [9]. As a complimentary finding, muscle activation of the biceps brachii reaches significant levels during the windmill pitching motion, exceeding that observed during overhand throwing and peaking at the 9 o’clock position immediately preceding ball release [6]. Expressed as a percentage of maximal muscle activation, windmill pitchers see up to 38% activation of the biceps brachii versus 19% with overhand throwing [6]. The significant stresses encountered by the biceps–superior labral complex during the windmill pitching motion may play a prominent role in the frequency of anterior shoulder pain in fast-pitch players and should heighten awareness in treating physicians of the possibility of structural superior labral pathology.

MRI can be considered to be the imaging modality of choice for diagnosis of superior labral pathology. Although musculoskeletal ultrasound has significant limitations with respect to imaging of the glenoid labrum, it can be helpful as a screening modality, providing valuable information about the rotator cuff and long head of the biceps tendon, both potential primary sources of anterior shoulder pain in a throwing athlete.

Although there is no published literature documenting outcomes following superior labral repair in fast-pitch softball players, results following repair in other throwing athletes, such as baseball pitchers, can be considered relevant. Rates of return to baseball pitching at pre-injury level following arthroscopic SLAP repair ranges from 57 to 73% at between 9 and 13 months postoperatively [15, 16]. Authors have reported rates of failure to return to pitching at any level at up to 17% [15, 16].

Clinical Pearls and Pitfalls

- Fast-pitch, windmill softball pitchers see significantly higher volumes of pitches thrown during a given season or tournament than baseball pitchers.
- Overuse injuries are common in the upper extremity of fast-pitch, windmill softball pitchers and often present with a chief complaint of anterior shoulder pain.
- The biceps–labral complex experiences significant stress immediately prior to the release phase of the windmill pitching cycle, with angular velocity as high as 2190 deg/s,

distraction forces reaching up to 80% of body weight, and activation of the biceps brachii up to 38% of maximal activation.
- Participation in overhead sports, traumatic etiology, and a positive compression–rotation test on physical exam are predictive of failure of nonoperative treatment of SLAP lesions.

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Chapter 6
Synovial Chondromatosis Involving the Long Head of the Biceps

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Case Presentation

The patient is a 35-year-old right-hand-dominant male that presented with a 1-year history of right shoulder pain that acutely worsened while playing basketball 3 months prior to his first office visit. While playing, he was running down the court when a teammate passed him the ball, and he reached up with his right hand. During that time, he felt a significant amount of pain in his right shoulder with a sensation of something shifting within the joint. The patient denied any history of antecedent trauma to his right shoulder. The shoulder pain was rated as 5/10 in severity at rest that worsened to 8/10 with activity. The pain has interfered with his sleep, and he has modified his daily activities to compensate. He denies any

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_6,

previous medical conditions or surgical procedures to his shoulder.

Physical examination of the right shoulder revealed decreased forward flexion to 120°, abduction to 50°, internal rotation to 30°, and external rotation to 40° with pain at terminal extent of motion. The contralateral, non-painful left shoulder demonstrated full active and passive range of motion in all planes. There was mild tenderness to palpation over the anterior, posterior, and superior aspects of the right glenohumeral joint without palpable crepitus. No warmth or erythema was appreciated. The left and right shoulders had 5/5 rotator cuff strength on exam. Provocative testing revealed positive Speed's test and Yergason's test on the right side.

With regard to imaging, plain films were remarkable for calcific densities within the soft tissues adjacent to the proximal right humerus and subcoracoid region (Figs. 6.1 and 6.2).

Figure 6.1 AP radiograph of the right shoulder. Note the multiple calcific densities within the glenohumeral joint and soft tissues adjacent to the proximal humerus

FIGURE 6.2 Radiograph with axillary view of the right glenohumeral joint. Note the presence of metaplastic disease within the proximal bicipital groove

Magnetic resonance (MR) arthrography was remarkable for glenohumeral effusion, multiple loose bodies, and mild degenerative joint disease (Figs. 6.3 and 6.4). Notably, the proximal biceps groove appeared synovialized and within the joint (Fig. 6.4). This finding suggested that this location might serve as a site for synovial-based disease.

Assessment/Diagnosis

As with any new patient encounter, a comprehensive history and physical examination is integral. In patients with shoulder pain, pertinent information include the timing and

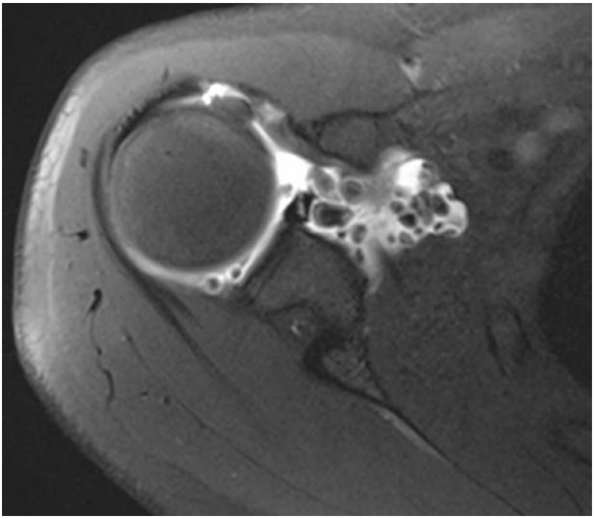

Figure 6.3 T1-weighted MR arthrogram of the axial section demonstrating multiple loose bodies within the joint space

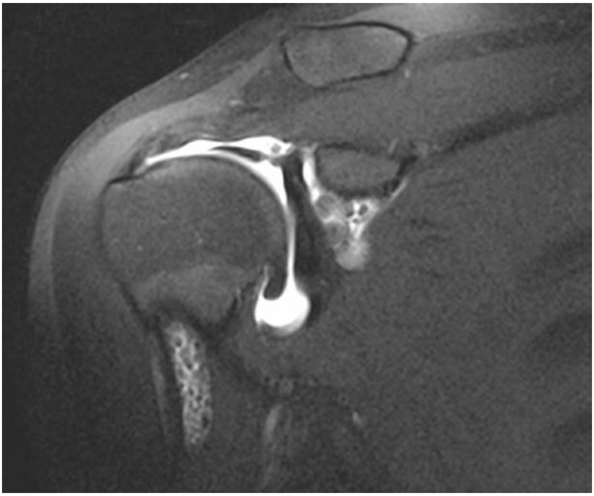

Figure 6.4 T1-weighted MR arthrogram of the coronal section demonstrating high signal near the proximal humerus and biceps tunnel and within the glenohumeral joint. Again, significant metaplastic tissue is noted within the proximal biceps and biceps groove

severity of pain and the presence of nighttime symptoms and mechanical symptoms, and feelings of weakness or fatigue should be sought. Relevant physical exam findings include limitations of motion or strength, location of pain, crepitus, instability, or any mechanical signs (catching, locking, clicking, etc.). In our patient, the history was notable for shoulder pain that worsened with activity, night pain, and mechanical symptoms. On physical examination, pertinent findings included limited range of motion, tenderness to palpation of the shoulder joint, and positive Speed's and Yergason's tests.

The physical examination should begin with inspection to assess for any gross deformities and asymmetry compared to the contralateral shoulder. Note any scarring around the shoulder joint, which may suggest previous surgery and aid in establishing a diagnosis. Next, both active and passive range of motion should be assessed and comparisons made to the unaffected side. Palpation of the shoulder joint and surrounding musculature should be performed in order to evaluate for any warmth, crepitus, or swelling. In the case of SC, examination typically reveals diffuse joint swelling, tenderness to palpation, crepitus, and joint locking [1].

Specific physical examination maneuvers are utilized to evaluate biceps pathology including the Yergason's test and Speed's test. The Yergason's test is performed with the patient's elbow flexed to 90° and forearm positioned such that the lateral border of the radius faces upward. The examiner stands on the involved side and places one hand on the patient's forearm and the other at the bicipital groove. The examiner actively resists the patient's attempt to supinate their forearm. Pain upon resisted supination and snapping in the bicipital groove is a positive finding. Speed's test is performed with the shoulder flexed to 90°, the elbow fully extended, and the forearm supinated. The examiner places one hand on the forearm and the other over the bicipital groove while resisting forward flexion of the shoulder. A positive finding is noted with tenderness and pain in the bicipital groove.

Patients with an affected shoulder may be initially misdiagnosed with adhesive capsulitis given their similar clinical presentation. The astute clinician must not rely on imaging to establish a diagnosis of SC of the shoulder. Butt et al. [2] reported a case of a 32-year-old woman who presented with restricted, painful range of motion that was previously diagnosed as adhesive capsulitis following examination under anesthesia. Conventional radiography showed significant osteopenia and periarticular calcification. Magnetic resonance imaging (MRI) established the presence of heterogeneous soft tissue within the glenohumeral joint, which suggested SC. The diagnosis was later confirmed with arthroscopy and biopsy.

Appropriate radiographic imaging of the shoulder is essential to the proper assessment of patients with suspected SC, as there exist pathognomonic findings associated with the diagnosis. Classic radiographs may reveal multiple intra-articular calcifications in approximately 70–95% of cases, typically evenly distributed throughout the joint space (Figs. 6.1 and 6.2) [1]. The pathognomonic appearance of these calcifications is innumerous in quantity with similarities in shape between each entity. These loose bodies may mature further by undergoing endochondral ossification [3]. The ability to detect these nodules on radiographs is directly associated with the level of maturity of the nodule, known as the Milgram stage [4].

Chronic disease may also lead to the development of secondary osteoarthritis and asymmetric joint space narrowing [1]. Radiographic findings are normal in approximately 5–30% of primary SC; therefore, further advanced imaging is required [1].

Computed tomography (CT) imaging is the optimal modality to detect and characterize calcifications [1]. The erosion of bony surfaces can also be detected using CT due to its cross-sectional imaging capabilities. On MRI, the appearance of nodules depends on the amount of mineralization. Typically, the nodules display signal intensity comparable to the muscle on T1-weighted imaging and a high signal on T2-weighted imaging [4]. MR arthrography can also be utilized to further characterize the location and extent of disease (Figs. 6.3 and 6.4). In our case, MR arthrography revealed the presence of metaplastic synovium within the proximal biceps groove thereby contributing to preoperative planning for surgical loose body removal and concomitant open synovectomy of the groove with subsequent tenodesis.

Management

Patients diagnosed with SC can be initially managed nonoperatively if their disease is inactive, in the absence of mechanical symptoms [5, 6]. These treatment options include nonsteroidal anti-inflammatory drugs (NSAIDs), activity modification, and cryotherapy [4, 7]. Despite these options, our patient underwent surgery given the duration and severity of his symptoms.

Surgical management of SC includes both open and arthroscopic approaches. The type of approach is routinely chosen based on the surgeon's preference, disease location, stage of the disease, and anticipated size of the loose bodies [4, 5, 8, 9]. The elected management of our patient was chosen to prevent further intra-articular damage and avoid the future complication of secondary osteoarthritis. Lunn et al. reported that asymptomatic patients are still vulnerable to joint degeneration by loose bodies; therefore, surgical removal should always be considered [10].

The decision was made to perform a right shoulder arthroscopy with loose body removal, synovectomy, and open biceps tenodesis based on the clinical exam findings and positive Speed's and Yergason's tests. An arthroscopic approach was chosen to perform an efficient and comprehensive debridement and to facilitate removal of the several anticipated loose bodies. This also allowed for a thorough debridement of the biceps groove.

The benefits of an arthroscopic surgical approach are well established in the literature for patients diagnosed with

SC [4, 7, 9]. These advantages include a reduced risk of neurovascular injury, greater visualization of the glenohumeral joint, decreased postoperative pain, shorter course of postoperative rehabilitation, and reduced morbidity. However, there are disadvantages including higher recurrence rates, poor visualization of the bicipital groove, and inability to remove larger loose bodies [6, 11]. In addition to improved access to specific locations within the glenohumeral joint, an open approach allows the surgeon to remove the synovium in its entirety, thereby reducing the recurrence rate. Case reports by Fowble [9] and Tokis [12] have reported that a total synovectomy may not be needed depending on the stage of the disease. However, if the disease is in Milgram stage 1 or 2, a total synovectomy will greatly reduce the risk of recurrence [4, 13].

In addition, given the appearance of the MRI (Figs. 6.3 and 6.4) and apparent presence of synovial disease in the proximal biceps groove, a decision was made to perform an open synovectomy, debridement, and tenodesis of the proximal portion of the intertubercular groove as this region is poorly accessible arthroscopically.

Our patient was taken to the operating room and placed in the supine position. A two-portal diagnostic arthroscopy was carried out with subsequent removal of multiple loose bodies identified upon entering the joint space (Figs. 6.5 and 6.6). A shaver and basket were used during the removal, and synovium was debrided back in the anterior, inferior, and posterior compartments. Multiple loose bodies were noted in the inferior compartment; therefore, an accessory 7 o'clock portal was created to allow for retrieval. The long head of the biceps was noted to have confluent areas of inflammation and was then released (Fig. 6.7). The inferior labrum was noted to have mild fraying requiring debridement. The rotator cuff was intact including the subscapularis. The subscapularis recess had multiple loose bodies that were removed using a 70° scope, shaver, and grasper (Fig. 6.8).

Next, a deltopectoral incision was made and carried down sharply to the underlying deltopectoral groove. A retractor was placed as we opened the bicipital groove distally to the

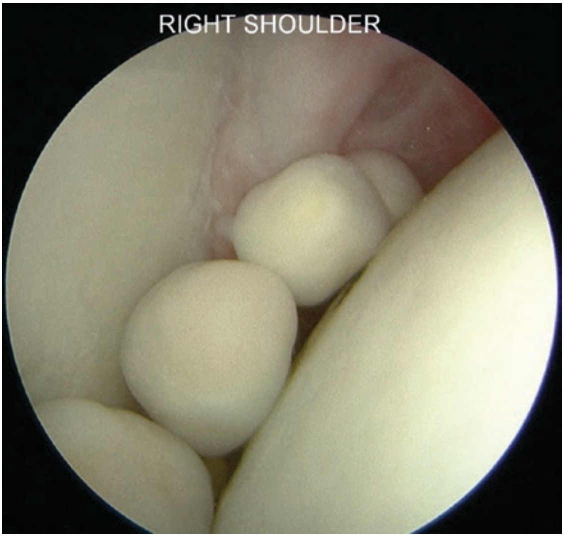

FIGURE 6.5 Multiple loose bodies identified arthroscopically within the glenohumeral joint

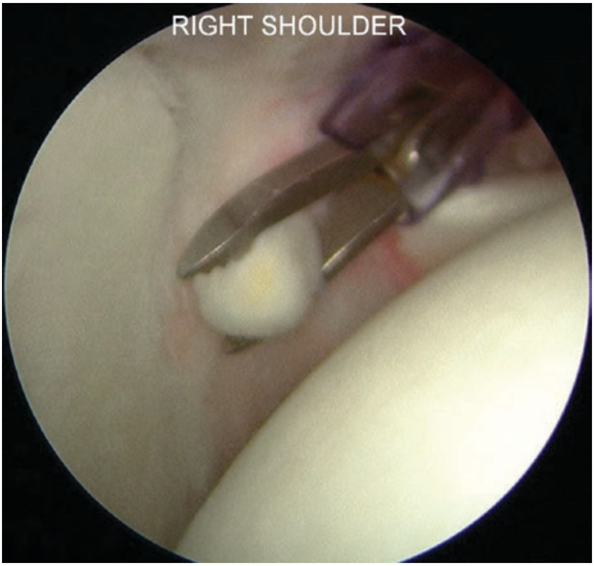

FIGURE 6.6 Arthroscopic removal of loose body using a grasper

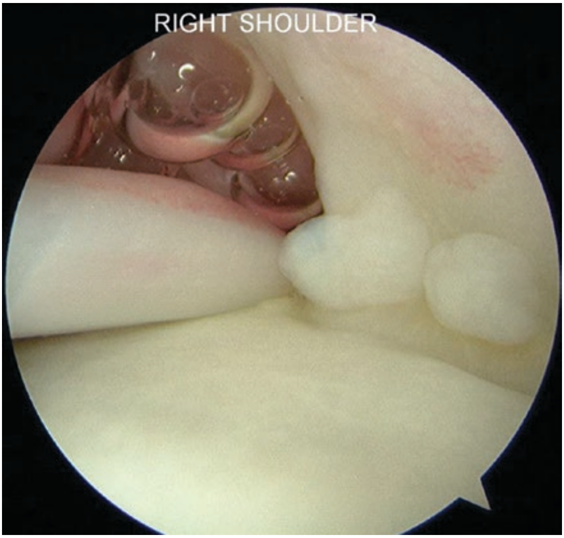

FIGURE 6.7 Loose bodies identified adjacent to inflamed biceps tendon (lipstick sign)

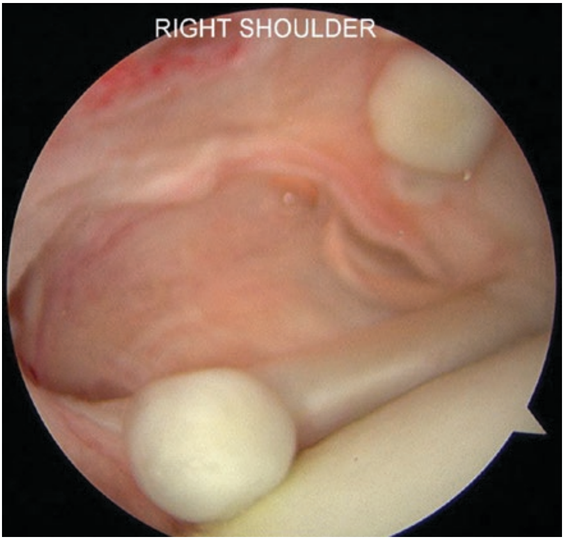

FIGURE 6.8 Multiple loose bodies identified in the subscapularis recess

level of the pectoralis major. Multiple small loose bodies were noted as well as significant metaplastic tissue, which was debrided both sharply and with needle tip cautery. After removal of the loose bodies, the base of the groove was curetted. A suture anchor was placed at the base of the bicipital groove, and sutures were passed through the long head of the biceps approximately 10–15 mm above the musculotendinous junction. The remaining proximal tendon was transected, and sutures were tied, completing the tenodesis.

Following copious irrigation, the deltopectoral incision was closed as well as all portal incisions. The patient's arm was placed in a sling immobilizer. The loose bodies were sent to pathology for official analysis in order to rule out malignant transformation. The report was significant for fragments of focally ossified synovium and negative for malignancy.

Outcome

The primary goal of surgical management was to relieve the patient's symptoms and help him return to full level of function at work and recreation. The patient returned to clinic 1 week after surgery with a well-healing incision and was slowly regaining range of motion. A range of motion program was prescribed to the patient along with gentle strengthening exercises during physical therapy. Three months after surgery, the patient had achieved near full range of motion with minimal pain levels. Approximately 4 months after surgery, the patient returned to work with no significant limitations while continuing physical therapy to build strength in the shoulder.

Clinical Pearls and Pitfalls

- Failure to thoroughly debride the biceps and sheath/tunnel will lead to refractory symptoms in the patient.
- Suspect biceps chondromatosis in patients with positive biceps findings on exam along with mechanical symptoms.

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Chapter 7
Partial Subscapularis Tear with Long Head of Biceps Tendon Subluxation

Adam C. Dooley and Larry D. Field

Case Presentation

A 45-year-old, right-handed male, manual laborer presents to the physician's office with a 6 months history of progressively worsening anterior shoulder pain. He denies any previous injury to the shoulder but describes daily anterior shoulder pain exacerbated by use of the affected extremity (that often limits his ability to perform his work obligations). He also reports a slight weakness with most overhead work as well as some limitations in performing heavy lifting (an integral component of his job's responsibilities). He denies any sense or history of instability and also denies shoulder popping, clicking, or catching.

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_7,

On physical examination, the patient is non-tender to palpation about the shoulder except directly over the bicipital groove anteriorly where he has moderate tenderness to deep palpation. This patient has full, normal active and passive range of motion and normal glenohumeral joint stability and is neurovascularly intact. Strength testing demonstrates 5/5 forward flexion and 5/5 external rotation strength, but he did demonstrate only 4/5 internal rotation strength. Other positive physical examination findings included a positive "belly-press test" and a positive "bear-hug test" suggesting possible injury to the subscapularis.

Diagnosis/Assessment

Rotator cuff tears involving the subscapularis tendon are less common than tears involving the supraspinatus or infraspinatus tendons [1]. When subscapularis tears are present, the majority occur in conjunction with supraspinatus tendon tears [2–4]. However, even when present, subscapularis tears are often not recognized [5]. Subscapularis tendon pathology may present as an isolated complete tear, partial-thickness tear, or as a combined anterosuperior tear. In addition, these subscapularis tears often occur in conjunction with biceps long head fraying and subluxation [1, 6].

Anatomy

The subscapularis muscle is the strongest and largest of the rotator cuff muscles [6]. It is innervated by the upper and lower subscapular nerves [7]. The subscapularis originates from the anterior surface of the scapula, inserts along the lesser tuberosity and metaphysis of the proximal humerus, and functions primarily to internally rotate the humerus and help impart stability to the glenohumeral joint [8]. The subscapularis insertional footprint is broad and wide superiorly and narrows distally resembling a trapezoid. The mean length of the footprint averages 2.5 cm, the superior width of the footprint is 1.8 cm, and the lower 40 % of the footprint narrows to a minimum width of 0.3 cm. The upper 60 % of the footprint provides the major surface area for subscapularis tendon insertion [9] with the superior edge of the subscapularis tendon forming the lower border of the rotator cuff interval. The remaining anatomic borders of the interval include the anterior margin of the supraspinatus tendon and anterior glenoid rim [10].

A "reflection pulley" is formed from the common insertions of the coracohumeral and superior glenohumeral ligaments at the lesser tuberosity. This "pulley" helps to stabilize the long head of the biceps at its proximal entrance into the bicipital groove [11]. Thus, upper border subscapularis tendon tears may render the long head of the biceps unstable, leading to medial subluxation or dislocation [6].

The long head of the biceps tendon originates from the supra-glenoid tubercle and superior glenoid labrum and then courses anterosuperiorly across the glenohumeral joint intra-articularly [12]. After passing through the "pulley" system, the biceps tendon is then contained within the bicipital groove. The lesser and greater tuberosities form the bony walls of this groove. Superficial fibers of the subscapularis and lateral fibers from the supraspinatus form the roof of the bicipital sheath, while deep fibers from the subscapularis tendon form the floor [13]. Finally, the tendon travels distally with the short head to form the biceps brachii and inserts on the radial tuberosity at the forearm [12].

The function of the long head of the biceps tendon is controversial. Descriptions of biceps tendon function within the shoulder have included acting as a humeral head depressor, an anterior stabilizer, a posterior stabilizer, or even merely representing a vestigial structure [1, 11, 12]. Regardless of its role in the shoulder, however, the biceps tendon is recognized as a pain generator causing anterior shoulder symptoms [14]. The blood supply to the tendon is derived from branches of the anterior circumflex humeral artery along the bicipital groove [15].

Patho-anatomy

Injury to the subscapularis tendon can occur as a consequence of both degenerative and traumatic etiologies. Degenerative tears occur more commonly in older patients, while acute, traumatic tears present more often in younger persons. Acute traumatic tears are often caused by a hyperextension and external rotation mechanism or by extreme acute contraction [16]. Greatest tension on the subscapularis tendon occurs when the arm is positioned in external rotation and abduction [17]. In addition, an association between anterior glenohumeral dislocations and partial subscapularis tendon tears has been identified [18, 19]. Undersurface subscapularis tears may also occur due to anterosuperior impingement of the subscapularis on the anterior superior glenoid rim in the position of flexion, internal rotation, and adduction [20]. Finally, tears can be found in the setting of coracoid impingement when the arm is positioned in forward elevation, internal rotation, and cross-body adduction [21, 22].

Other lesions of the shoulder have been found in conjunction with subscapularis tendon tears. Li et al. found that 49 % of patients with subscapularis tears have associated bicep tendon subluxations present, and this correlation between subscapularis pathology and medial biceps subluxation has been recognized in other studies as well [23].

History

The primary complaint of a patient with a partial subscapularis tendon tear combined with long head of the biceps tendon subluxation is anterior shoulder pain that is usually localized directly over or adjacent to the biceps groove. The patient may also complain of pain at night and weakness [2]. In addition, biceps instability can present with a history of anterior shoulder clicking, snapping, or popping, although this symptom is reported relatively infrequently [24, 25].

Physical Examination

Tenderness to palpation of the anterior shoulder is common with both subscapularis and biceps pathology. Also, the examiner may note weakness with resisted internal rotation. Compensation from pectoralis major, latissimus dorsi, and teres major muscles may disguise the true underlying pathology [2]. Clinical tests designed to determine subscapularis function and to help identify subscapularis tears include the lift-off test, Napoleon test, and bear-hug test [26]. Specifically, the lift-off test is carried out by placing the hand of the patient's affected extremity behind the lower back. An attempt is then made by the patient to lift the hand away from the back. When the patient cannot lift or hold the hand away from his or her back, a positive lift-off test is recorded [2]. The Napoleon sign is performed by asking the patient to hold his or her palm against the abdomen with the wrist in a neutral position and the flexed elbow maintained anterior to the body. A positive test is documented if the patient volar flexes the wrist and the elbow falls posteriorly [27]. The bear-hug test was originally described as a physical examination test designed to detect upper border tears of the subscapularis tendon. To accomplish this test, the affected hand is positioned across the front of the body, resting on the contralateral anterior shoulder. The examiner then attempts to pull the hand away from the shoulder. A positive test is noted if the patient experiences pain or weakness with this maneuver [28].

Biceps pathology can be difficult to accurately and reliably confirm on physical examination. Nonetheless, point tenderness over the bicipital groove is a common positive examination finding. Eliciting tenderness upon palpating the biceps tendon medial to the pectoralis major insertion with resisted internal rotation is called the "subpectoral long head of the biceps tendon test" [26, 29]. This test, devised to evaluate for subluxation of the biceps tendon, is carried out by positioning the arm at 90° of abduction and full external rotation. The arm is then moved passively to full cross-body adduction and internal rotation. This maneuver may cause an unstable biceps tendon to shift medially resulting in pain or even a palpable shift in biceps location [30]. The active compression test, anterior slide test, and compression rotation test all can also aid in the examination for biceps pathology [31]. Likewise, Yergason and speed testing are commonly included in a physical examination but have not been shown to be very sensitive or specific in identifying biceps tendon pathology [32]. Finally, the treating physician may also perform a diagnostic injection into the bicipital groove to confirm the LHB as a source of the patient's symptoms [33].

Imaging Studies

Plain radiographs are routinely obtained in evaluation of shoulder complaints. Anteroposterior, axillary lateral, and outlet views should be carefully evaluated but frequently fail to demonstrate any abnormalities at the lesser tuberosity in patients with subscapularis tears. Chronic subscapularis pathology may result in anterior subluxation of the humeral head that is best seen on an axillary lateral view [34]. Also, using plain radiographs, biceps tendon pathology may occasionally be suggested when osteophytes or hypertrophic bony prominences are noted surrounding the bicipital groove [35].

Ultrasound is an inexpensive, noninvasive tool that easily provides bilateral shoulder information and can be utilized to reliably identify subscapularis tendon tears [36]. Another benefit of ultrasound may be in its ability to detect partial tears and even interstitial tears [37]. Also, ultrasound can reliably diagnose complete ruptures, subluxations, and dislocations of the biceps tendon [38].

Magnetic resonance imaging (MRI) is frequently utilized to assess for shoulder pathology. Tears are recognized on MRI as abnormally high signal on T2-weighted imaging [39]. In studies comparing findings on MRI as they correlate with arthroscopic assessment, it has been noted that MRI often fails to recognize partial subscapularis tears, while large tears are more readily identified [40, 41]. Also, when attempting to identify partial subscapularis tears preoperatively, utilizing MRI or magnetic resonance arthrography (MRA) appears to make little difference [42]. However, when MRA is used, the "pulley sign" may be more reliably identified [43]. This positive "pulley sign" has been described as being represented on MRA by a collection of contrast seen extra-articularly just anterior to the superior border of the subscapularis tendon on an axial image. A positive "pulley sign" on MRA suggests an injury to the insertion of the coracohumeral and superior glenohumeral ligaments at the lesser tuberosity that helps stabilize the biceps long head tendon. In a recent study evaluating non-contrasted MRI as the primary tool in diagnosing biceps disease, the authors found MRI to be highly sensitive when correlated with arthroscopic assessment for the diagnosis of instability of the long head of the biceps [44]. A separate study noted that when axial MRI scans fail to demonstrate evidence of long head of biceps tendon (LHBT) subluxation, it is also unlikely that a full-thickness subscapularis tear is present [45].

Management

Subscapularis and proximal biceps pathology can be successfully treated utilizing both nonoperative and operative management. However, acute injuries to the subscapularis and biceps tendon complex resulting in significant functional loss may warrant more aggressive treatment for improved outcomes [46]. Nonoperative treatment typically incorporates periods of rest, activity modifications, anti-inflammatory medications, and physical therapy into a cohesive, organized program. If these nonoperative interventions fail to relieve symptoms adequately, a corticosteroid injection placed into the glenohumeral joint, subacromial space, or the biceps tendon sheath may reduce symptoms [18].

Arthroscopy is an excellent tool for accurately diagnosing and facilitating treatment of subscapularis and biceps tendon pathology. Partial subscapularis tears are typically either articular-sided tears of the tendon or complete detachments

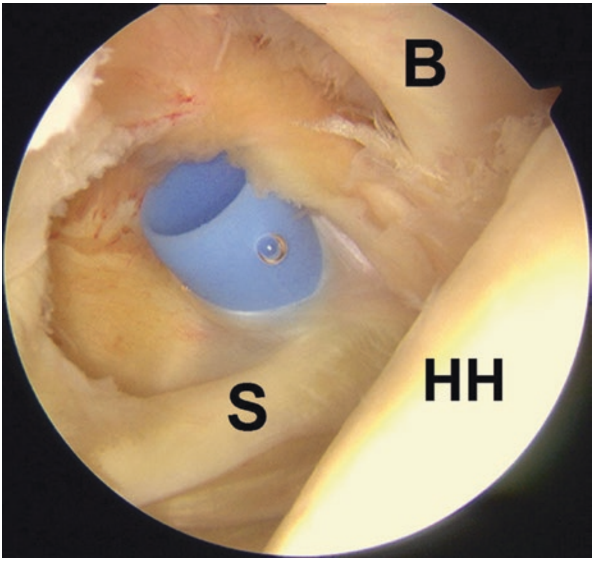

FIGURE 7.1 In this right shoulder positioned in the beach chair position, the upper border of the subscapularis tendon is easily visualized (*arrow*) from the posterior arthroscopy portal and appears to be intact. Note that the blue cannula is in the standard anterior portal position and is seen passing through the rotator interval. *HH* humeral head, *B* biceps tendon, *S* subscapularis tendon

of the upper subscapularis tendon border [34]. Visualization of the majority of the subscapularis tendon and any exposed lesser tuberosity is possible by internally rotating and posteriorly translating the humeral head while viewing from the posterior portal [47] (Figs. 7.1 and 7.2). However, the middle and inferior glenohumeral ligaments may obscure portions of the subscapularis tendon limiting the sensitivity of arthroscopy to fully appreciate the extent of pathology [48, 49]. Likewise, arthroscopic assessment of the biceps tendon is enhanced by using a probe to pull a portion of the extra-articular biceps tendon into the glenohumeral joint (Fig. 7.3). This maneuver not only increases the amount of biceps tendon that can be directly evaluated for fraying or partial tears

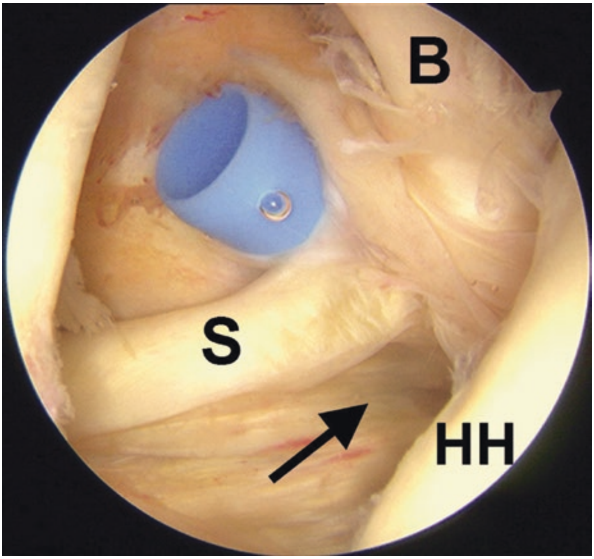

Figure 7.2 Internal rotation of the humerus improves visualization of the upper border of the subscapularis tendon at its insertion onto the lesser tuberosity and exposes an upper border tear (*arrow* demonstrates detachment site of the upper border subscapularis tendon from the lesser tuberosity). *HH* humeral head, *B* biceps tendon, *S* subscapularis tendon

but pulling on the biceps tendon with the probe also affords the surgeon an opportunity to assess for subtle subluxation or instability of the biceps tendon at its exit point from the shoulder into the bicipital groove.

Assessment of the competency of the coracohumeral and superior glenohumeral ligaments, in their respective roles as biceps stabilizers, can also be accomplished using the arthroscope. These two ligaments combine to form the "comma tissue" which is normally located immediately adjacent and medial to the biceps tendon as it exits the glenohumeral joint [5]. When this "comma tissue" becomes detached from its insertion site adjacent to the bicipital groove, it may translate medially along with the subscapularis tendon when a sub-

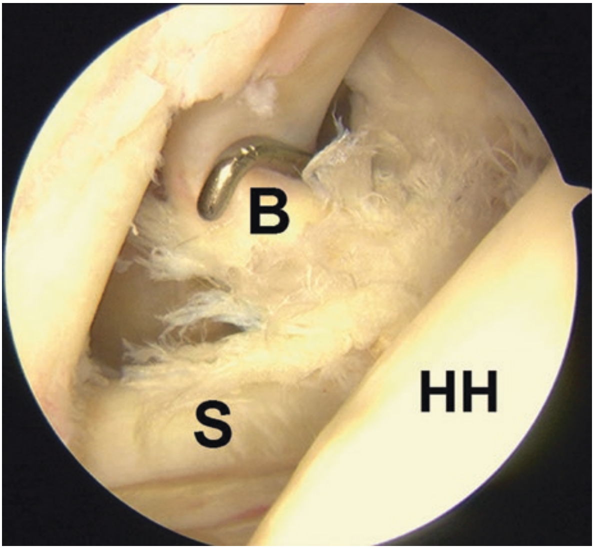

Figure 7.3 Using a probe to pull additional, extra-articular biceps tendon into the glenohumeral joint exposes not only that significant fraying of this extra-articular portion of the biceps tendon is present but also demonstrates some medial subluxatability of the biceps tendon as well. *HH* humeral head, *B* biceps tendon, *S* subscapularis tendon

scapularis tendon tear is present. When this comma tissue is identified arthroscopically as medially translated, this represents a positive "comma sign" [5]. In addition, the biceps tendon can also be evaluated for fraying and stability by utilizing the arthroscope. Pulling the biceps tendon into the glenohumeral joint using a probe allows the surgeon an opportunity to evaluate a portion of the extra-articular biceps and assess for biceps instability as well. Biceps tendon subluxation with or without a subscapularis tendon tear is an indication for surgical intervention [50, 51].

Arthroscopic repair of subscapularis tendon tears is a highly successful surgical intervention [52]. Partial-thickness tears of the subscapularis tendon can be easily addressed

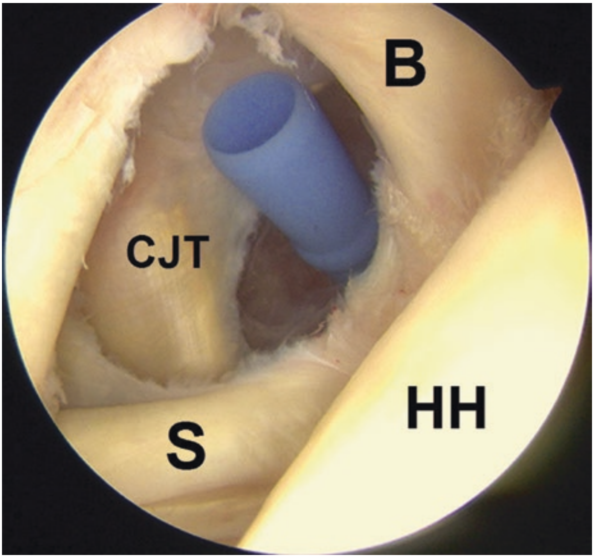

FIGURE 7.4 Excising the central portion of the rotator interval capsule (shown here) creates an important "window" allowing access to the anterior, extra-articular structures of the shoulder. This rotator interval window greatly improves visualization of the subscapularis tear and facilitates repair. Note that the conjoined tendon (CJT) can also be visualized through this rotator interval window. *HH* humeral head, *B* biceps tendon, *S* subscapularis tendon

arthroscopically. Visualization within the subscapularis recess allows for access to the more medial aspects of the subscapularis tendon [27]. Once a partial-thickness subscapularis tear is identified arthroscopically and is determined to be indicated for repair, arthroscopic excision of the central portion of the rotator interval tissue, taking care to preserve the superior and middle glenohumeral ligaments within or adjacent to this rotator interval capsule, effectively creates a "window" that allows the surgeon to visualize and work anterior to the glenohumeral joint (Fig. 7.4). The anterior extra-articular structures and surfaces, including the anterior surface of the subscapularis tendon, the coracoid tip, and the

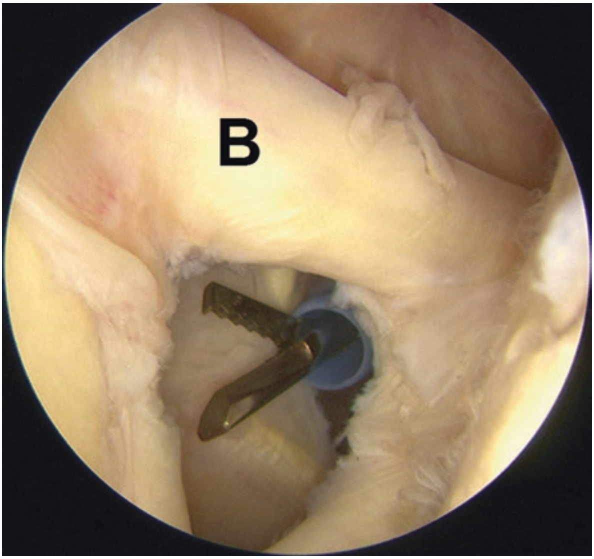

FIGURE 7.5 Due to its significant fraying and subtle medial subluxation, the biceps tendon is released from its origin. When tenotomy or tenodesis of the biceps is felt to be indicated, releasing the biceps tendon early in the procedure (and prior to subscapularis repair) allows for improved visualization and access to the upper border of the subscapularis. *B* biceps tendon

conjoined tendon, are easily and reliably visualized and accessed through this rotator interval "window" as necessary. Also, if a frayed or subluxed biceps tendon is present and is indicated for release from its origin at the supraglenoid tubercle due to its pathologic state, early release prior to subscapularis repair should be considered since removal of the biceps from the glenohumeral joint usually improves both visualization of and accessibility to the upper border tear of the subscapularis tendon (Fig. 7.5).

Once the affected upper border detachment of the subscapularis is identified and debrided along with the lesser tuberosity, a suture anchor can then be inserted into the lesser tuberosity under direct arthroscopic visualization

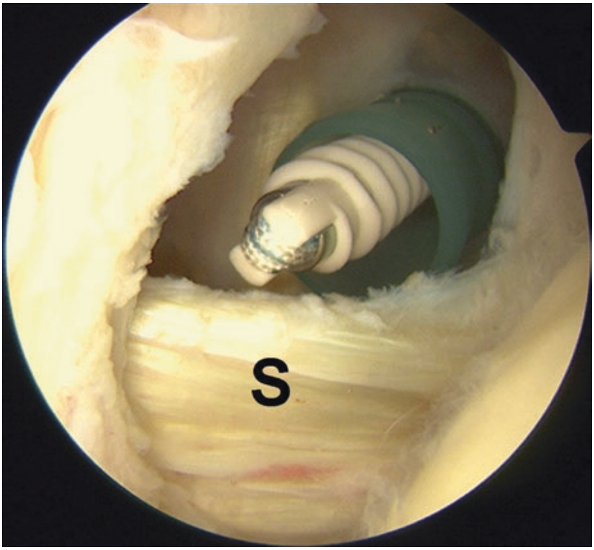

FIGURE 7.6 Following debridement of the subscapularis tendon and biceps release, a suture anchor is delivered through the rotator interval window and subsequently inserted into the lesser tuberosity bony footprint. *S* subscapularis tendon

(Fig. 7.6). The suture anchor sutures can then be sequentially passed through the subscapularis tendon and then tied to achieve secure re-approximation of the detached upper border of the subscapularis tendon to its native insertion site (Fig. 7.7).

Large subscapularis tears often must be released from the capsule and thoroughly mobilized to allow for re-approximation to the lesser tuberosity [27]. When significant mobilization is required so as to allow for anatomic repair, care should be taken with this mobilization step to ensure that the axillary nerve and adjacent neurovascular structures are not inadvertently injured. Thorough knowledge and familiarity with the orientation and location of these neurovascular structures is required prior to attempting to mobilize a very medially retracted subscapularis muscle and tendon. Finally,

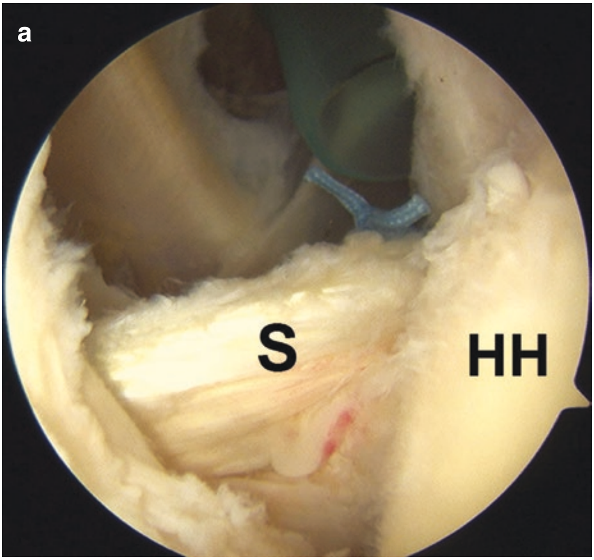

FIGURE 7.7 (**a**) Following the completion of suture passage and knot tying, and with the glenohumeral joint internally rotated, the upper border of the subscapularis tendon can be seen to be securely and anatomically reattached to the lesser tuberosity. *HH* humeral head, *S* subscapularis tendon. (**b**) Rotating the glenohumeral joint to the neutral (0° of external/internal rotation) position after this repair allows the reattached insertion site of the subscapularis tendon to move laterally so that the repair site and suture knots are no longer visible (as shown). The limited view of this newly repaired tendon in neutral shoulder rotation highlights the importance of maintaining some internal rotation of the shoulder, as necessary, during repair to maximize visualization and access to the detached tendon. *HH* humeral head, *S* subscapularis tendon. (**c**) The repaired subscapularis tendon, as viewed from the anterior portal, is seen here. The rotator interval window, created and used for visualization and access during the repair, can be clearly identified. Also, through this "window," the humeral head and glenoid can be seen. *HH* humeral head, *G* glenoid, *S* subscapularis tendon

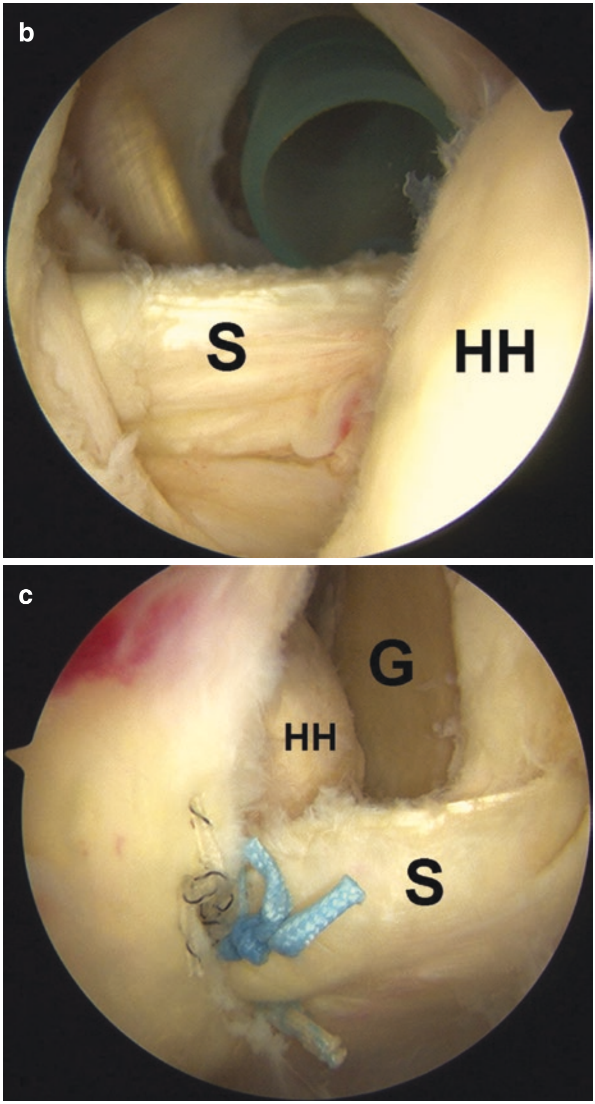

FIGURE 7.7 (continued)

in the unusual clinical situation in which the retracted subscapularis tear is deemed irreparable, the combination of arthroscopic debridement and biceps tenotomy may yield adequate objective improvement and patient satisfaction [53].

Surgical treatment options for management of biceps subluxation when associated with a subscapularis tear include either biceps tenotomy or tenodesis. Tenotomy is performed by releasing the tendon at its attachment point from the superior glenoid rim and labrum complex. The described "Popeye deformity" may be present following rupture or tenotomy but is often not clinically significant in large, obese arms or in older, sedentary patients [51, 54, 55]. Tenotomy in younger, more active patients may contribute to fatigue and/or cramping complaints of the biceps muscle belly [54]. Tenodesis of the biceps tendon is often the preferred surgical treatment option for younger patients, those with cosmetic concerns, athletes, and laborers.

Biceps tenodesis can be performed using an open surgical technique at different locations along the proximal humerus and can be effectively accomplished utilizing many different methods of fixation. Options include proximal tenodesis with the tendon retained in bicipital groove or a tenodesis site located more distally. Some researchers suggest that removing the tendon from the biceps groove may lead to decreased postoperative symptoms [12, 56, 57].

Arthroscopic techniques can also be utilized to effectively perform biceps tenodesis. The treating surgeon may secure the tendon to the surrounding rotator cuff or conjoined tendon, or perform a bony tenodesis proximal to, within the biceps groove, or distal to the groove [12].

Outcome

There is limited literature describing the results of repair of partial subscapularis tears. Kim et al. found that arthroscopic intra-articular repair of partial subscapularis tendon disruptions yields good to excellent outcomes and demonstrates significant improvements in both internal rotation motion and strength postoperatively [58]. However, most of the available published research examines treatment of anterosuperior rotator cuff tears that involve both the supraspinatus tendon and the subscapularis. Deutsch et al. reported satisfactory results following repair of isolated subscapularis tears in 13 of 14 patients 2 years following surgical intervention [16]. Likewise, Gerber et al. reported good or excellent results after repair of acute traumatic tears in 13 of 16 patients at 43 months average follow-up [2]. The prognosis for patients diagnosed and treated for anterosuperior rotator cuff tears was found to be inferior to those patients with isolated subscapularis tears in a multicenter study [59]. Also, good to excellent results following arthroscopic subscapularis repair were observed in 92 % of patients in a study by Burkhart and Tehrany [27]. Arthroscopic subscapularis repair for isolated tears demonstrated significantly improved physical examination testing maneuvers, including the belly-press, lift-of-test, and biceps test with outcomes remaining stable 2–4 years postoperatively [60].

Outcome studies reporting the results of subscapularis repair combined with concurrent treatment of biceps pathology are limited. Biceps tenotomy has been shown, however, to provide high patient satisfaction, pain-free recovery, return to work, and return to sports [54, 55]. When biceps tenodesis is performed, Sanders et al. reported a 12 % revision rate following proximal tenodesis and a 2.7 % revision rate following tenodesis distal to the groove [61]. In addition, patients undergoing proximal tenodesis have been found to maintain an average biceps power of 90 % compared to the unaffected side in a review of 43 patients following interference screw fixation [62]. Biomechanical studies of fixation techniques following bicep tenodesis have shown that interference screw fixation has a higher load to failure rate and the least amount of displacement after cyclic loading compared to suture anchor fixation [57, 63–66].

Clinical Pearls and Pitfalls

- A thorough history and physical examination is key to aiding the physician in accurately recognizing anterior shoulder pathology as the source of the patient's symptoms when partial-thickness subscapularis tears and biceps subluxation are present.
- Careful review of the MRI/MRA images is required to consistently recognize the presence of potentially indistinct upper border subscapularis pathology and subtle medial biceps tendon subluxation.
- At the time of diagnostic arthroscopic glenohumeral joint assessment, always internally rotate the shoulder while visualizing the subscapularis tendon insertion. This will facilitate identifying upper border partial-thickness subscapularis tendon tears when they are present. Similarly, careful visualization and assessment of the biceps tendon at its point of exit from the glenohumeral joint is imperative to accurately and consistently recognize subtle medial biceps subluxation when present.
- Establish and use additional, accessory anterior shoulder portals as helpful to improve both access to and repair of partial-thickness subscapularis tears.
- When an upper border subscapularis tear is indicated for repair, excise the central portion of the rotator interval to create a "window" which will improve visualization and facilitate access to the subscapularis tendon.
- When medial biceps subluxation is present, release of the proximal biceps tendon from its origin at the superior glenoid *prior* to repairing the subscapularis tear often improves visualization of and access to the subscapularis tendon, making repair easier and more reliable since the subluxed biceps tendon no longer obscures visualization or limits access to the lesser tuberosity.
- Using a 70° arthroscope may occasionally be helpful in visualizing and repairing some subscapularis tears.

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Chapter 8
Proximal Tenodesis with Persistent Pain Revised to Distal Tenodesis

Matthew T. Provencher, William H. Rossy, and George Sanchez

Case Presentation

The patient is a 41-year-old laborer. He sustained a right shoulder inferior traction injury at work 18 months prior to presentation while lifting a 100 lb object. He initially underwent an arthroscopic SLAP repair; however, his pain never fully resolved postoperatively. Six months following the index

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_8,

procedure, the patient underwent a repeat arthroscopy with arthroscopic suprapectoral biceps tenodesis and subacromial decompression. The biceps was fixed with a suture anchor at the superior aspect of the bicipital groove. Postoperatively, the patient continued to complain of pain over the anterior aspect of his shoulder. He also noted limited range of motion and pain with overhead activities that prevented him from returning to work.

On physical examination, the patient had active shoulder flexion to 130° and passive flexion to 160°. Abduction external rotation of the shoulder was limited to 60°, and abduction internal rotation was limited to 40°. All arcs of motion were limited by pain at extremes. Impingement signs were mildly positive, and rotator cuff strength was noted to be 5/5 in external rotation as well as internal rotation. His most notable finding was significant tenderness to palpation over the proximal bicipital groove. This tenderness remained in a consistent location with internal and external rotation of the shoulder at the biceps groove. He was also found to have a positive Speed's sign and a positive O'Brien's test.

Radiographs of the shoulder were obtained and found to be unremarkable. The prior tenodesis site demonstrating a tenodesis screw could be identified within the proximal aspect of the bicipital groove. An MRI demonstrated signal change consistent with edema surrounding the screw site, as well as edema within the biceps tendon distal to the tenodesis site (Fig. 8.1a–c).

Due to concern for continued pathology at the previous proximal tenodesis site, the patient underwent a bicipital groove injection with 40 mg of cortisone and 4 mL of 1% lidocaine. Following the injection, the patient reported full resolution of his anterior shoulder pain for 2 weeks. Once the effects of the diagnostic and therapeutic injection began to dissipate, the patient's pain returned, and he returned to clinic to discuss additional options.

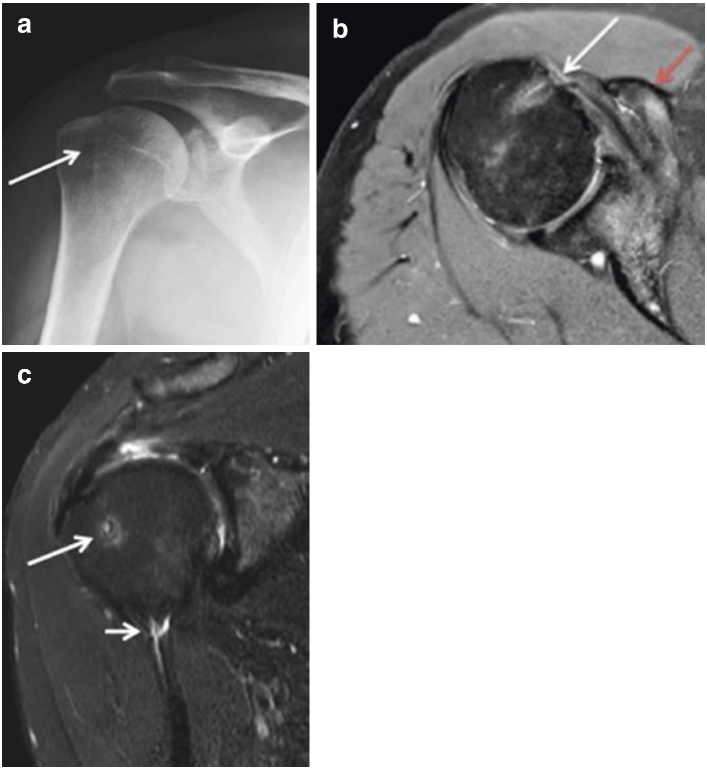

FIGURE 8.1 (**a**) AP radiograph of the right shoulder. Circular lucency shown by the *arrow* signifying placement of prior tenodesis within the bicipital groove. (**b**) T2 axial MRI demonstrating mild edema at the site of prior arthroscopic anchor insertion and within the groove (indicated by *white arrow*). The coracoid process (identified by *red arrow*) as well as the subscapularis muscle can be used as reference points for anatomical level consistent with midportion of the bicipital groove. (**c**) T2 coronal MRI showing the biceps tendon running superiorly (identified by *small arrow*) with area of surrounding edema. Also noted is continued edema at prier tenodesis site (*larger arrow*)

Given the significant improvement, the patient experienced with the injection, along with his prolonged history of anterior shoulder pain that proved recalcitrant to all previously rendered treatments; revision surgery to a distal subpectoral tenodesis was recommended.

Diagnosis/Assessment

The patient's history, physical exam and imaging studies were consistent with continued pathology of the proximal biceps tendon following prior proximal tenodesis. While arthroscopic biceps tenodesis is an acceptable treatment for proximal tendon pathology, the presence of inflammation distal to the proximal tenodesis site likely necessitates a more distal site of fixation.

An MRI is typically obtained in order to assess the remaining tendon and tenodesis site. It is also useful to rule out other potential etiologies of anterior shoulder pain. Once a diagnosis of failed proximal biceps tenodesis is suspected, a bicipital groove injection with lidocaine and/or cortisone can be utilized to confirm the diagnosis. Furthermore, this injection can gauge a patient's likely response to revision surgery should the pain return in the future. If there is no improvement in pain following a bicipital groove injection, one should be weary of indicating a patient for revision tenodesis and first rule out other causes of anterior shoulder pain.

Management

Due to the patient's physical exam findings, imaging, and positive response to a diagnostic bicipital groove injection, he was indicated for a revision proximal to distal mini-open subpectoral biceps tenodesis.

At the time of revision surgery, an arthroscopic evaluation was undertaken of the shoulder in order to assess the prior tenodesis site and rule out other intra-articular pathology.

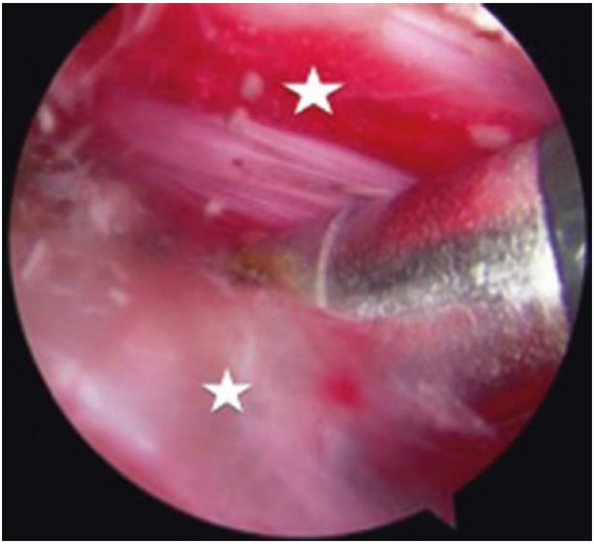

FIGURE 8.2 Arthroscopic view of inflamed bursal and scar tissue (indicated by the *white stars*) overlying the bicipital groove. The tenodesis site has not yet been visualized

The proximal aspect of the bicipital groove was first identified and was filled with an abundance of inflamed scar tissue (Fig. 8.2). The inflamed tissue surrounding the proximal bicipital groove was removed with a cautery device and arthroscopic scissors. The underlying groove and LHB tendon were then visualized (Fig. 8.3) and noted to demonstrate significant inflammation within the remaining distal tendon.

On diagnostic arthroscopy, no other intra-articular pathology was identified; therefore the decision was made to continue with the planned procedure, and the remaining LHB tendon was tenotomized. All surrounding scar and inflamed bursal tissue were also removed. A mini-open subpectoral approach was then made distally, and the tendon was identified and extracted with the aid of a surgical clamp. Figure 8.4 demonstrates the diseased proximal biceps tendon following distal extraction.

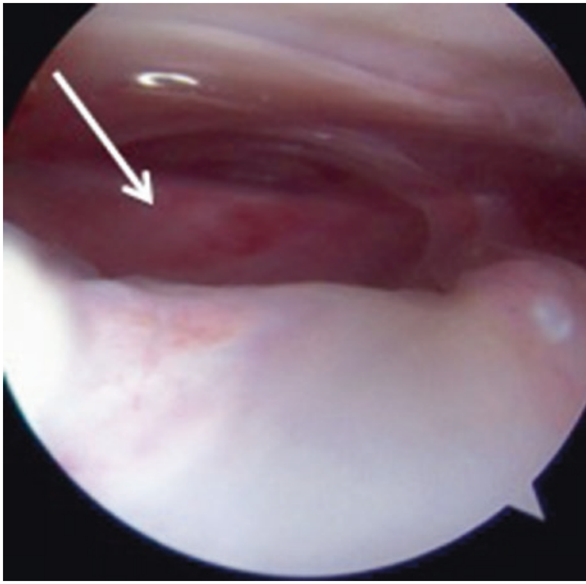

FIGURE 8.3 Arthroscopic view of bicipital groove following debridement of inflamed bursal tissue and scar with radiofrequency device. The *arrow* is within the bicipital groove and points to the biceps tendon within the groove. Note the inflammation present throughout the length of the LHB tendon

A no. 2 nonabsorbable suture was then used to place Krackow stitch configuration at the biceps tendon, 2 cm proximal to the muscle-tendon junction. The diseased proximal tendon was then excised (approximately 2 cm). The remaining biceps tendon was sized, and a corresponding reamer was used to drill a unicortical hole perpendicular to the anterior cortex of the humerus. Prior to drilling the hole, visual inspection ensured maintenance of the appropriate length-tension relationship of the biceps muscle. The level of the inferior border of the pectoralis major is an important anatomical landmark used for this step of the procedure as the muscle-tendon junction of the biceps should lie at the

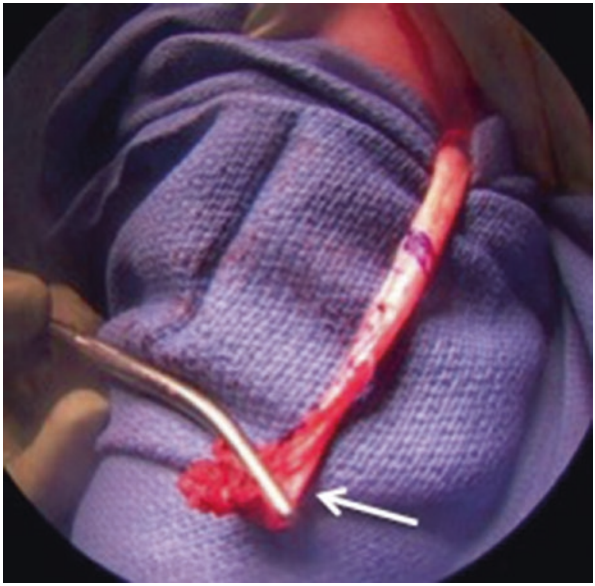

FIGURE 8.4 LHB tendon following extraction from distal mini-open incision. The *arrow* identifies the most proximal aspect of the LHB that was previously left within the bicipital groove at the time of prior tenodesis. Note the significant inflammatory and scar tissue attached to the tendon. This pathologic area will be excised, leaving behind the healthy, more distal tendon after revision completed

level of the inferior border of the pectoralis major insertion. Once confirmed, the unicortical hole was drilled, and the remaining tendon was fixed in place with a tenodesis screw.

Outcome

Postoperatively the patient was placed in a sling for 3 weeks. During this time, physical therapy was initiated, and passive and active assisted range of motion in the scapular plane was permitted only under the guidance of a trained therapist. Passive stretching of the elbow was also permitted by the therapist in order to optimize range of motion. At 4 weeks, the sling was fully discontinued, and active range of motion of the elbow was initiated. At 8 weeks, light resistive exercises were initiated, and by week 12, full, unrestricted strengthening under the guidance of a therapist was permitted.

At the patient's most recent follow-up (6 months post surgery), he reported a resolution in his pain and an ability to resume overhead activities without limitation. The patient was noted to have painless forward flexion to 150°, abduction external rotation of the shoulder to 90°, and abduction internal rotation to 80°. There was no tenderness to palpation anteriorly along the bicipital groove. Strength testing scored 5/5 on motor strength of the biceps, triceps, and rotator cuff muscles. The patient had a negative Speed's sign, a negative O'Brien's test, and no Popeye deformity. At this visit, the patient was cleared for return to work without restrictions.

Literature Review

Arthroscopic proximal biceps tenodesis with interference screw fixation is a commonly used surgical treatment for LHB tendon pathology [1, 2]. This technique is attractive because it does not require an additional incision, is able to provide stable fixation of the LHB tendon, preserves the length-tension relationship, and has low rates of cosmetic deformity [3–5].

An alternative operation is the distal mini-open subpectoral tenodesis. In this technique, the LHB tendon is fixed close to its musculotendinous junction near the inferior border of the pectoralis major tendon. Various fixation methods have been described and have not been found to have a statistically significant difference in failure strength [6, 7]. The subpectoral tenodesis technique has the advantage of removing the LHB tendon from the bicipital groove, a site of potential irritation and pain. Additionally, arthroscopic proximal tenodesis may not be able to visualize distal LHB tendon pathology. This "hidden" pathologic tendon could serve as a pain generator following proximal tenodesis [8, 9].

In 2011, Sanders and colleagues performed a retrospective study of 127 biceps tenodesis procedures with a mean follow-up of 22 months. They concluded that biceps tenodesis techniques that release the biceps sheath or remove the tendon from the sheath have a rate of revision surgery of 6.8% compared to 20.6% for those techniques that do not release the tendon or sheath [10].

Gregory et al. specifically looked at the outcomes of revision biceps tenodesis utilizing a subpectoral approach in 2012. They demonstrated significant improvement in both pain relief and functional outcomes with this technique at a mean follow-up of 33.5 months. A complete satisfaction rate of 93% was also reported in this revision patient population [11].

Clinical Pearls and Pitfalls

- The key to minimizing recurrent anterior shoulder pain following biceps tenodesis is to ensure removal of the entire diseased tendon at the index procedure. Any remaining pathologic tendon within the bicipital groove places the patient at increased risk of recurrent pain.
- A postoperative physical examination consistent with proximal biceps pain following a prior proximal tenodesis should warrant further imaging workup in the form of an MRI.
- In patients with positive physical exam findings and positive or equivocal imaging findings, the first line of treatment should be a bicipital groove injection with local anesthetic. This is most accurately accomplished with the assistance of an interventional radiologist via ultrasound or fluoroscopy.
- The key to a successful revision biceps tenodesis is to remove remaining pathologic tendon and scar tissue from the inferior groove and reattach it more distally. A standard subpectoral approach is ideally suited for a more distal attachment of the biceps tendon which has previously undergone tenodesis.

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Chapter 9
A 60-Year-Old Active Female with Concomitant Type 1 SLAP and Rotator Cuff Tear

David Goodwin and Eric J. Strauss

Case Presentation

A 60-year-old female presents with a 4-month history of right shoulder pain and weakness. She is right-hand dominant and notes that her pain and weakness have progressively worsened. She is an active tennis player and notes that her pain is localized to the lateral and anterior aspects of her shoulder. Her pain is worse with serving overhead, and she also notes difficulty holding her arm in the abducted position on the tennis court and when reaching for objects at home. During the last 2 months, she reports experiencing aching night pain making lying on her right side difficult. She has been taking oral anti-inflammatory medication without much benefit.

On physical examination, she is a well-developed female with active forward flexion to 120°, passively to 165°. Active abduction is to 115°, passively to 160. Active external rotation

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_9,

with the arm to the side is 40°, passively to 55. Active internal rotation is to the T12 level. A positive drop arm sign is seen. She has significant weakness with supraspinatus testing when resistance is applied. She has full strength with external rotation and the belly press test is negative for weakness. Impingement signs, including Neer and Hawkins tests, are negative. Speed's test is positive and she has significant tenderness in the bicipital groove on palpation. Yergason's test is mildly positive as is O'Brien's test. There is no tenderness to palpation over the acromioclavicular joint. There is no evidence of muscular atrophy or scapular winging. There is no evidence of instability with load and shift testing and negative apprehension signs.

Plain radiographs demonstrated no evidence of osteoarthritis (Fig. 9.1). Magnetic resonance imaging (MRI) revealed a full-thickness rotator cuff tear of the supraspinatus and a type I SLAP tear with evidence of long head of the biceps tendinopathy (Fig. 9.2). There was no evidence of biceps subluxation on the axial images.

The patient failed 8 weeks of nonoperative management consisting of NSAIDs, formal physical therapy, and a corticosteroid injection into the subacromial space. Due to her age, health, activity level, and persistent symptoms and functional limitations, she was indicated for surgical intervention. She underwent a right shoulder arthroscopy which revealed a

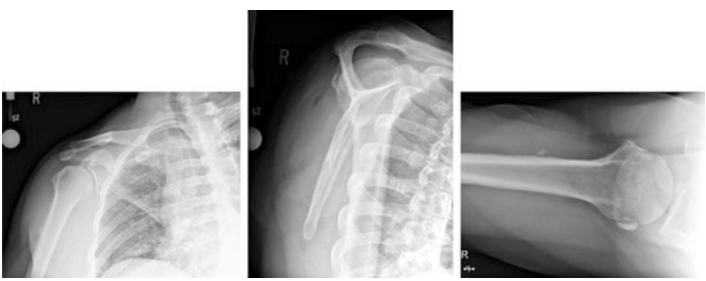


FIGURE 9.1 Anteroposterior (AP), scapular Y, and axillary views of the right shoulder showing a reduced glenohumeral joint with no evidence of osteoarthritis

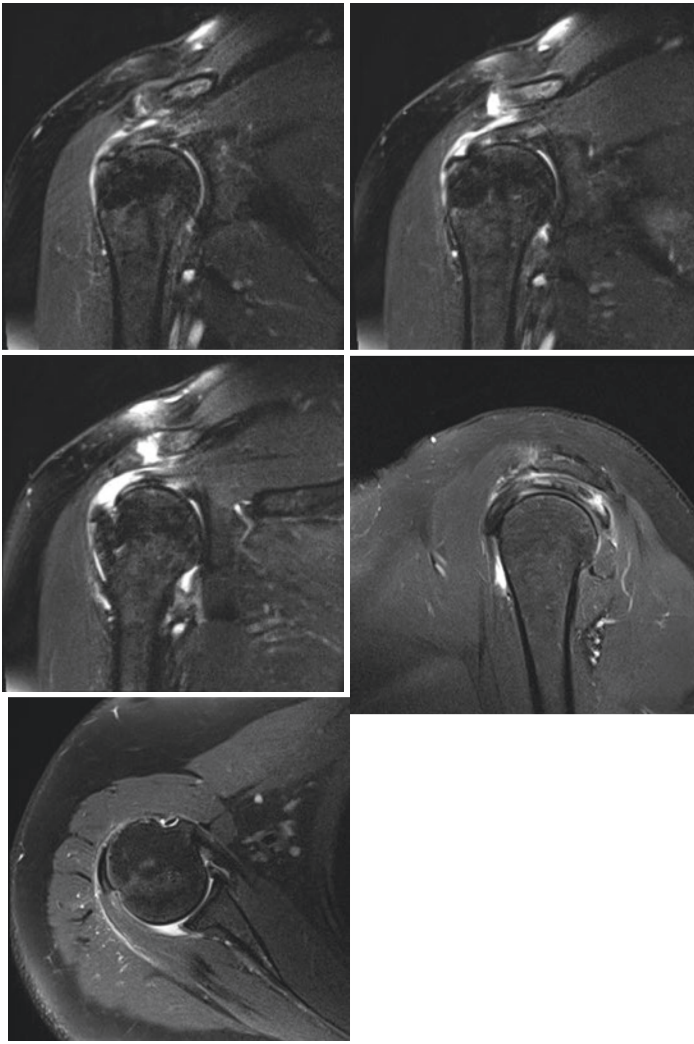


FIGURE 9.2 Magnetic resonance imaging of the right shoulder shows evidence of a full-thickness tear of the supraspinatus tendon. Additionally, the coronal cuts demonstrate increased signal within the superior labrum consistent with degenerative tearing, and the axial cuts show fluid around the long head of the biceps tendon consistent with tendinopathy

full-thickness tear of the supraspinatus and a type I SLAP tear with associated long head of the biceps tendinopathy. She was treated with an arthroscopic rotator cuff repair and an open subpectoral biceps tenodesis.

Diagnosis

History

A differential diagnosis of patients in this age group with shoulder pain and weakness should include osteoarthritis, adhesive capsulitis, and rotator cuff pathology [1, 2]. When limitations in range of motion are the chief complaint, it is more likely to be osteoarthritis or adhesive capsulitis. However, weakness is more likely to be from rotator cuff pathology. While rotator cuff pathology may result from a traumatic event, most rotator cuff tears in this age group are due to a degenerative process [1]. Rotator cuff symptoms typically present with lateral-sided shoulder pain, and biceps pathology is more likely to present with anterior shoulder pain often referred to the biceps muscle itself, particularly localized to the bicipital groove in the proximal humerus [2].

Physical Examination

Physical examination should begin with inspection. Prior scars suggest the patient has had previous surgery which may aid in diagnosis. Muscular atrophy should also be noted, especially in cases with long-standing pain where full-thickness rotator cuff tears or cysts in the spinoglenoid or scapular notch may cause atrophy to affected muscles. Next, active and passive range of motion is assessed. Significant limitations in both active and passive range of motion suggest adhesive capsulitis or glenohumeral osteoarthritis. Limitations in only active range of motion in one plane, such as abduction or internal rotation, may aid in the diagnosis of rotator cuff pathology.

After inspection and range of motion examination, specific tests are utilized to assess for rotator cuff weakness, internal impingement, and labral pathology. Instability is typically not tested in this patient population without a history of trauma, dislocations, or subluxations. The drop arm test is performed with the examiner placing the patient's affected arm into 90° of abduction with the patient's thumb pointing down. Inability to hold the arm abducted or significant weakness and pain with mild resistance suggests supraspinatus pathology. The infraspinatus is tested with resisted external rotation with the arm at the patient's side and the elbow flexed 90°. The hornblower test specifically assesses the posterior rotator cuff including infraspinatus and teres minor. This test is performed with the examiner placing the patient's shoulder into 90° of forward flexion. The elbow is then flexed 90° and the patient is asked to externally rotate the shoulder. Inability to externally rotate in this position is indicative of a positive finding. Subscapularis pathology is noted with the belly press test. This is performed with the arm held in front of the body and the patient applying force with internal rotation toward the torso. Weakness or pain is a positive finding. The lift off test is another test for subscapularis pathology. With the lift off test, the patient places the dorsum of his/her hand onto his/her back and pushes backward creating an internal rotation force. Weakness or pain is a positive finding.

Impingement signs are also common with rotator cuff pathology [3]. The Neer test is performed by the examiner ranging the patient's arm through forward flexion. A positive finding is anterior shoulder pain with this maneuver. The Hawkins test is performed by the examiner internally rotating the patient's shoulder while it is flexed forward to 90°. Pain in the lateral or anterior shoulder is a positive finding.

Biceps brachii pathology is tested with Speed's and Yergason's tests. Speed's test is performed with the arm supinated and shoulder flexed 90°. Resistance to forward flexion is then applied and pain specifically along the biceps tendon proximally is positive. Yergason's test is performed with elbow flexed 90°. The forearm is held in neutral or pronation and resistance to supination is applied by the examiner. Pain with resisted supination is a positive finding. The biceps is also evaluated with direct palpation over the proximal humerus in the bicipital groove. Tenderness here is associated with tendinosis of the long head of the biceps.

Shoulder instability is not common in an older population with rotator cuff tears. However, superior labral tears may be present and contribute to the patient's symptoms. The superior labrum is tested with O'Brien's test. This is performed with the patient upright and arm placed in 40° of adduction with maximal internal rotation (thumb pointing down). Resistance to shoulder flexion is then applied. The test is then performed with maximal external rotation of the shoulder (thumb pointing up). If pain is present with resisted flexion in maximal internal rotation but relieved in maximal external rotation, the test is positive for a suspected SLAP tear.

Imaging

Radiographs are typically the first imaging modality used. AP, axillary, and scapular Y views are often utilized. An axillary view is critical to rule out dislocation which may be missed on other views. Radiographs are also useful to assess for osteoarthritis, particularly rotator cuff arthropathy in which superior migration of the proximal humerus has occurred.

In cases with suspected rotator cuff tears, MRI is the golden standard for imaging. MRI has been shown to accurately detect tear location, size, tendon retraction, atrophy, and fatty infiltration [4]. More recently, ultrasound has gained popularity in evaluating rotator cuff tears. Ultrasound has been shown to be comparable to MRI in detecting size and location of rotator cuff tears [4, 5].

Management

The patient failed an 8-week course of nonoperative treatment including physical therapy, NSAIDs, and a corticosteroid injection into the subacromial space. The patient was then taken to the operating room.

Initially the patient underwent a diagnostic arthroscopy of the shoulder. A full-thickness tear of the supraspinatus tendon was identified as well as a type I SLAP lesion with associated long head of the biceps tendinopathy (Fig. 9.3). The labrum was otherwise intact anteriorly and posteriorly. There was no evidence of glenohumeral arthritis or subscapularis tear.

An anterior portal was then placed and the biceps anchor was cut using arthroscopic scissor. The labral tear and stump of the biceps anchor were then debrided to stable margins with an arthroscopic shaver.

The arthroscope was then placed in the subacromial space (Fig. 9.4). The subacromial bursa was debrided and the rotator cuff tear was visualized. The supraspinatus tendon was debrided back to normal-appearing tendon and a cuff grasper was used to confirm adequate mobilization of the tear. The greater tuberosity was cleared of the tissue, and two knotless suture anchors, each loaded with one suture tape, were placed on the medial edge of the greater tuberosity. The sutures were passed into the torn rotator cuff and then placed into two additional lateral row anchors. Following repair, the supraspinatus tendon was found to be firmly reapproximated, and the proximal humerus was taken through a gentle range of motion confirming a stable, anatomic repair.

A 2 cm incision was then made on the anteromedial border of the proximal humerus just distal to the pectoralis major tendon insertion. The fascia and interval between the short head biceps and pectoralis major were incised, and the long head of the biceps was identified and pulled out of the bicipital groove. The biceps tendon was prepared at the musculotendinous junction with suture. A

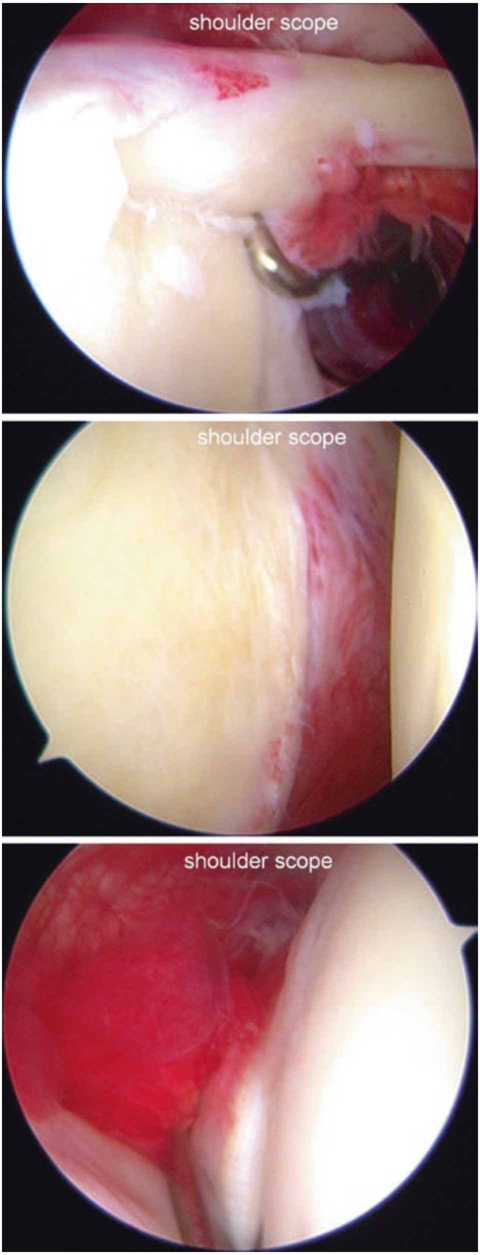


FIGURE 9.3 Arthroscopic assessment of the glenohumeral joint viewed from the posterior portal. The superior labrum had evidence of fraying consistent with type 1 tearing. The remainder of the labrum was intact. Evaluation of the long head of the biceps showed evidence of a "lipstick biceps sign" consistent with significant tenosynovitis. A biceps tenotomy was performed with an arthroscopic biter

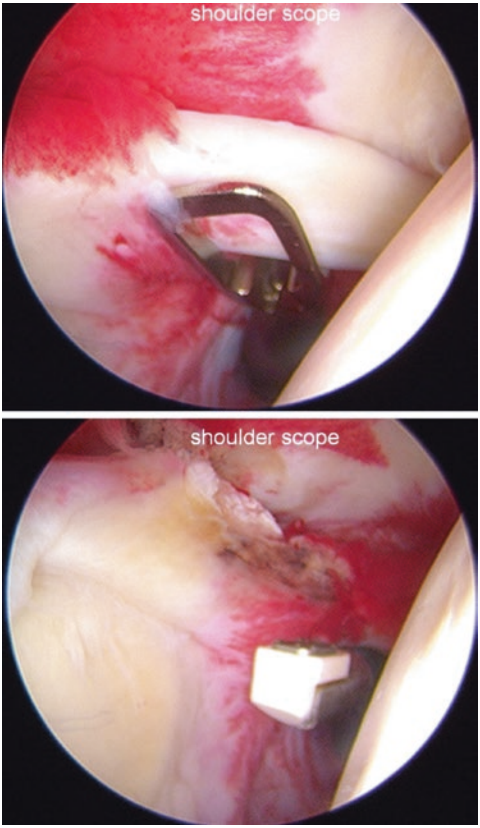


Figure 9.3 (continued)

guide pin was then placed in the proximal humeral shaft in the sub-pectoralis major position at a location that recreated the length-tension relationship of the long head of the biceps. The guide pin was overdrilled with a 6 mm reamer. The biceps tendon was then secured using a cortical button.

The decision to perform a biceps tenodesis was based on the patient's preoperative history and physical examination suggestive of long head of the biceps tendinopathy as well as intraoperative findings of an inflamed long head of the biceps tendon in the setting of a superior labral tear.

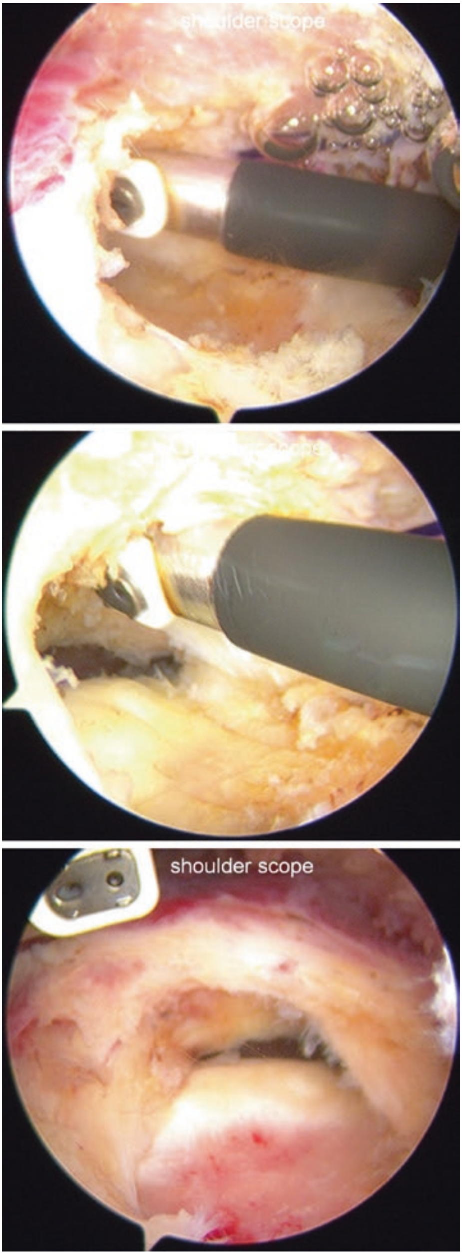
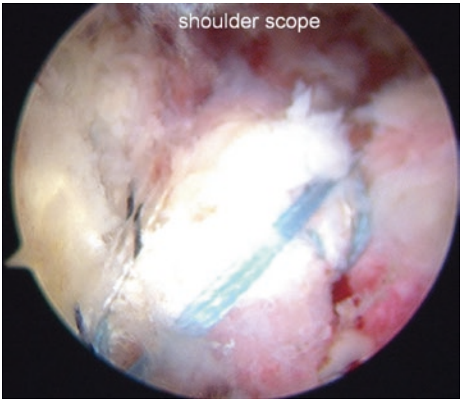


FIGURE 9.4 Evaluation of the rotator cuff from the subacromial space confirmed the presence of a medium-sized U-shaped tear of the supraspinatus. The tendon edge and the greater tuberosity were prepared and a knotless double-row rotator cuff repair was performed

FIGURE 9.4 (continued)



The decision to perform tenodesis versus tenotomy is controversial. In a review of 54 patients with biceps tendinitis treated with arthroscopic tenotomy, Kelly et al. reported that 38% of patients experience postoperative biceps muscle fatigue [6]. Tenotomy also carries with it a risk of cosmetic ("popeye') deformity. Thus, biceps tenotomy is generally reserved for older less active patients. Given this patient's active lifestyle, it was decided to perform a biceps tenodesis.

The rotator cuff was repaired utilizing a double-row technique. Although there is no consistent data to suggest clinical superiority of a double-row construct versus single row, it is the authors' preference to perform a double-row repair when the tear is large enough to allow fixation with medial and lateral anchors because of increased biomechanical strength with the double-row repair [7, 8].

Outcome

The patient was placed in a sling for 4 weeks postoperatively and started on passive range of motion. Active range of motion was initiated at 6 weeks and strengthening with resistance began at 12 weeks after surgery. At 6 months, the patient's active forward flexion was to 165°, active abduction to 160°, and active external rotation with the arm at the side to 55°. She had full strength in all planes and no longer described pain or weakness with overhead activity. She was cleared to return to tennis at 8 months postoperatively.

Clinical Pearls/Pitfalls

- History can elicit symptoms of long head of the biceps or SLAP pathology.
- Physical examination should assess the rotator cuff as well as labrum and long head of the biceps as concomitant pathology may otherwise be overlooked.
- Surgery should be reserved for patients that fail nonoperative management.
- Surgery should address the patient's functional level as well as sources of pain.
- Tenodesis versus tenotomy may be individualized based on patient preference, activity level, and age and body habitus.

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Chapter 10
Type II SLAP Tear in an 19-Year-Old Baseball Pitcher Treated with SLAP Repair

Siddharth A. Mahure, Mina M. Abdelshahed, and Andrew S. Rokito

Case Presentation

The patient is a 19-year-old left-hand dominant (LHD) collegiate baseball pitcher who presented for initial evaluation of left shoulder pain. He denied any history of direct or indirect shoulder trauma to the shoulder region, including any history of shoulder instability. He did, however, recall feeling a "pop" in his shoulder while pitching in a baseball game 5 months prior. Since this episode, he had been experiencing intermittent pain while pitching as well

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_10,

as a noticeable loss of pitch command and velocity. He reported that he had stopped playing baseball 1 week prior to presentation and had started taking over-the-counter analgesic medication.

On physical examination, he appeared as a well-developed, muscular young male standing 5 feet 9 inches tall and weighing 194 pounds. Focused shoulder examination revealed no obvious deformity, discoloration, swelling, or muscle atrophy. There was no evidence of generalized ligamentous laxity. There appeared to be normal, symmetrical scapulohumeral motion with no evidence of winging or dyskinesia. Active range of motion of the left shoulder consisted of 180° forward flexion, internal rotation to T12, 70° of external rotation in adduction, 130° of external rotation in abduction, and 30° of internal rotation in abduction. Neer and Hawkin's impingement signs were absent. Anterior apprehension and sulcus signs were negative as was a posterior stress test. Speed's and Yergason's tests were negative; however, an active compression (O'Brien's) and relocation tests were both positive. Manual muscle testing revealed normal strength in all muscle groups, and there were no neurologic deficits identified. Plain radiographs were unremarkable and a magnetic resonance arthrogram (MRA) was ordered.

MR arthrogram revealed supraspinatus tendinosis without tear, subdeltoid bursitis, and a tear involving the superior labrum (Fig. 10.1a, b, c).

The patient was counseled with regard to the nature and natural history of his condition and was started on a course of rest from throwing and an exercise program that included posterior capsular stretching exercises and strengthening of the rotator cuff and periscapular muscles. After 3 months a progressive throwing program was initiated. He continued to experience pain with throwing and surgery was recommended.

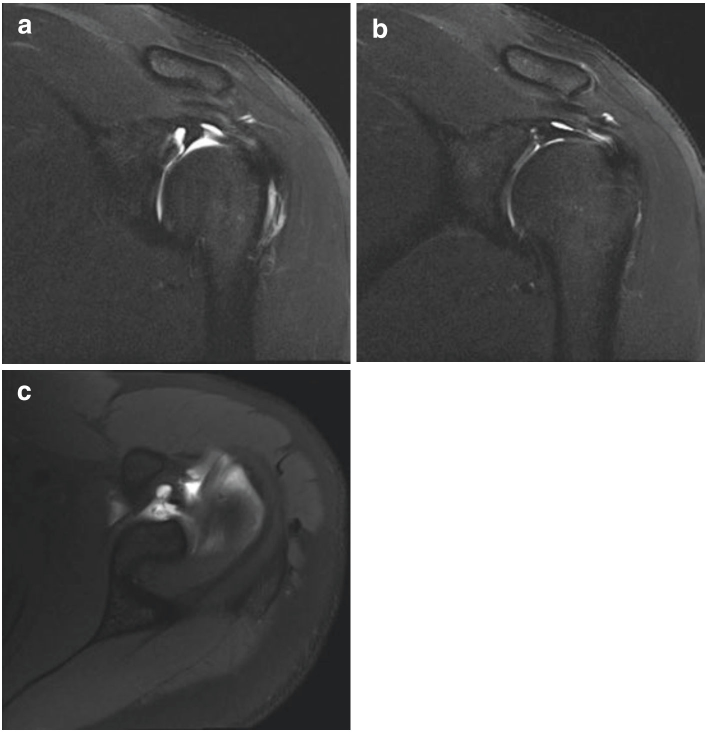

FIGURE 10.1 A 3 Tesla MR arthrogram of the left shoulder: (**a**) T2 Coronal view demonstrating increased signal intensity and contrast extravasation into the superior labral tear. (**b**) T2 coronal view demonstrating superior labral tear. (**c**) T1 axial sequence demonstrating contrast extravastion into superior labral tear

Diagnosis/Assessment

After careful consideration of this patient's history, physical examination, and imaging findings, a symptomatic SLAP lesion was suspected. Snyder originally classified SLAP lesions into four distinct types [1–3], with further subclassification by Maffet (Table 10.1) [4]. Type II SLAP lesions are the most common and are also amenable to surgical management.

Overhead-throwing athletes in particular are at risk for developing tears involving the superior labrum. A variety of explanations have been proposed regarding the pathophysiology of SLAP lesions in overhead athletes, including torsional, compressive, tensile, and shear forces [3].

Mechanical symptoms such as popping or clicking while throwing as well as a loss of pitch control and velocity are common symptoms identified in baseball pitchers with SLAP tears [5]. During the physical examination of patients with a suspected SLAP lesion, it is important to identify signs of shoulder instability and/or rotator cuff involvement, as these conditions often coexist in this patient population [6].

A multitude of physical examination maneuvers have been described for diagnosing SLAP lesions. The active

Table 10.1 SLAP tear classification

Type	Description
I	Fraying of superior labrum and biceps; both remain intact and attached to glenoid; patients may often be asymptomatic
II	Both superior labrum and biceps anchor are detached from glenoid; most common type
III	Bucket-handle tear of superior labrum; biceps anchor intact however
IV	Bucket-handle tear of superior labrum that extend into fibers of biceps; often creating split appearance of tendon
V	Anteroinferior Bankart lesion which continues superiorly to include separation of the biceps tendon
VI	Unstable flap tear of the labrum with biceps tendon separation
VII	SLAP lesion that extends anteroinferiorly along the labrum to below the MGHL

compression test involves forward flexion of the shoulder to 90° with 10–15° adduction, with the arm in internal rotation against resistance. Pain "inside" the shoulder with this maneuver constitutes a positive test, suggestive of a SLAP lesion [7]. Tests to assess proximal biceps tendon pathology (i.e., Speed's and Yergason's) have also been utilized to identify patients with SLAP lesions. In general, most tests that have been described for identifying patients with SLAP lesions have been shown to lack sensitivity and specificity and suffer from lack of interobserver reliability [8]. Due to a lack of consensus however regarding the ideal test for diagnosing SLAP tears [9], most authors advocate utilizing a combination of clinical exam and imaging findings.

While standard radiographs of the shoulder should be utilized for initial evaluation of patients, these are typically negative and MRI or MR arthrogram are obtained for patients with suspected SLAP lesions. Although sensitivity of MRI at diagnosing SLAP lesions can be as high as 86%, specificity is much lower, with some authors reporting rates as low as 12% [10–14]. Sheridan et al. found that the addition of contrast increased sensitivity (contrast 80% vs non-contrast 36%), but reduced specificity (contrast 67% vs non-contrast 85%), and suggested that these results were due to the high degree of concomitant co-pathology that exists with SLAP lesions [15]. MR arthrogram findings include: contrast extension between the superior labrum and glenoid on axial images, contrast extension into the long head of biceps insertion on sagittal and coronal views, concomitant extension of the tear into the anterosuperior or anteroposterior labrum, and detachment and inferior displacement of the superior labrum on sagittal and coronal views consistent with bucket-handle tears. Paralabral cysts are commonly noted in association with SLAP tears on MRA and typically resolve with treatment of the SLAP [16, 17].

The high degree of normal anatomic variability of the insertion of biceps onto glenoid labrum may be partly responsible for the high degree of false-positive diagnoses via MRI, with additional factors such as a sub-labral foramen, cord-like middle glenohumeral ligament, absent anterosuperior labrum, or presence of a Buford complex contributing to difficulty in making a diagnosis through imaging [18, 19]. A commonly discussed anatomic variant is the meniscoid-like superior labrum where the free edge of the labrum drapes over the underlying glenoid and extends into the center of the joint. This variant can simulate a SLAP tear as contrast may extend under the free edge of the labrum. Contrast must extend posterior to the biceps tendon anchor to be considered a tear [16]. The combination of these potentially confounding factors results in a high degree of ambiguity regarding utility of imaging for management of SLAP lesions, highlighting the importance of interpreting diagnostic imaging results in context of a complete clinical history and thorough physical exam.

Conservative management of SLAP lesions consists of rest, NSAIDS, and physical therapy. Physical therapy protocols should include rotator cuff strengthening, addressing scapular dyskinesia, and exercises for enhancing posterior capsular flexibility [3, 9, 16, 20]. A recent study by Jang et al. reported a 72% success rate with initial non-operative management of SLAP lesions and found that a history of trauma, presence of mechanical symptoms, and greater demand for overhead activities were associated with higher rates of failure [21]. When conservative modalities fail, arthroscopy is recommended for both definitive diagnosis and management.

Normal anatomic variants may also be confused with SLAP tears during arthroscopy. It is important to note that the superior labrum typically inserts just medial to the glenoid rim. A probe is used to assess the superior labrum. With the labrum retracted with a probe, the insertion is assessed; chondral fraying at the site of insertion is indicative of an injury, while smooth cartilage represents an anatomic variant of a more medial attachment [22].

While a static arthroscopic examination is useful, a dynamic arthroscopic exam should be added to help with your diagnosis. A “peel back” test may be performed by abducting the shoulder to 70–90° and external rotating the arm; this causes the biceps tendon force vector to shift from a horizontal to a vertical orientation, producing a torsional force at the base of the biceps, which is transmitted to the posterior labrum [23]. If the labrum is injured, this will result in peeling back of the labrum medially over the glenoid. An arthroscopic active compression test can also be done; with the arm forward flexed to 90° and adducted to 10–15°, the shoulder is internally and externally rotated. In the setting of a SLAP lesion, the damaged anchor can be seen displacing inferiorly and medially.

Management

After receiving an interscalene block and general anesthesia, an examination under anesthesia of both shoulders was performed assessing both range of motion and stability. Noted again was an internal rotation deficit on the affected side with no evidence of instability.

The patient was subsequently transferred to right lateral decubitus position and the shoulder suspended using 10 pounds of skin traction. A standard posterior viewing portal was created, and the arthroscope was introduced into the glenohumeral joint. A systematic inspection of the glenohumeral was performed assessing the articular surfaces, biceps and subscapularis tendons, the articular surface of the rotator cuff, integrity of the capsule, and glenohumeral ligaments and the entire labrum. In anticipation of performing a SLAP lesion repair, a "high" anterior working portal was created using an outside-in technique. A spinal needle was directed into the joint across the rotator interval, placing it just off the anterolateral edge of the acromion. The needle was visualized as it entered the joint adjacent to the biceps tendon verifying an appropriate angle for suture anchor placement. The needle was then exchanged for a 5-mm diameter arthroscopic cannula. An arthroscopic probe was used to carefully inspect the superior labrum and a type II SLAP lesion was identified.

The labrum was detached from the underlying glenoid rim beginning anterior and extending posterior to the biceps tendon, rendering the biceps-labral anchor unstable. The underlying cartilage appeared frayed along the length of the tear. Furthermore, as the arm was abducted and externally rotated into a "cocking" position to simulate overhead throwing, the posterosuperior labrum was observed to "peel back" from the underlying glenoid rim.

An arthroscopic rasp and shaver were used to debride and gently decorticate the glenoid rim adjacent to the tear site. A spinal needle was then used to localize an ancillary trans-cuff portal that would be used for anchor insertion (Port of Wilmington) [24]. A spinal needle was directed at a point 1-cm lateral and 1-cm anterior to the posterolateral corner of the acromion and introduced into the joint across the musculotendinous portion of the rotator cuff. Alternatively, an additional rotator interval portal can be established to assist with suture management and shuttling. The drill sleeve/trocar was placed percutaneously under direct visualization at a 45° angle with respect to the posterosuperior glenoid rim. Suture anchors were placed as needed to repair the posterosuperior portion of the labral tear. After each anchor was placed, sutures were shuttled working superior to the biceps tendon, and arthroscopic knots were tied in standard fashion. Mattress (horizontal or vertical) or simple suture configuration can be used depending upon tear and tissue configuration. Knots should be placed superior and medial, away from the articular surfaces. Alternatively, knotless devices can also be utilized. For lesions that extend anterior to the biceps tendon, suture anchors are delivered directly through the anterior rotator interval cannula, and sutures can be passed either with a shuttling device or directly using a tissue punch or penetrating device. Once the labrum is repaired, the biceps anchor is probed to verify stability.

A regimented postoperative rehabilitation protocol was followed. The patient remained in a sling for 4–6 weeks. Passive ROM was progressed in the first 6 weeks with avoidance of external rotation of the abducted arm as this would stress the biceps anchor repair. In weeks 7 through 16, a focus on increasing ROM, active ROM, and progression into resistance exercises was initiated. Weight-bearing exercises are typically not performed for at least 8 weeks to avoid compression and shearing forces on the healing labrum, and aggressive strengthening of the biceps is typically avoided until week 12. Sports-specific training and return to sports typically occurs at the 4–6-month mark with return to throwing at this time.

Outcome

Our patient is a 19-year-old LHD collegiate pitcher who initially presented with a clinical history, physical exam, and MRA suggestive for a SLAP lesion. After initial attempts at non-operative treatment failed, he underwent successful arthroscopic repair of a type II SLAP lesion. He is now 2 years from the date of surgery and reports resolution of symptoms with return of throwing velocity and pitch command.

Literature Review

SLAP lesions are a frequent cause of pain and shoulder dysfunction in the overhead throwing athlete. Incidence rates have been reported as high as 26%, and numerous authors have reported on the significant rise in SLAP repairs over the last decade [25–27].

By increasing the depth of the glenoid fossa, the labrum enhances concavity compression within the glenohumeral joint, subsequently minimizing humeral head translation. Although the superior labrum serves as an attachment for the biceps anchor, a number of authors have reported a number of anatomic variations. Habermeyer and Vangsness both commented on the variability of biceps originations including superior labrum, supraglenoid tubercle, posterior labrum, or the combination of above [28, 29], while Rao described the existence of a Buford complex [30]. The significant amount of anatomic variability surrounding superior labral-biceps complex complicates the ability to make a definitive diagnosis regarding true SLAP pathology.

Further confounding the ideal management of a SLAP lesion is the difficulty in making an accurate diagnosis, particularly when considering poor reliability of physical exam tests and imaging studies. Additionally, SLAP tears may exist concomitantly with other shoulder pathology in upward of 88% of patients [1, 6, 24, 31], further confounding our understanding of the source of symptoms in these patients and factors involved with failure of SLAP lesions repairs (Figs. 10.2, 10.3, 10.4).

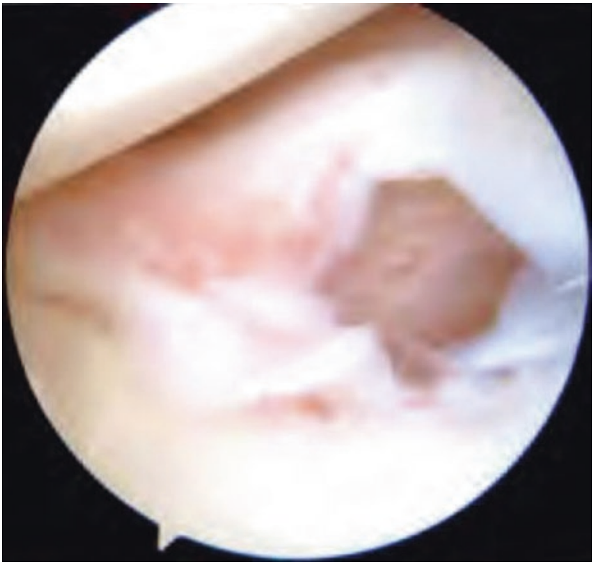

Figure 10.2 Arthroscopic image demonstrating superior labral defect; the probe is used to elevate defect and allow for size and severity estimation

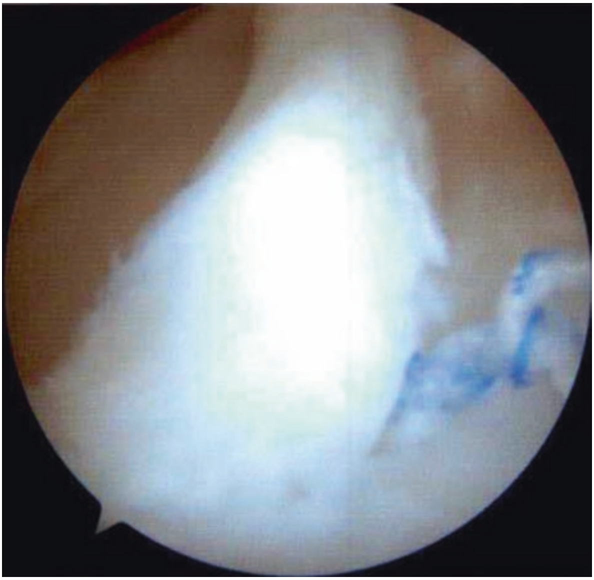

Figure 10.3 Labral tear after horizontal mattress fixation with suture anchor

A focused review of the literature for outcomes in overhead-throwing athletes reveals equivocal outcomes. In a retrospective review of 102 throwers, Morgan et al. reported that 87% were able to return to sport at pre-injury level [24]. By comparison, although many series report improved visual analog scale (VAS) pain scores and improved subjective outcome scores among all patients, return to previous level of throwing remains consistently low for overhead-throwing athletes [32–34]. A systematic review by Sayde et al. examined 506 athletes, of which 39% (198) were overhead throwing athletes, and reported that while 78% of non-throwers returned to previous level of competition, only 63% of overhead athletes were able to return to pre-injury levels [35].

Recently, greater attention has been given to the impact that concomitant rotator cuff pathology has on

Figure 10.4 After fixation is complete, probe is again used to examine integrity of SLAP repair; here the probe was unable to elevate the labrum, indicating complete repair

outcomes in SLAP repair. A series of 17 overhead athletes with SLAP tears and infraspinatus tendon injuries reported a 35% return to prior level of injury, with another one third being unable to return to play in any capacity [36]. Another examination by Neri et al. reported that partial thickness rotator cuff tears (PTRTC) were negatively correlated with return to sport in the presence of SLAP tears [37]. In the cohort without PTRCTs, an 80% return to prior level of sport was observed, as compared to 12.5% in those with tears.

As patients continue to remain physically active, clinicians are encouraged to counsel their patients appropriately regarding realistic outcomes after arthroscopic SLAP repair, particularly in those high-level overhead-throwing athletes wishing to return to sport.

Clinical Pearls & Pitfalls

- Diagnosis of SLAP tears should be made through a combination of history, clinical exam, and imaging. Due to variability regarding sensitivity and specificity of provocative maneuvers and MRI imaging, shoulder arthroscopy remains the gold standard for diagnosis.
- Clinicians should have a high index of suspicion regarding concomitant shoulder pathology during evaluation of a patient with presumed SLAP tear. In particular, older patients may have rotator cuff tears/tendinopathy, while younger patients may be experiencing symptoms related to shoulder instability.
- Although subjective outcome scores and pain levels show good to excellent outcomes for the majority of patients undergoing SLAP repair, return to sport at a pre-injury level or higher remains consistently low in overhead-throwing athletes.
- Adequate static and dynamic assessment for diagnosis is imperative; improperly addressing a normal biceps-labrum variant may result in chronic pain and stiffness, especially an appreciable loss of external rotation.
- When addressing a true SLAP lesion, it is important to only capture labrum; capturing capsule and structures in the rotator interval may result in constraining the joint and restriction of shoulder range of motion.
- Appropriate anchor placement will limit surgical time and optimize anchor placement; use of the port of Wilmington and a trans-cuff portal typically gives adequate direct access to the posterosuperior labrum.

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Chapter 11
Type II SLAP Tear in a 50-Year-Old Recreational Athlete Treated with Biceps Tenodesis

John P. Begly and Mehul Shah

Case Presentation

The patient is a 50-year-old, right-hand dominant male who presents to orthopedic care with a chief complaint of several months of left shoulder pain. The patient works in an office setting but is a recreational athlete who enjoys running and playing softball. He denies acute injury but reports worsening pain in his right shoulder. Specifically, he reports deep, aching shoulder pain, occasionally radiating down into his biceps, associated with athletic activities. In particular he has

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_11,

difficulty throwing a ball and serving a tennis ball. He reports occasional mechanical symptoms such as popping and clicking but denies instability. Other symptoms include subjective weakness and easy fatigability. Upon examination, pain is elicited with O'Brien's active compression test and the crank test. He has anterior apprehension, Yergason's test is negative, and there is no tenderness with palpation of the bicipital groove. Plain radiographs are unremarkable. An MRI arthrogram is obtained and demonstrates a Type II SLAP tear. He fails to improve with therapy, anti-inflammatory medication, and rest. The patient is indicated for left shoulder arthroscopy and biceps tenodesis.

The patient undergoes left shoulder arthroscopy and open subpectoral biceps tenodesis (Figs. 11.1 and 11.2). His immediate postoperative course is uncomplicated, and he makes appropriate progress with physical therapy following surgery. At most recent follow-up, he is pain-free,

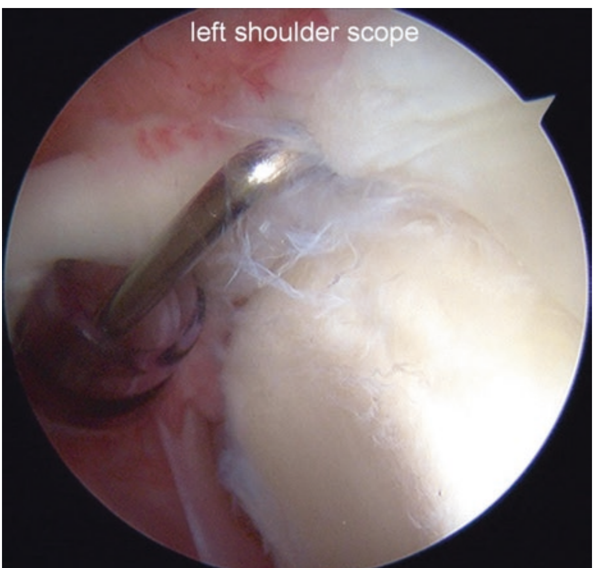

FIGURE 11.1 Intraoperative arthroscopic photograph demonstrating Type II SLAP tear

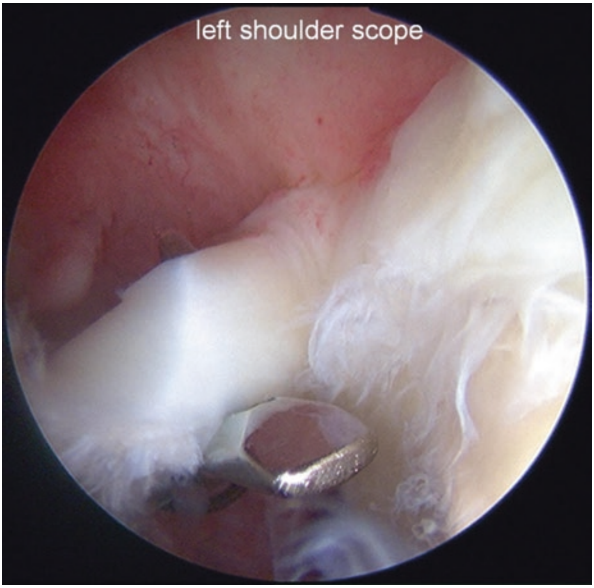

FIGURE 11.2 Intraoperative photograph demonstrating biceps tenotomy in treatment of Type II SLAP tear

demonstrates full range of motion, and has returned to his previous activities, reporting performance equal to his preoperative baseline. Figure 11.3a and 11.3b demonstrate postoperative radiographs.

Diagnosis/Assessment

Superior labrum from anterior to posterior (SLAP) tears represent a common shoulder injury pattern, particularly in athletes who participate in overhead activities. Andrews and colleagues first identified injuries to the superior glenoid labrum in 1985 [1], while Snyder et al. coined the term "SLAP lesion" in 1990 in efforts to classify the subtypes of glenoid labral lesions [2]. Type II tears were further described by Morgan et al. into three separate subtypes (anterior, posterior, combined) [3].

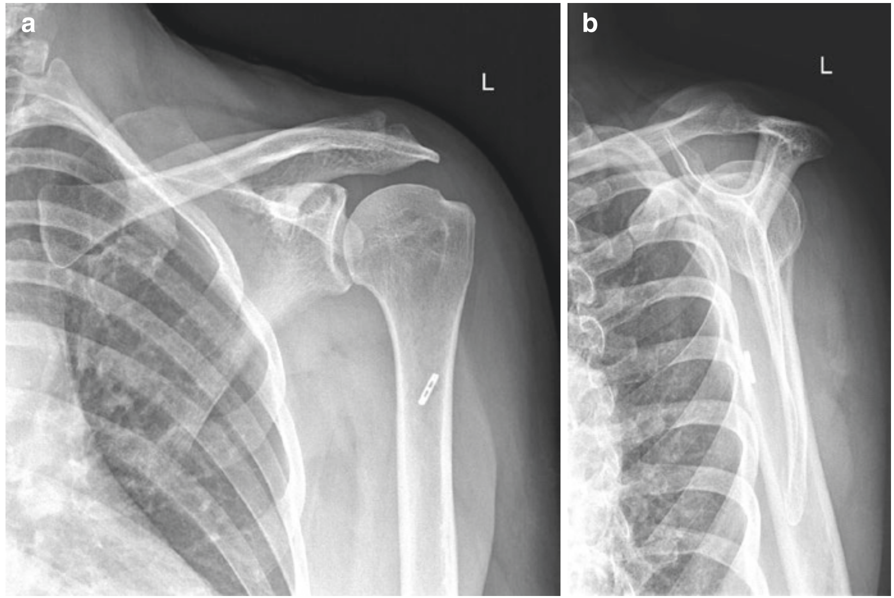

FIGURE 11.3 (**a**, **b**) Postoperative AP and transthoracic lateral shoulder radiographs demonstrating acceptable positioning of unicortical biceps button (Arthrex, Naples, FL)

Type II tears are the most common variant and are defined as labral fraying with a detached biceps tendon anchor from the superior glenoid [4]. The mechanism of injury for SLAP tears is variable. Injuries may occur secondary to acute trauma or overuse. Traumatic mechanisms include a fall onto an abducted arm in flexion, while repetitive overhead activity is the most common overuse mechanism associated with SLAP lesions [2, 5]. Despite being the subject of much investigation, the definitive case of SLAP tears remains controversial. SLAP tears are often accompanied by concomitant pathology, including glenoid lesions, rotator cuff tears, chondral injuries, and acromioclavicular arthritis. Type II lesions are associated with Bankart lesions and internal rotation deficits in patients under 40 years of age, while patients over 40 years may sustain associated rotator cuff tears and demonstrate evidence of preexisting glenohumeral arthritis [6].

Patients present with shoulder pain and often report weakness and impaired athletic performance. Mechanical symptoms and instability may also be present. Although nonspecific, provocative tests such as compression testing, labral shear, and apprehension testing may be positive. In most cases, radiographs are unremarkable or demonstrate mild degenerative changes. MRI arthrogram is the diagnostic imaging test of choice in the workup of a SLAP lesion. First-line therapy is nonoperative and consistent of activity modification, rest, anti-inflammatory medications, corticosteroid injection, and physical therapy. Operative intervention is indicated in cases of persistent symptoms in the setting of failed nonoperative management.

Management

Rates of SLAP lesion repair are increasing, including in older age groups [7–9]. Repair of Type II SLAP tears is associated with good results in younger populations [3, 7, 10, 11]. However, many studies suggest Type II lesions in patients of advanced age are more appropriately treated with biceps tenodesis [5, 10, 12–17]. In this patient population, repair of a Type II SLAP tear may lead to symptomatic postoperative stiffness [18–20]. While Schroder et al. found no significant age-associated differences in outcomes status post arthroscopic repair of isolated SLAP lesions, 79% of patients who developed postoperative stiffness requiring additional treatment were older than 40 years of age [20]. Additionally, the proximal portion of the long head of the biceps tendon is innervated by a complex sympatric fiber system and may represent a source of residual pain after repair [21]. Elimination of this potential source of pain has been theorized to encourage resumption of natural shoulder mechanics postoperatively [5]. Although overall rates of repair continue to increase [9], many authors prefer tenodesis in patients of advanced age, citing quicker recovery, less potential for stiffness, and more predictable recovery when compared to SLAP repair in this age group [13, 15].

Patients treated with tenotomy without tenodesis often experience an improvement in pain; however, this technique allows for distal migration of the biceps tendon, which may result in a classic Popeye deformity [4]. Tenodesis carries the proposed advantages of improved strength and cosmesis, as well, and less residual biceps fatigue and cramping [5], although this has yet to be definitively demonstrated in the literature. Multiple authors have proposed the biceps as a superior stabilizer, important in the dynamics of the shoulder during overhead activities [22–24]. However, Gottschalk et al. and Boileau et al. demonstrated no significant humeral head instability following treatment with biceps tenodesis [5, 12]. The authors do not consider shoulder instability to be a concern following biceps tenotomy.

Many successful methods of tenodesis have been described, including the use of interference screws, suture anchors, or suture alone [4, 5]. In particular, interference screws have been demonstrated to be a reliable, successful implant used in biceps tenodesis [12, 18, 25–29]. Additionally, various methods of surgical techniques have been described, including suprapectoral and subpectoral biceps tenodesis. Sanders et al.

examined the failure rates associated with these techniques, and found a decreased risk of failure with proximal fixation with an open sheath, or with a subpectoral tenodesis [30]. The authors proposed that eliminating residual groove pain contributed to the success of subpectoral biceps tenodesis. Reported complications of biceps tenodesis include fixation failure, infection, musculocutaneous neuropathy, reflex sympathetic dystrophy, and humerus fracture [5, 31–33]. However, complications are rare; in their series of 353 patients who underwent open subpectoral biceps tenodesis, Rho et al. reported a complication rate of 2% [32].

When treating a patient such as that described in the case presentation above, the authors prefer to perform an open subpectoral biceps tenodesis with unicortical biceps button (Arthrex, Naples, FL). The patient is positioned in the standard beach chair position and a diagnostic shoulder arthroscopy is performed. The superior labrum is evaluated with a probe and classification of the SLAP tear is made (Img 1). Biceps tenotomy is performed with either bipolar radiofrequency or arthroscopic scissors (Img 2). The superior labrum is then debrided back to a stable edge with the use of an arthroscopic shaver.

In the beach chair position, the arm is placed on a padded mayo stand in a slightly abducted position. Alternatively, a pneumatic arm positioner can be utilized. An incision is made in line with the humeral shaft centered over the inferior border of the pectoralis tendon, which can be palpated in the anterior axillary fold. Subcutaneous dissection is performed and advanced deep to the pectoralis musculotendinous junction. At this point, the pectoralis tendon is retracted superolaterally. Medial retraction of the short head of the biceps brachii and coracobrachialis is made with a small Richardson retractor. The biceps tendon is identified in the base of the wound and retrieved from the groove.

The proximal biceps tendon is whipstitched 2–2.5 cm proximally from the myotendinous junction. A unicortical drill hole is made 1 cm proximal to the inferior border of the pectoralis tendon. Care is taken not to overtension the biceps, as this may lead to pain and spasm postoperatively. The authors suggest erring on the side of less tension, than over-tensioning the tenodesis. The biceps button is inserted through the unicortical hole and flipped intraosseously. The whipstitch sutures are pulled to reduce the biceps tendon to the humeral shaft and tied over the button. The excess biceps tendon proximally is excised. Fluoroscopy can be used to confirm proper button deployment. The authors prefer the unicortical button technique as it provides secure fixation of the biceps tendon while minimizing the risk of radial and axillary nerve injury associated with the bicortical technique (Img 3, Img 4).

Postoperatively, the patient is provided a sling for the first 4 weeks, with instructions to perform pendulum exercises as well as passive range of motion in the frontal plane from approximately 0 to 145°. Gentle active elbow flexion is initiated at 4 weeks from the date of surgery. Provided that full, painless range of motion has been achieved, the patient is allowed to begin strengthening at approximately 8 weeks from the date of surgery.

Outcome

Despite being a common and well-studied shoulder injury, controversy regarding the particularities of SLAP tear treatment continues. Although most studies report successful outcomes, the results following repair of SLAP tears are inconsistent throughout the literature, varying from 65% to 95% success rates [5, 10, 11, 18, 34–40]. Rates of return to sports range widely from 20% to 87% [12], and typically inferior results are reported in athletes who depend on overhead activities [39, 41]. O'Brien et al. examined repairs of Type II SLAP tears in 31 patients, with a mean age of 39 years, at an average follow-up of 3.7-year status post procedure and reported good or excellent outcome in 71% of patients [10]. Rhee et al. studied a group of 44 isolated SLAP lesions repaired in 41 patients with an average age of 24 years at the time of surgery. Eight-six percent of these patients reported good or excellent outcome at follow-up [11]. Similarly, Paxinos et al. reported a 92% rate of return to preoperative activities at 6-month follow-up in 24 patients (mean age 36 years) treated with SLAP tear repair [40].

The success of SLAP tear repair is highly dependent on the age of the patient [8]. While Alpert et al. did not find a significant difference in patient outcome and satisfaction when comparing arthroscopic SLAP repair in patients younger and older than 40 years of age [34], other studies have demonstrated significant age-related differences. Franceschi et al. performed a randomized controlled study to examine the outcomes of 63 patients with rotator cuff and SLAP tears who were treated operatively [16]. Thirty-one patients underwent repair of both the cuff and SLAP tear, while 32 patients underwent repair of the rotator cuff tear and tenotomy of the long head of the biceps. Average age of the subjects was 63 years. At a minimum follow-up of 2.9 years, the tenotomy group demonstrated significantly improved range of motion and outcomes scores compared to the SLAP repair group. In the tenotomy group, the University of California Los Angeles (UCLA) score significantly increased from a preoperative average score of 10.1 to a post-operative average score of 32.1. The authors concluded no advantage of repairing a Type II SLAP tear when associated with a rotator cuff tear in patients over 50 years of age.

In a case-control study of 179 patients, Provencher et al. prospectively analyzed clinical outcomes in patients treated with arthroscopic repair for isolated Type II SLAP tears [17]. Failure was defined as revision surgery, a mean American Shoulder and Elbow Surgeons (ASES) score of under 70, or an inability to return to sports and work. 36.8% of patients met failure criteria, and advanced age (age >36 years) was the only statistically significant factor associated with failure. Relative risk of failure in patients older than 36 years was 3.45 (95% CI, 2.0–4.9).

Boileau et al. performed a cohort study of 25 consecutive patients operated for an isolated Type II SLAP lesion [12].

Ten patients, average age of 37 years, underwent SLAP repair with suture anchors. Fifteen patients with an average age of 52 years underwent arthroscopic biceps tenodesis with an interference screw. Although Constant scores increased in the repair group, 60% of the patients reported dissatisfaction with their level of pain and ability to regain preoperative level of sports participation. On the contrary, 93% of the tenodesis group were either satisfied or very satisfied with their surgery, and 87% of these patients regained their level of preoperative sports performance compared to 20% in the repair group.

Ek et al. performed a retrospective analysis of outcome following arthroscopic treatment of isolated Type II SLAP lesions [15]. Fifteen patients with a mean age of 47 years underwent biceps tenodesis, while ten patients with an average age of 31 years. No statistically difference in outcome was identified between the two groups. Despite a lack of significant findings, the authors concluded that their preference is to treat Type II SLAP lesions in patients over 35 years of age with tenodesis, citing a more rapid recovery and less potential for stiffness as advantages in this age group.

Denard et al. examined arthroscopic repair of isolated SLAP lesions in 55 patients. Overall, 87% of patients had good or excellent results. Although not statistically significant, there was a trend toward improved outcomes in patients younger than 40 years compared to those older than 40 years. Regarding the management of patients older than 35 years with Type II SLAP lesions, the authors stated their preference to perform biceps tenodesis, noting a higher rate of satisfaction and return to activity in patients treated with this method.

Gottschalk et al. reported on outcomes in 37 patients treated with subpectoral biceps tenodesis for Type II and Type IV SLAP lesions. The average age of patients in the study was 46.7 years. The authors reported significant improvement in both ASES and visual analog scale (VAS) for pain. 89.66% of patients were able to return to their previous level of activities following subpectoral biceps tenodesis.

Clinical Pearls and Pitfalls

- Unicortical biceps button fixation can be utilized to avoid potential injuries to the axillary and radial nerves.
- Avoid overtensioning the biceps tenodesis.
- If planning a biceps tenodesis, it is often technically easier to perform with the patient in the beach chair position. However, the procedure is still possible with the patient positioned laterally.
- Consider biceps tenodesis rather than repair of SLAP lesions in the older patient population.

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Chapter 12
Type 2 Superior Labral Anterior Posterior (SLAP) Tear in 55-Year-Old Male with Concomitant Full-Thickness Rotator Cuff Tear Treated with Long Head of the Biceps Tenodesis and Rotator Cuff Repair

Robert A. Duerr and Darren A. Frank

Case Presentation

The patient is a 55-year-old right hand-dominant male who sustained an injury to his right shoulder 2 months prior to initial presentation. He reports that he was lifting an approximately 100 pound case from the floor and felt a

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_12,

sudden "pop" and sharp pain deep within the right shoulder. He now complains of persistent pain within the shoulder and weakness that are worse with overhead activity. He also reports occasional "clicking" within the shoulder. He was previously treated by his primary care physician who prescribed a 6-week course of physical therapy and anti-inflammatory medications, which have provided minimal relief.

On physical exam, the patient stands 5 feet 11 inches tall, weighing 200 pounds. Focused exam of the right shoulder demonstrates intact skin envelope with no scars or rashes. Normal and symmetric deltoid contour was appreciated. Mild prominence is noted over the acromioclavicular joint, but no tenderness and no pain with cross-body abduction are noted. He has limited active range of motion from 0° to 100° of forward elevation and abduction, with assistance and passively, full range of motion 0–180°. In the scapular plane, he has 90° of external rotation and 80° of internal rotation, actively and passively. He has discomfort with Neer and Hawkins impingement maneuvers. Rotator cuff strength testing reveals 3/5 strength in forward elevation with a positive drop arm sign and positive lag signs, 4/5 external rotation strength with the elbow at the side, and 5/5 internal rotation strength. He has pain with O'Brien's active compression maneuver. He has some minimal tenderness over the bicipital groove. His neurovascular examination is normal.

Radiographs of the right shoulder show acromioclavicular joint arthrosis and are otherwise unremarkable. Magnetic resonance imaging (MRI) demonstrates superior labral tear with biceps tendinopathy (Fig. 12.1). There is also a full-thickness tear of the supraspinatus without evidence of tendon retraction (Fig. 12.1).

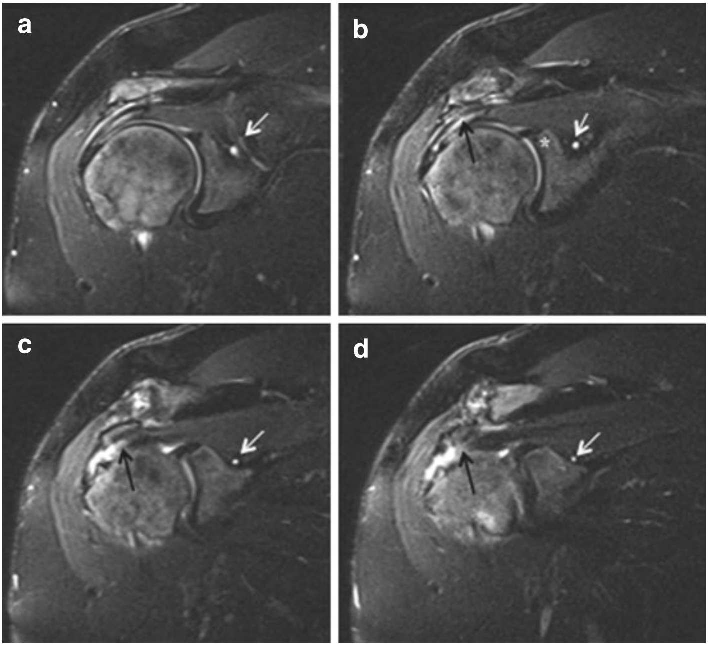

FIGURE 12.1 Sequential sagittal images of T2-weighted shoulder MRI demonstrating supraglenoid cyst (*white arrow*), superior labrum with linear signal intensity between labrum and glenoid rim (*asterisks*), and full-thickness tear of supraspinatus (*black arrow*)

Diagnosis/Assessment

In middle-aged patients presenting with unilateral shoulder pain, rotator cuff disease is the most common diagnosis found in up to 64% of patients [1]. In this patient age group, rotator cuff tears are often associated with concomitant intra-articular pathology, with labral tears being the most frequent [2, 3]. The superior labrum and biceps anchor complex likely undergo degenerative changes similar to the rotator cuff with aging, making it susceptible to injury with even minor trauma [4, 5]. SLAP lesions were originally described by Andrews et al. [6] and classified by Snyder et al. [7] into four subtypes. Type 2 SLAP lesions, with detachment of the biceps anchor and superior labrum, are the most common [7].

This patient's history, physical exam, and imaging findings are consistent with injury to the biceps anchor and superior labrum complex with a concomitant rotator cuff tear. These patients will often relay a history of some minor trauma, especially a sudden or forceful downward force with the arm at the side and elbow fully extended. In laborers or other physically active older patients, no specific traumatic event may have occurred, and the pathology is more likely due to a degenerative process. Physical examination will often demonstrate findings consistent with both rotator cuff and biceps anchor pathology. In my practice, I have found the O'Brien's active compression test to be the most reliable physical exam maneuver to identify the biceps anchor pathology. In addition direct tenderness over the biceps groove may indicate extra-articular biceps involvement. In patients who have failed conservative treatment or who present with signs and symptoms suggestive of significant pathology, MRI is obtained to aid in definition of the injury complex.

On MRI, superior labrum and biceps anchor pathology are best identified on T2 coronal images as a linear signal intensity between the superior labrum and glenoid rim [8]. There may also be an associated paralabral ganglion cyst, which can occur in the spinoglenoid notch and lead to compression of the suprascapular nerve and denervation of the infraspinatus. T2 coronal and sagittal images are typically most useful to evaluate the rotator cuff. Care must be taken to correlate MRI findings with clinical history and exam as incidental findings in the superior labrum are common in this age group.

Management

Once the diagnosis of a type 2 SLAP lesion with concomitant rotator cuff tear is confirmed, in this patient age group, first-line management is often conservative. Nonoperative treatment options include physical therapy and oral anti-inflammatory medications or intra-articular corticosteroid injection for pain relief. In the case of full-thickness rotator cuff tears, the risk of tear progression is discussed with the patient, and surgical treatment may be elected. In patients who fail conservative treatment, surgical management is discussed.

Surgical options for management of the type 2 SLAP lesion include SLAP repair, biceps tenotomy, or tenodesis with debridement of the superior labrum. In this patient population, SLAP repair in combination with rotator cuff repair has been shown to lead to decreased motion and poorer functional outcomes compared with biceps tenotomy or debridement of the SLAP lesion [9–12]. Biceps tenotomy, or releasing the long head of the biceps from its insertion on the superior labrum and supraglenoid tubercle, has been shown to provide excellent pain relief [13, 14]. However, some patients have suboptimal results secondary to cosmetic "popeye" deformity, cramping, and/or fatigue pain in the biceps muscle [13–16].

Performing a tenodesis of the long head of the biceps minimizes the occurrence of a "popeye" deformity and has been demonstrated to mitigate biceps fatigue pain [16, 17]. Results of tenodesis have been limited by complaints of persistent pain over the bicipital groove and/or pain at the site of tenodesis [12, 16]. A variety of techniques for biceps tenodesis have been described, including bone fixation with suture anchors, interference screws, ligament washer, cortical button, through bone tunnels, and a keyhole with interference screw [18–23]. Soft tissue tenodesis has also been described [20].

In addition to fixation techniques, biceps tenodesis may be performed in different anatomical locations. The tendon may be fixed anywhere along its course, including above, or proximal to, the bicipital groove (suprapectoral), within the groove, or below, or distal to, the groove (subpectoral) [18, 24–26]. Distal fixation requires the use of an additional incision, and cases of musculocutaneous nerve palsies have been reported [27, 28]. Proximal tenodesis has been reported to have a higher revision rate, thought to be due to persistent inflammation within the bicipital groove, where the tendon remains [29]. Some authors advocate an all-arthroscopic suprapectoral tenodesis distal in the bicipital groove that has been shown to provide similar pain relief and clinical outcomes as open subpectoral tenodesis but avoids the complications of an additional open incision [11, 30]. The all-arthroscopic suprapectoral tenodesis is our technique of choice if sufficient long head of the biceps tendon tissue remains.

Our patient had failed conservative treatment, and arthroscopic management was elected. After induction of anesthesia, the patient was positioned on the operating table in a lateral decubitus position with the surgical arm suspended at approximately 45° of abduction and 20° of forward flexion with 10 pounds of traction. A posterior viewing portal was established into the glenohumeral joint and diagnostic arthroscopy completed to identify the extent of the rotator cuff tear and biceps pathology. An anterior working portal was established by spinal needle localization through the rotator interval directly over the biceps tendon. The detached superior labrum and biceps anchor complex was identified, and peel-back of >5 mm was demonstrated (Fig. 12.2). Biceps tenodesis was completed using the "Loop-n-tack" method as described by Paci and Akhavan [31] (Fig. 12.3). This technique allows for all-arthroscopic tenodesis of the biceps tendon within the bicipital groove without over-tensioning to minimize the risk of postoperative groove pain and avoid "popeye" deformity. The remaining superior labrum was debrided (Fig. 12.4).

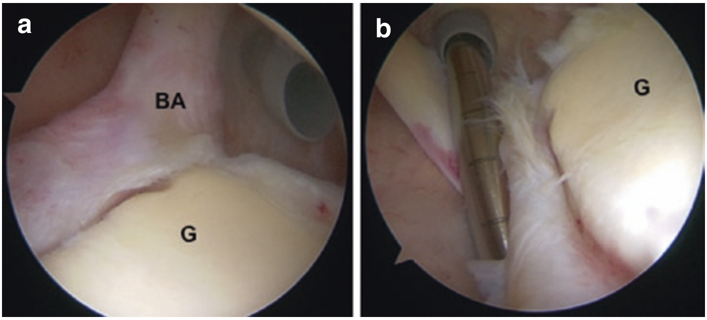

FIGURE 12.2 Arthroscopic image from posterior viewing portal in lateral decubitus position of right shoulder. (**a**) Fraying and detachment of superior labrum with synovitis surrounding biceps anchor. (**b**) >5 mm peel-back of superior labrum with fraying of superior labrum (*G* Glenoid, *BA* Biceps Anchor)

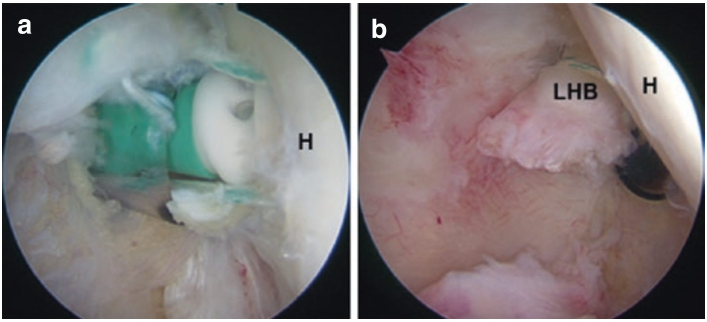

FIGURE 12.3 Arthroscopic image from posterior viewing portal in lateral decubitus position of right shoulder. (**a**) 4.75 mm SwiveLock (Arthrex, Naples, FL) anchor being placed to tack suture to humeral head (H) at top of bicipital groove. (**b**) Long head of biceps tendon (LHB) anchored to humeral head (H)

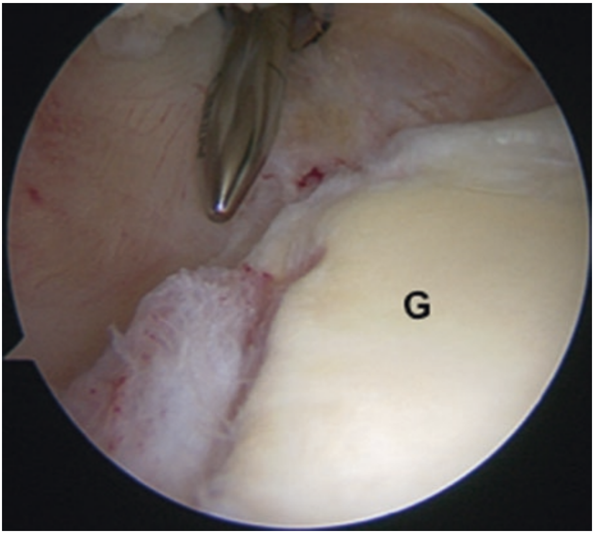

FIGURE 12.4 Arthroscopic image from posterior viewing portal in lateral decubitus position of right shoulder after debridement of superior labrum with the arthroscopic shaver

The arthroscope was then placed into the subacromial space and the degenerative edge of the torn rotator cuff debrided to healthy appearing tissue (Fig. 12.5). A double-row rotator cuff repair was completed (Fig. 12.6).

Postoperatively the patient was immobilized using a gravity sling for the first 4 weeks for comfort. Passive motion physical therapy was introduced at week 2 postoperatively and continued until week 6. After week 6, active and active-assisted exercises in all planes were started. Once full motion was attained without discomfort, light resistance band exercises can be started as early as week 8. Progressive resistance exercises with weights commence after week 12 and continue until goals are met. At most recent follow-up, this patient was 9 months postoperative. He reported marked improvement in his pain level and normal motion and strength. Biceps function was normal, with no evidence or cosmetic deformity and no complaint of cramps or muscle spasms.

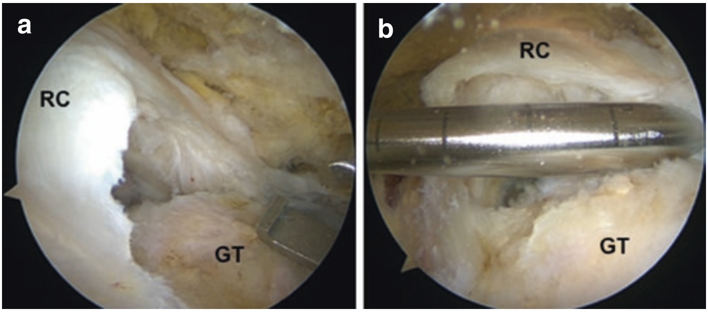

FIGURE 12.5 (**a**) Arthroscopic image from posterior viewing portal in subacromial space of rotator cuff (RC) tear after debridement of degenerative tendon edge. (**b**) Arthroscopic image from lateral viewing portal of rotator cuff tear measuring approximately 2.5 cm. *GT* greater tuberosity of the humerus

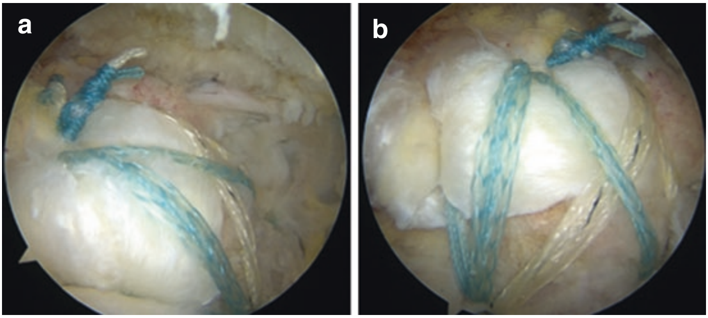

FIGURE 12.6 (**a**) Arthroscopic image from posterior viewing portal in subacromial space of double-row rotator cuff repair. (**b**) Arthroscopic image from lateral viewing portal of rotator cuff repair

Literature Review

While up to 80% of patients with rotator cuff or SLAP tears have combined lesions, there remains a relative paucity of data in the orthopedic literature on clinical outcomes in patients >40 years of age [9]. Only a single level 1 study was identified [10]. In a randomized controlled trial, Franceschi et al. [10] evaluated SLAP repair versus biceps tenotomy in 63 patients older than 50 years who underwent concomitant rotator cuff repair. At a minimum of 2.9 years' follow-up, while both groups demonstrated significant improvements, the biceps tenotomy cohort had significantly better UCLA scores (32.1 vs. 27.9, respectively; $P < .05$) and range of motion when compared to the SLAP repair cohort (forward flexion: 166° vs. 133°, external rotation: 134.3° vs. 121.4°, internal rotation: 40° vs. 34.3°, respectively; $P < .05$ for all). The authors concluded that there is no advantage to repairing a type 2 SLAP lesion when associated with a rotator cuff tear in patients over 50 years of age and recommend biceps tenotomy. However, 19 of 31 patients who underwent biceps tenotomy developed a "popeye" cosmetic deformity, though the effect of this deformity on shoulder strength or fatigability was not quantified.

Abbot et al. [9] prospectively evaluated 38 patients over the age of 45 years with type 2 SLAP lesions undergoing rotator cuff repair. All patients underwent arthroscopic rotator cuff repair with subacromial decompression and were randomized intraoperatively to repair versus debridement of the type 2 SLAP lesion with biceps tenotomy. At 2 years' follow-up, patients who underwent debridement and tenotomy of their type 2 SLAP lesion had significantly better overall UCLA score (34.0 vs. 31.0, respectively; $P < .001$), improved function and pain relief compared with those who underwent SLAP repair with concomitant rotator cuff repair.

In a similar study, Kim et al. [32] prospectively followed a group of 36 patients who underwent rotator cuff repair and either SLAP repair (mean age 61.1 ± 5.1 years) versus biceps tenotomy (mean age 63.3 ± 6.0 years) based on intraoperative assessment of biceps tendon quality. At 2 years' follow-up, both groups demonstrated significant improvements; however, the biceps tenotomy group had significantly higher postoperative outcome scores (UCLA: 29.6 vs. 26.0, respectively; $P = .007$ and ASES: 88.6 vs. 80.4, respectively; $P = .009$).

A recent systematic review of the surgical management of symptomatic SLAP tears in patients older than 40 years identified seven studies that addressed concomitant SLAP lesions with rotator cuff tears [4]. Complications after SLAP repair included postoperative stiffness, continued pain, and need for revision surgery with a trend toward higher complication rates with increasing age. These authors found the evidence for performing SLAP repair in the setting of rotator cuff repair to be mixed, though overall the literature favors debridement or biceps tenotomy over SLAP repair [4].

In conclusion, in a middle-aged patient population with concomitant rotator cuff tear and type 2 SLAP tear, we recommend biceps tenodesis or tenotomy over SLAP repair. The decision for tenodesis versus tenotomy is made depending on quality of biceps tendon tissue remaining, patient age and activity level, body habitus, and patient preference.

Clinical Pearls and Pitfalls

- In middle-aged patients presenting with shoulder injury, there is often mixed pathology that may be identified by thorough physical examination and high-quality MRI and confirmed at arthroscopy.
- The literature supports debridement and biceps tenotomy/tenodesis over SLAP repair in combination with rotator cuff repair.
- Avoid over-tensioning biceps tendon when performing tenodesis to minimize risk of postoperative groove pain.
- There is significant risk of motion loss/stiffness associated with concomitant SLAP repair and rotator cuff repair.

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Chapter 13
Type 2 SLAP Tear in 22 Year Old Male with Associated Buford Complex Treated with SLAP Repair with Care to Avoid Overconstraining Anteriorly

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_13,

Case Presentation

A 22-year-old right-hand dominant male patient presented with complaints of right shoulder pain for approximately 4-month duration. The patient was a recreational athlete who had played various sports throughout his life, including baseball, tennis, golf, and ice hockey. He did not have any significant past medical or surgical history and was not taking any regular medications. The pain was aggravated by overhead activities including tennis and throwing during baseball and ultimate frisbee. He had no history of instability and no previous shoulder problems in the past. His left, nondominant shoulder was asymptomatic.

The patient first noted his symptoms during a tennis match approximately 4 months previously, when he developed an aching sensation in his right shoulder that came on suddenly while serving. The patient had attended a few sessions of physiotherapy without any significant improvement. He had also completed a period of rest with a 2-week course of nonsteroidal anti-inflammatories under the advice of his primary care physician, but his symptoms returned with physical activity and resumption of tennis.

Physical examination began with inspection of the shoulder with comparison to the contralateral side after exposing the patient appropriately. The patient was neurovascularly intact bilaterally, without evidence of muscle wasting, scars, scapular winging, or skin changes around the shoulder girdle. All bony prominences around the shoulder, including the acromioclavicular (AC) joint, were palpated without any evidence of point tenderness. Range of motion was assessed with the patient lying supine on the examination table. Total arc motion was 10° less on the affected side with loss of internal rotation. Pain was experienced with replication of the overhead tennis serve with maximal external rotation and forward elevation. Rotator cuff testing was negative, with equal strength in all muscles bilaterally. No sign of instability was noted, with a negative sulcus sign and anterior apprehension test. Impingement tests were negative. Active compression test and Speed's biceps tension tests were positive.

Diagnosis/Assessment

History

As with all orthopedic problems, the work-up should begin with a detailed history and focused on pertinent positives and negatives. Since superior labral anterior to posterior (SLAP) lesions are often associated with other underlying pathologies, including labral tears and rotator cuff lesions, the diagnosis is often difficult to elucidate. It should be noted that a true SLAP lesion is a disease of the young adult. Although repairable SLAP lesions can occur in older patients, isolated repair of these lesions should be undertaken with caution as the symptomatology may be related to other pathology as the biceps anchor undergoes normal age-related degeneration. A thorough history should help direct the treating physician toward the correct diagnosis. A complete pain history should be obtained with a focus on associated symptoms as well as the history of the pain and symptomatology, which may be suggestive of a possible SLAP lesion. Patients may report either an acute traction or compression event leading to their symptoms, such as a fall on an abducted arm or a chronic deterioration of their shoulder over time that developed with repetitive activity. In addition, repetitive overhead sports activity including throwing may predispose to tears. Unless the lesion was caused by an acute traumatic shoulder dislocation or repetitive subluxations as part of recurrent shoulder instability, SLAP lesions are generally not associated with true instability symptoms. The patient will instead complain of vague shoulder pain that has progressed over time.

In competitive throwing athletes, SLAP lesions may cause "dead arm syndrome," in which the thrower is unable to throw with their pre-injury velocity and control because of a combination of pain and associated mechanical symptoms, such as clicking and popping [1]. Posterior SLAP tears in throwing athletes have distinct clinical and anatomic features that distinguish them from anterior type 2 SLAP lesions. As described by Burkhart et al., patients with posterior SLAP tears can develop posterosuperior instability that manifests itself by an anterior pseudolaxity [1, 2]. This chronic superior instability can lead to lesion-specific articular-sided partial thickness rotator cuff tears that may progress to full-thickness tears.

A SLAP lesion in association with a Buford complex can only be diagnosed with advanced imaging such as an MRI. Patients with SLAP lesions generally complain of vague shoulder pain that may be related to or exacerbated by overhead activity, such as throwing or serving with the arm extended overhead. The pain may be associated with mechanical symptoms such as clicking, locking, or catching if the unstable labral segment becomes trapped between the humeral head and glenoid surface. Although the presence of a Buford complex may predispose the patient to a superior labral lesion, there is no specific sign or symptom that is specific for a Buford complex. MR arthrogram may improve the specificity and sensitivity of diagnosis, and abduction/external rotation view (ABER) should be considered in the throwing athlete.

Physical Exam

The utility of physical examination tests for the accurate diagnosis of SLAP lesions is limited [3, 4]. However, a thorough physical examination is essential for focusing the differential diagnosis in a patient presenting with shoulder pain and should always be part of the routine work-up. As with the patient's history, physical examination for SLAP lesions is often nonspecific secondary to associated pathology, and there is no physical examination finding specific or indicative of a Buford complex associated with a SLAP lesion. Furthermore, studies have shown that no single or combination of tests could conclusively or reliably predict the exact lesion found at arthroscopy [5–7].

The combination of absent anterosuperior labral tissue and an abnormal MGHL may result in increased external rotation of the affected arm compared to the unaffected side. However, the arc of motion must be examined as a whole, as an overhead athlete may be lacking internal rotation of the affected shoulder due to posterosuperior glenoid impingement (internal impingement) [8].

Two described tests for detecting biceps pathology include Speed's biceps tension test and Yergason's test [9–11]. Speed's test is performed by resisting shoulder flexion with the shoulder forward flexed to 90°, the elbow extended, and the forearm fully supinated. Pain in the bicipital groove area or the glenohumeral joint with resisted flexion in this position may suggest irritation of either the biceps anchor or within the tendon. Yergason's test is performed with the elbow flexed to 90° and stabilized against the thorax with the forearm pronated. The patient is asked to resist a supination force to the forearm, which is applied by the examiner. A positive test may also suggest pathology around the proximal biceps anchor. However, studies have shown these tests to be of limited utility for the diagnosis of SLAP lesions [7, 12].

O'Brien's active compression test was originally reported as a highly sensitive test for a SLAP lesion. With the patient standing, the arm is forward flexed to 90° and held in an adducted position approximately 10–15° across the patient's chest. The arm is internally rotated so that the patient's thumb is directed toward the floor. The examiner applies a uniform downward force on the arm while the patient is instructed to resist this force. With the arm in the same position, the palm is then fully supinated and the maneuver is repeated. The test is considered positive if pain is experienced during the first maneuver but is reduced or eliminated with the second. Pain localized to the acromioclavicular joint was diagnostic of an acromioclavicular joint abnormality, whereas pain or painful clicking described as "inside" the shoulder was considered indicative of a labral abnormality [13]. It had been suggested that the positive position of the test (shoulder flexion, horizontal adduction, and internal rotation) tensioned the bicipital labral complex relative to the negative position (shoulder flexion, horizontal adduction, and external rotation). However, this theory has been questioned in a recent study [14].

Imaging

As with most shoulder problems, imaging should begin with conventional radiographs, including AP internal and external, axillary, and outlet views. Although radiographs are useful in ruling out other etiologies, including glenohumeral osteoarthritis, acromioclavicular osteoarthritis, and shoulder instability, they are not helpful in diagnosing a SLAP lesion or Buford complex.

Magnetic resonance imaging arthrogram (MRA) is the imaging modality of choice for the diagnosis of labral pathology. The use of MRI for the diagnosis of labral variants, the sublabral foramen and Buford complex, has also been well described [15, 16]. A study by Bents and Skeete [17] showed that MRA had a sensitivity of 93% for non-Buford complex and 100% sensitivity for SLAP lesions in patients with Buford complexes.

Typical features of a SLAP tear on MRI include abnormal increased signal on T2-weighted and/or T1-weighted imaging extending into the superior labrum, blunting of the labral free margin, and/or detached labral tissue. Occasionally, there may be involvement of the biceps anchor.

It is important to distinguish on MRI between a labral tear and normal labral variants that can occur in this location, including sublabral recess, sublabral foramen, and a Buford complex (Fig. 13.1). Imaging characteristics typical of labral tears include a lateral orientation of the abnormal high signal intensity, irregular margins, depth of separation from the glenoid articular surface greater than 2 mm, extension of the abnormal signal posterior to the biceps tendon, and abnormal morphology or signal of the labrum. In contrast, normal variants demonstrate medially oriented high signal intensity on oblique coronal images, smooth margins, minimal separation, and normal dark labral signal [18].

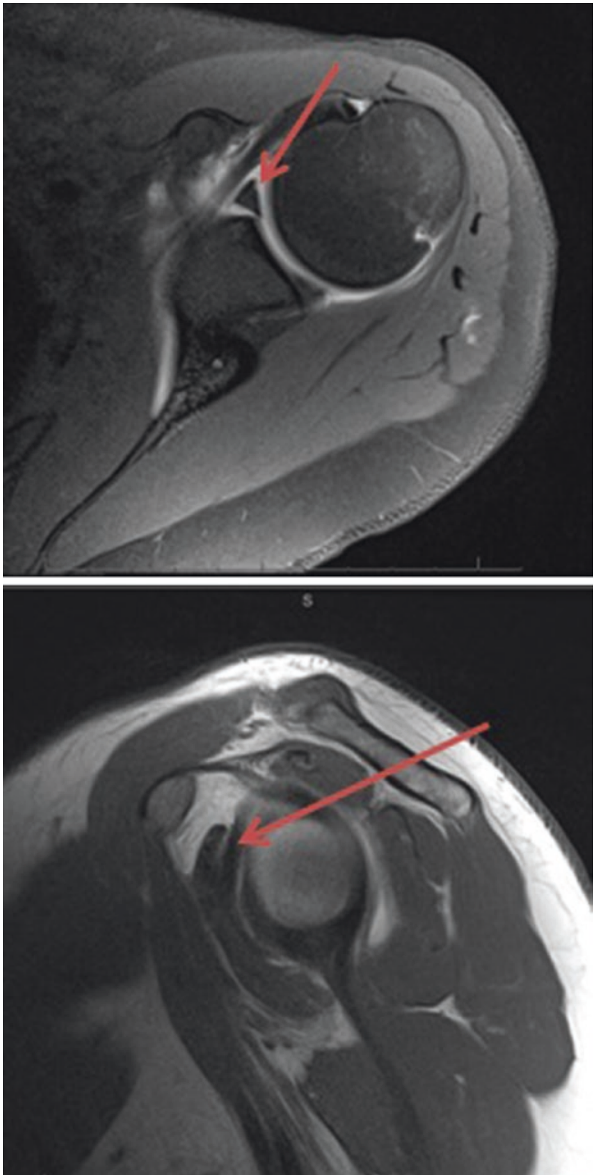

Figure 13.1 Image of a thickened middle glenohumeral ligament on axial and sagittal MRI (*arrows* point to the Buford complex)

Management

Management includes initial nonoperative management focusing on correcting scapula kinematics as well as addressing a possible limitation in shoulder internal range of motion that is outside the total arc range of motion [19, 20]. Posterior capsular stretching, if started early, can prevent strain on the biceps anchor secondary to abnormal glenohumeral mechanics caused by posteroinferior capsular contracture. Patients with continued symptoms for 4–6 months despite appropriate physical therapy are candidates for surgical intervention. Repair is generally considered in this age population with biceps tenodesis reserved for older patients or failed SLAP repairs. Repair generally consists of one to two anchors posterior to the biceps anchor and one anterior to the biceps anchor if anterior detachment is present. Care is taken to avoid overconstraining anterior at the level of the Buford complex taking care to not repair the cordlike middle glenohumeral ligament as well as avoiding getting into the biceps tendon which can constrain normal bicipital excursion with shoulder motion. Often, if no major instability of the biceps anchor is present anteriorly after the posterior aspect is repaired, it can be left alone. Knotless repair has been reported to be successful with the advantage of avoidance of knots as these can abrade the glenohumeral chondral surface with normal shoulder external rotation and abduction seen with overhead positioning of the arm [21, 22].

Outcome

Patient underwent SLAP repair with two posteriorly based knotted suture anchors and one anterior anchor. He started a throwing program at 4 months and was back to overhead sports at 6 months with no complaints.

Literature Review

A potential association between the Buford complex and superior labral pathology has been reported. A study by Ilahi et al. [23] reported a higher prevalence of labral variants than initially reported by Williams et al. [24]. A Buford complex or sublabral foramen was found in 27 (25%) of 108 shoulders. Furthermore, the study suggested that a variant of the anterosuperior labrum may predispose patients to developing a significant SLAP lesion. A SLAP lesion was found in 15 (56%) of the 27 shoulders with either a sublabral foramen or a Buford complex, compared with only ten (12%) of the 81 remaining shoulders ($P < 0.005$). The authors proposed that in the context of an anterosuperior glenoid rim devoid of labral tissue, more stress can be transferred to the superior labral-biceps complex. This additional stress may increase the chance of the superior labral biceps complex suffering an injury either from an acute traumatic event or from repetitive overuse.

Bents and Skeete [17] also demonstrated at statistically significant correlation of Buford complexes and SLAP lesions. Of 235 shoulder cases, six (2.5%) patients were noted to have a Buford complex. Of these six patients, five (83.3%) had a corresponding SLAP lesion. Of the remaining 229 patients, 40 (17.5%) patients had a SLAP lesion, giving a statistically significant difference between the two groups ($P < 0.003$). The authors proposed that in patients with absent anterosuperior labral tissue, forces would be more concentrated to the biceps origin and superior labrum. This would therefore predispose patients with a Buford complex to the development of the superior labral lesion.

In a study of 546 patients, Rao et al. [25] illustrated the influence of anterosuperior labral variants on glenohumeral biomechanics that may predispose the shoulder to other abnormalities. Three distinct variations of the anterosuperior labrum were found in 73 patients (13.4%): a sublabral foramen only (18 patients, 3.3%), a sublabral foramen with a cordlike middle glenohumeral ligament (47 patients, 8.6%), and an absence of labral tissue at the anterosuperior portion of the labrum with a cordlike middle glenohumeral ligament (eight patients, 1.5%). In multivariate analysis, the presence of one of these three variations revealed a significant positive association with anterosuperior labral fraying ($P = 0.00$), an abnormal superior glenohumeral ligament ($P = 0.01$), and increased passive internal rotation with the arm in 90° of abduction ($P = 0.046$). The increase in internal rotation was hypothesized to alter joint biomechanics leading to increased pressures on the anterosuperior labrum.

The original article describing the Buford complex by Williams et al. [24] also described the case of a 28-year-old woman who had previously undergone arthroscopic repair of a Buford complex, where the cordlike MGHL had been mistaken for an anterior labral tear and attached to the anterior glenoid rim with two absorbable tacks. The patient presented with severely restricted motion requiring further surgical intervention for manipulation under anesthesia and lysis of adhesions to restore range of motion. Since this original publication, it has been accepted that individuals with a Buford complex who sustain a SLAP lesion should have a standard SLAP repair without altering the native anatomy of the Buford complex in order to preserve range of motion. Given the increasing evidence suggesting a predisposition toward developing a superior labral lesion in the presence of a Buford complex, the dilemma facing the treating surgeon is that a patient with a Buford complex who receives a standard SLAP repair is left with the same shoulder anatomy that predisposed them to superior labral injury in the first place.

Crockett et al. [26] have described a novel surgical technique for the repair of a SLAP lesion associated with a Buford complex. In addition to the standard SLAP repair, their technique involves complete transection of the MGHL. The proximal segment of the MGHL is secured to the anterosuperior glenoid rim to replace the absent native labral tissue defining the Buford complex. The distal segment of the MGHL is left free. The authors propose three advantages of their surgical technique. Firstly, by transecting the

MGHL, the superior labrum is freed from the concentrated forces of the cordlike MGHL pulling on the biceps anchor and labral tissue. Secondly, by repairing the proximal segment of the transected MGHL to the glenoid rim, you enhance fixation of both the anterior biceps insertion and the repair SLAP lesion. Thirdly, the transecting and releasing the MGHL, external rotation should not be impaired postoperatively due to an overconstrained MGHL.

One consideration for the treating surgeon is the option of a primary biceps tenodesis in a young athlete with a type 2 SLAP tear and an associated anatomic variant, which may in fact increase the possibility of recurrence following repair. There is conflicting literature on the return to pre-injury level of play in overhead athletes following SLAP repair, with multiple studies showing that arthroscopic SLAP repair does not provide consistent return to overhead sports [22, 27–30]. In addition, Boileau et al. concluded that arthroscopic biceps tenodesis can be considered an effective alternative to the repair of a type II SLAP lesion, allowing patients to return to a presurgical level of activity and sports participation [8].

One might also consider a biceps tenodesis following a failed repair as a salvage procedure, which has shown improved results [31–33].

Clinical Pearls and Pitfalls

- Recognize and understand normal anterosuperior labral variants including the Buford complex to avoid repairing normal anatomy.
- Superior labral pathology is potentially part of the degenerative process, and repair is generally not indicated in patients above 50 years old.
- Care must to be taken to avoid overconstraining the biceps anchor during repair.
- Concomitant pathology associated with SLAP lesions including superior anterior and posterior labral pathology and rotator cuff tearing is common.

- The posterosuperior aspect of the SLAP tear is the most critical portion to fix as anterior reattachment can lead to an overconstrained biceps anchor particularly in the overhead athlete.

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Chapter 14
Failed Arthroscopic SLAP Repair in 35-Year-Old Male Police Officer

Allison J. Rao, Eamon D. Bernardoni, and Nikhil N. Verma

Case Presentation

The patient is a 35-year-old male police officer who presented for evaluation of his left shoulder. He had sustained a prior injury to his left shoulder that required a prior arthroscopy with superior labral repair, completed 1 year prior to presentation. The patient was able to return to work full duty after his initial surgery. He sustained another injury, when he suffered a twisting and traction injury to the left shoulder and felt a “pop.” In the 2 weeks from injury to presentation, he experienced recurrent anterior shoulder pain, primarily over the biceps region anteriorly, radiating into the biceps muscle belly and deep within the shoulder itself. He tried rest, ice, and anti-inflammatories prior to evaluation.

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_14,

On examination, he had no signs of muscle atrophy or deformity. He had well-healed incisions over the shoulder. Full cervical range of motion through flexion, extension, lateral bend, and rotation was present with no axial neck pain. He endorsed no pain over the acromioclavicular (AC) joint, but did have moderate pain to palpation of the long head of the biceps tendon. Shoulder range of motion was 150° of forward flexion and 60° of external rotation. He did have pain with resisted elevation with strength graded as a five out of five with both abduction and rotation. There was a positive O'Brien maneuver present, as well as a positive load and crank maneuver. He had a negative anterior apprehension test, negative posterior jerk test, negative Speed sign, and mildly positive Yergason maneuver.

Radiographs of the shoulder were obtained including anteroposterior (AP), scapular Y view, axillary, and outlet views. These revealed that the glenohumeral joint was well maintained and there was postsurgical change noted secondary to anchor position. The AC joint was well maintained, with a type I acromion.

Given the patient's history, acute onset of pain with associated "pop" and subsequent pain with mechanical clicking and catching, the initial concern arose for a recurrent SLAP tear (Fig. 14.1). The decision was made to obtain a magnetic resonance (MR) arthrogram, and the patient was kept off work in the interim. The MR arthrogram demonstrated intrasubstance biceps signal. It was also noted that there was undersurface signal of the labrum with a possible small recurrent tear as well as capsular effusion (Fig. 14.2a, b).

At this point, options were discussed with the patient. These included conservative treatment including a cortisone injection versus surgical treatment. Given the degree of his functional deficit and physical demands of his job, the patient elected to pursue surgical treatment.

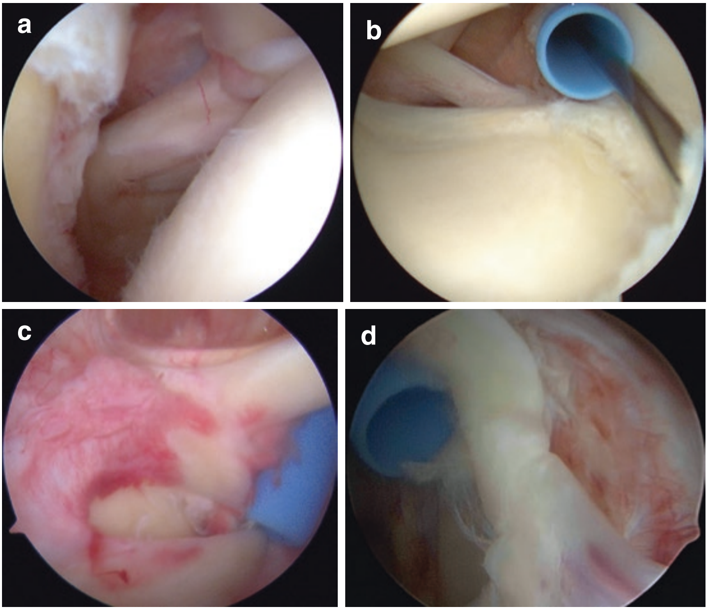

FIGURE 14.1 (**a**) Type I tear shows an intact biceps anchor and fraying of the superior labrum, (**b**) type II tear shows a detached biceps anchor and superior labrum, (**c**) type III tears show the biceps is intact and there is a bucket handle tear of the superior labrum, and (**d**) type IV tears show the bucket handle tear of the superior labrum partially extends into the biceps tendon

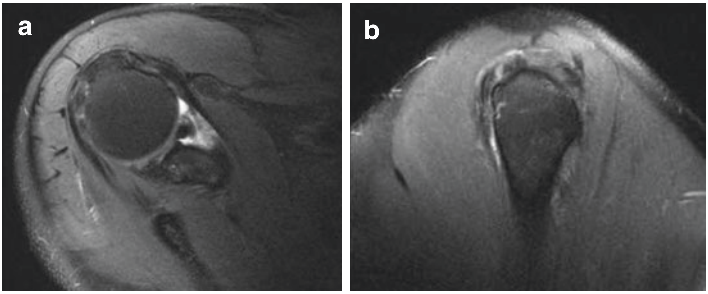

FIGURE 14.2 (**a** and **b**) The MRI shows undersurface signal of the labrum with a possible small recurrent tear as well as capsular effusion

Diagnosis/Assessment

As with all new patient encounters, a thorough history and physical examination should be performed. History should include hand dominance; job and job-related physical demands; professional or recreational level of activity; history of overhead activity; location of pain; duration of pain; mechanical symptoms including popping, catching, and clicking; and prior treatments. Physical examination should start with an inspection of both shoulders undressed, looking for signs of atrophy, deformity, or asymmetric appearance. As stiffness may be one of the most common causes of failure, special attention should be made to passive and active range of motion, comparing both the affected and unaffected sides, with specific emphasis of external rotation at the side [1, 2].

Specific exam maneuvers should be performed as part of the shoulder examination to aid in the diagnosis of a SLAP tear. The O'Brien's test should be performed with the patient's shoulder held at 90° of flexion, 10° of horizontal adduction, and maximum internal rotation with the elbow in full extension. A downward force is applied on the wrist, with the patient told to actively resist and report any pain at the top of the shoulder (indicating pain at the AC joint) or inside the shoulder (indicating SLAP pathology). Pain should be relieved with the shoulder taken from internal rotation to external rotation (Fig. 14.3) [3].

Additional examination maneuvers include the O'Driscoll maneuver, the biceps load II test, Speed's maneuver, and the labral tension test [4, 5]. In the O'Driscoll test, or the dynamic labral shear test, the patient is positioned supine or sitting with the arm at the side and the elbow flexed to 90°. Keeping the elbow flexed, the shoulder is abducted to 90° and then further from 90° to 120°. A positive test is indicated with deep or posterior shoulder pain with ranging from 90° to 120° of abduction. In the biceps load II test, the patient is positioned supine with the shoulder in 120° of abduction, the elbow flexed to 90°, and with the forearm in supination. The shoulder is then moved to terminal external rotation, and the

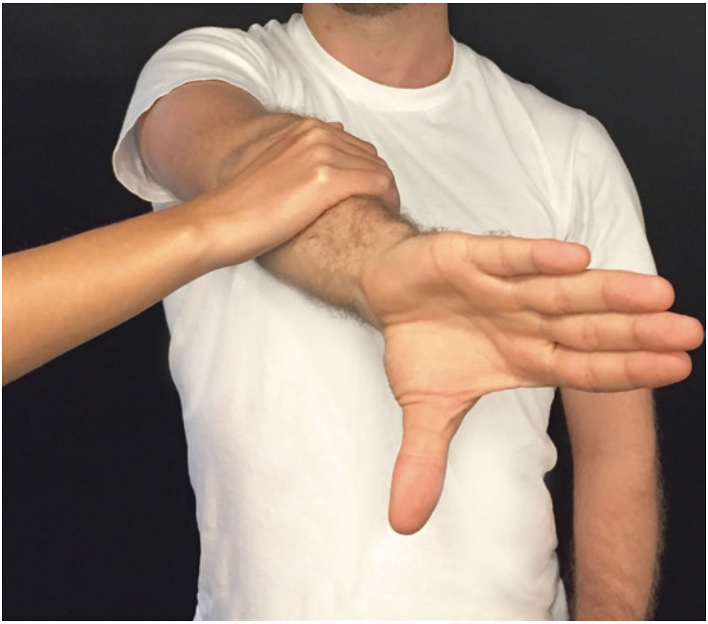

FIGURE 14.3 The O'Brien's test: While a downward force is applied on the wrist, pain should be relieved with the shoulder taken from internal rotation to external rotation with the shoulder held at 90 of flexion, 10 of horizontal adduction, and with the elbow in full extension

patient is instructed to flex the elbow against resistance. A positive exam maneuver is indicated by pain with resisted elbow flexion. In the Speed's test, the patient's elbow is fully extended and the forearm rotated into to full supination. The patient is told to elevate the shoulder from 0° to 60° of forward flexion against resistance. A positive test is indicated by pain in the shoulder localized to the bicipital groove (Fig. 14.4). Finally, in the labral tension maneuver, the patient is positioned supine, with the arm placed in 120 of abduction, with the forearm in neutral. The shoulder is then rotated to terminal external rotation. At terminal external rotation, the patient is asked to rotate the forearm in supination against

FIGURE 14.4 The Speed's test: The patient is told elevate the shoulder from 0 to 60 of forward flexion against resistance while the patient's elbow is fully extended and the forearm rotated into to full supination. A positive test is indicated by pain in the shoulder localized to the bicipital groove

resistance. A positive test is indicated by pain with resisted supination. Lastly, direct palpation of the biceps in the groove to assess for tenderness should be carried out.

Finally, imaging studies should be obtained and reviewed as indicated. Plain radiographs should be obtained, carefully inspecting for any signs of early arthritis formation. MR imaging (MRI) has been reported to aid in diagnosis. MR arthrogram may further improve the sensitivity and specificity of detection of a SLAP tear [3]. Additional consideration should be made to other etiologies, which may lead to persistent pain including infection, referred pain, or other anatomic sources of pain.

Failure can be categorized into failure to treat concomitant pathology, development of new pathology, technique-related failure, biologic failure (including failure to heal and development of postoperative stiffness), and implant-related failure [1, 3, 5–13]. Consideration of the mechanism of failure, including patient-specific factors, may aid in diagnosis and development of a treatment strategy [11–14]. Diagnosis should be made using the history, physical exam, laboratory, and imaging studies taken together; however, even combined, diagnosis may be difficult and the cause of failure hard to define.

Management

Nonsurgical management of recurrent or persistent pain after SLAP repair is the first line of treatment and should target the physical examination findings that reproduce pain. Early measures include analgesia, physical therapy, with consideration of cortisone injection (either subacromial or glenohumeral depending on the suspected pathology). Lastly, ultrasound guided biceps groove injection may be considered for both diagnostic and therapeutic purposes.

Surgical management of failed SLAP repair should be considered if nonoperative management does not improve pain. Surgical options vary widely, from SLAP debridement, revision SLAP repair, biceps tenotomy, or biceps tenodesis [3, 4, 15–18]. With no clinical evidence to support a specific procedure, selection of surgical plan should be made based on history and physical, imaging findings, diagnostic arthroscopy, pathology encountered, patient factors, and surgeon preference. Prior to surgical treatment, all previous medical records, imaging studies, or intraoperative photographs should be obtained. Additionally, identifying the number and type of previous implants can help to ensure that proper equipment for removal is available at the time of surgery.

Patients should be positioned according to surgeon preference, in either a beach-chair or lateral position. A preoperative examination under anesthesia should be performed to assess passive range of motion or instability. A diagnostic arthroscopy utilizing standard and anterior portals should first be performed to assess pathology. Careful examination should be performed of the labrum, biceps anchor, and biceps tendon; additionally, attention should be paid to carefully assess for new or overlooked pathology that could be the source of pain. This includes inspection of the entire labrum, rotator cuff, and subacromial space. Missed AC joint pathology can be confused with SLAP-related pain. Previous sutures or anchors should be removed if possible without causing further damage to tissue.

In our case, the patient was taken to the operating room and placed in a modified beach chair position. Examination under anesthesia showed that the patient had full range of motion with normal anterior, posterior, and inferior stability. Standard posterior and anterior portals were established. Diagnostic arthroscopy revealed that there were sutures within the labral anchor complex that appeared to have pulled out from the SLAP with a large inflammatory debris surrounding (Fig. 14.5a). The biceps tendon itself showed tenosynovitis, with biceps incompetence of the labral anchor. Therefore, the biceps was released (Fig. 14.5b). A cord-like middle glenohumeral ligament (MGHL) was noted with scarring surrounding it (Fig. 14.5c). The MGHL was left intact; however, the rotator interval anterior to this was debrided to take down scar tissue (Fig. 14.5d). As stiffness is one of the main causes of failure of SLAP repair, scar tissues was managed with arthroscopic release. The remaining sutures within the anterior labrum and superior labrum were removed. The labrum was further debrided. The undersurface of the rotator cuff was intact. The articular cartilage surrounding the most anterior anchor showed chondromalacia and limited chondroplasty was carried out. The arthroscope was then placed through the anterior portal, and the remaining posterior labrum, articular cartilage, and subscapularis were noted to be intact.

The arthroscope was then introduced into the subacromial space and a lateral portal was established. At this point, a thorough bursectomy was preformed, the coracoacromial ligament was released, and a revision acromioplasty was completed, creating a flat type I acromial surface (Fig. 14.5e).

A subpectoral incision was made in the interval between the pectoralis major and short head of the biceps. This interval was further developed and the long head of the biceps was removed from the wound (Fig. 14.6a). An 8 mm tunnel was drilled at the based of the bicipital groove using a cannulated reamer. The tunnel was prepared with a tap

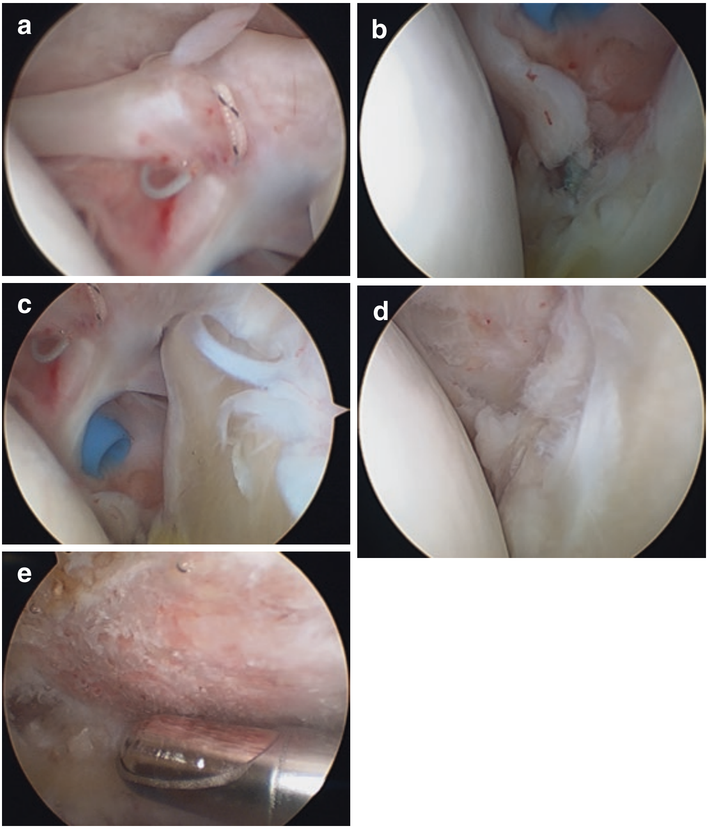

FIGURE 14.5 (**a**) Sutures within the labral anchor complex pulled out from the SLAP with a large inflammatory debris surrounding. (**b**) The biceps tendon showed tenosynovitis, with biceps incompetence of the labral anchor. (**c**) A cord-like middle glenohumeral ligament (MGHL) was noted with scarring surrounding it. (**d**) The rotator interval anterior to this was debrided of scar tissue. (**e**) A revision acromioplasty was completed, creating a flat type I acromial surface

(Fig. 14.6b), and the biceps was docked in to the base of the tunnel (Fig. 14.6c) and secured with a polyetheretherketone (PEEK) interference screw (Smith & Nephew, Inc., Andover, MA) (Fig. 14.6d).

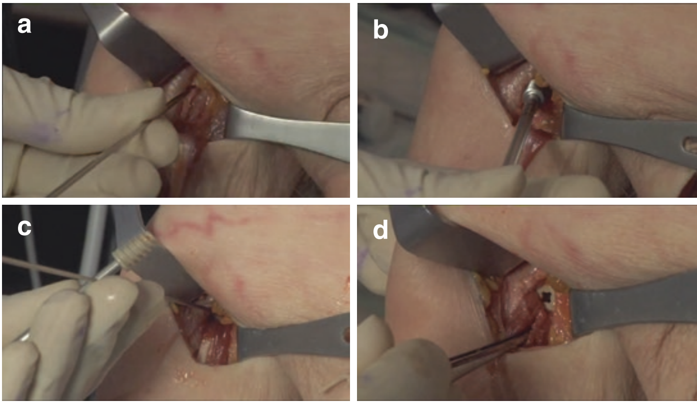

Figure 14.6 (**a**) Subpectoral incision with the long head of the biceps removed from the wound. (**b**) An 8 mm tunnel with a tap is created. (**c**) The biceps is docked in to the base of the tunnel (**d**) and secured with a PEEK interference screw

Postoperatively the patient was placed in to an UltraSling® (Donjoy Orthopedics, Carlsbad, CA) type brace for a total of 4 weeks, with active elbow, wrist, and hand range of motion with early range of motion about the shoulder. No resisted biceps function was allowed. Two weeks postoperatively, the patient was doing well and physical therapy was initiated. Six weeks postoperatively, he complained of persistent pain in the shoulder with difficulty with range of motion including behind the back rotation or overhead elevation. He had 140° of forward flexion, 50° of external rotation, and internal rotation to the level of L5 behind the back. He was prescribed a Medrol Dosepak, with continued physical therapy as well as a home exercise-stretching program. At 18 weeks postoperatively, he noted improvement in his anterior shoulder pain, with some persistent minor difficulty with terminal internal rotation and abduction. On physical exam, he had full range of motion, with some difficulty achieving terminal abduction. He had strength graded as four out of five with abduction and external rotation. He was prescribed an additional 4 weeks of physical therapy and another Medrol

Dosepak, after which he cleared a work-conditioning program and was allowed to return to work full duty.

Postoperatively, after a biceps tenodesis, patients are allowed to begin passive to active shoulder range of motion as tolerated immediately, with the only limitation of no rotation with the arm in abduction for the first 4 weeks. From 4 to 8 weeks, isometric exercises are initiated, with deltoid muscle isometric exercises and external rotation and internal rotation isometric exercises at neutral. From 8 to 12 weeks, patients can begin eccentrically resisted motion and closed chain activities.

Outcome

Although a majority of patients have satisfactory outcomes from primary SLAP repair, persistent or recurrent pain can occur and present a challenge in both diagnosis and management [9, 19]. Provencher et al. evaluated outcomes after arthroscopic repair of type II SLAP repairs and found a 37% of patients had failure of treatment, with a 28% revision rate [6]. Similarly, Boileau et al. reported on their outcomes of SLAP repair for type II lesions and found a 60% incidence of persistent pain, with 50% requiring revision surgery [7]. By further subgroup analysis, they found that in patients who had undergone a biceps tenodesis, 93% of patients were satisfied with their result, with 87% returning to their previous level of sports participation. In contrast, with SLAP repair alone, 40% of that underwent subsequent biceps tenodesis, ultimately resulting in a successful outcome and full return to sports [7].

With the increasing prevalence of SLAP repairs and subsequent failures leading to persistent pain, increasing evaluation has been done looking into treatment options for failed SLAP repair [20]. Katz et al. described that 71% of patients treated nonoperatively for recurrent pain after SLAP tears were unsatisfied with nonoperative treatment [1]. Focusing on surgical management, treatment options have focused on revision SLAP repair verse biceps tenodesis or tenotomy.

McCormick et al. prospectively utilized open subpectoral biceps tenodesis for failed type II SLAP tears. They defined failure after primary SLAP repair as patients who were unable to return to active duty within 6 months from surgery, patients with an American Shoulder and Elbow Score (ASES) score less than 75 at 1 year follow-up or patients who elected to undergo revision surgery because of dissatisfaction with primary results. At an average of 3.6 years postoperatively, they noted statistically significant improvement in shoulder outcome scores [21]. Similarly, Werner et al. reported on a case series of 17 patients who underwent a biceps tenodesis for failed SLAP repair. They found that at a mean 2-year follow-up, patients reported significantly improved satisfaction, range of motion, and shoulder scores after biceps tenodesis, with 81% returned to active duty [15]. Additionally, they noted return of range of motion after biceps tenodesis, with abduction, forward flexion, and external rotation returning to at least 90% of the contralateral side.

Gupta et al. reported on a smaller, similar series of nine patients who underwent open subpectoral biceps tenodesis for a failed type II SLAP repair. In this series, the authors defined failure as persistent pain at least 1 year after index SLAP repair. Intraoperatively, they noted partial (three patients) or complete (six patients) of the labrum; all patients underwent a labral debridement at the time of biceps tenodesis. They reported at 2-year follow-up improvement in shoulder scores postoperatively, with no failures or additional surgery [15].

Clinical Pearls and Pitfalls [3]

- Failed SLAP repair is characterized by continued pain or stiffness that does not resolve without surgical intervention.
- MRI with contrast arthrography is the imaging modality of choice for SLAP failure workup.

- Steroid and lidocaine intra-articular and subacromial injections can aid in localizing pain and aid in the diagnostic workup.
- The patient should be evaluated for signs of joint infection as a not to miss diagnosis.
- Nonsurgical management of SLAP repair failure includes pain control, cortisone injections, and physical therapy, all of which should be prioritized over surgical re-intervention especially in overhead athletes [22, 23].
- Surgical management of a failed SLAP repair includes debridement or revision of SLAP repair including a biceps tenotomy or biceps tenodesis. Alternatively, the biceps can be tenodesed without SLAP revision.

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Chapter 15
Management of Type III SLAP Lesion

James Kercher and Nick Rossi

Case Presentation

An 18-year-old male football quarterback that presents to the clinic with acute right shoulder pain starting 3 days ago after being tackled from behind in the last game of his season. He reported falling directly onto his right shoulder which resulted in immediate pain. He described pain localized to the anterior aspect of his right shoulder with a "popping" sensation during overhead motions. He also reported that his arm felt "heavy," but denied any numbness or tingling down his arm. He denied any history of prior shoulder symptoms of instability episodes.

On physical examination, palpation yielded pain over the anterior joint line and biceps tendon. Special testing revealed a positive O'Brien's test and anterior apprehension test. Active and passive range of motion was full and symmetric; however, abduction and external rotation produced pain. Manual muscle testing of the rotator cuff was full with pain

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_15,

FIGURE 15.1 Coronal MR image demonstrating the appearance of a type III SLAP lesion

in all planes as compared to the contralateral shoulder. He was found to be neurovascularly intact distally.

AP, axillary, and scapular Y x-rays of the right shoulder were taken demonstrating no fracture or bony abnormalities with a concentric glenohumeral joint. Given his exam and acuity, an MRI arthrogram was ordered to evaluate for superior labrum anterior to posterior (SLAP) tear.

MRI arthrogram on this athlete confirmed the diagnosis of SLAP tear and helped direct his treatment plan. The MRI demonstrated gadolinium dye "leaking" between a significant gap in the superior aspect of the labrum and glenoid (Fig. 15.1). After discussion of options, arthroscopy was determined to be his best treatment option to eventually return him to sports over conservative management. Diagnostic arthroscopy confirmed the SLAP tear but further delineated the tear to be type III with the integrity of the biceps tendon and its attachment preserved (Fig. 15.2).

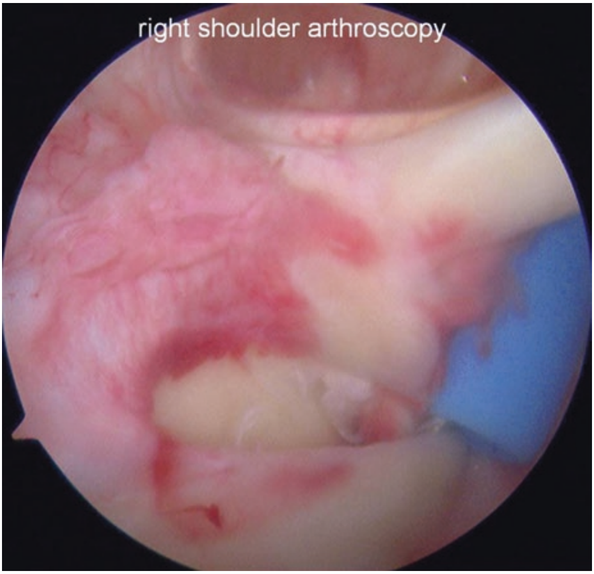

FIGURE 15.2 Type III SLAP lesion viewed from posterior portal. Probe through anterior cannula

Diagnosis/Assessment

A comprehensive history including mechanism of injury and sports participation should always be noted which evaluating for a SALP lesion. Although overuse is a common factor, patients with type III tears frequently describe a traumatic event such as a fall, abrupt traction, or a blow to the shoulder. The diagnosis of SLAP lesions is difficult because symptoms are commonly vague and concomitant pathology is often present confusing the picture. Patients with type III tears may more commonly report mechanical symptoms. Kim et al. examined the clinical features of the differing types of SLAP lesions. It was found that type I SLAP lesions were more often associated with rotator cuff pathology, while type III and IV lesions were more associated with traumatic instability [1]. Patients will typically describe deep activity-related anterior shoulder pain which occurs with a variety of overhead activities. In addition, strength training is often limited secondary to pain. Very commonly athletes will report an inability to perform a simple maneuver such as a pushup. Mechanical symptoms such as painful catching and locking are also frequently reported [2, 3]. Overhead athletes will report a loss of velocity with unsteadiness of the shoulder [4].

As with all SLAP lesions, physical examination should include a complete evaluation of bilateral passive and active range of motion noting any painful arc of motion. A wide variety of special tests have been described to help with the diagnosis of superior labral injuries. These tests include bicep tension maneuvers such as speeds and active compression test, as well as a variety of labral loading maneuvers such as the bicep load, crank and jerk test, and SLAP apprehension test. Berg et al. described the SLAP-prehension test and has reported good clinical utility in the evaluation of labral lesion when unstable [2]. However, the results often are confused with those of rotator cuff pathology and acromioclavicular arthrosis. Many studies have determined that the combination of multiple examination techniques should be used in conjunction with diagnostic studies to accurately diagnosis SALP injuries [3, 5–9].

The reliability of MRI for the diagnosis of SLAP lesions is disputed, and definitive diagnosis frequently requires arthroscopy. Several authors have shown that the addition of MR-enhanced arthrography will increase the ability to detect SLAP injuries [10–12]. A retrospective study by Bencardino et al. publicized that MR arthrography has a sensitivity of 89%, a specificity of 91%, and an accuracy of 90% (47 of 52 patients) in detecting SLAP lesions [13]; however, others have found that MR still has its limitations. A recent study by Kurji et al. noted the major drawback was secondary to interpretation. In this study, MR arthrograms were provided to multiple reviewers, and only 43% of the studies were constantly interpreted [14]. Sheridan et al. recently reported a similar weaknesses noting MR arthrography to have an accuracy of 69% with a sensitivity of 80% in diagnosis of SLAP tears [15]. Specific studies to evaluate the diagnostic accuracy for type III lesions have not been performed.

Management

Type III SLAP lesions are described as a bucket handle tear of the superior labrum with an intact biceps anchor. Management of these lesions must take into consideration timing, sports participation, and for younger athletes the expectations of the family. The decision in our scenario was easier as it was the last game of the season. In many circumstances, the question "can he/she play" is often asked of competitive athletes. As with all labral injuries, an attempt to return to sport is reasonable if you have the ability to monitor the patient closely if one is in season. Certain sports and positions may require earlier intervention. An example would be that of a football lineman who can play for the most part with his arms tucked in tight versus a skill position or throwing athlete who requires more overhead use of the arms.

Physical therapy is the mainstay of nonoperative management [16]. Selective intra-articular injections with local anesthetic and corticosteroids can be diagnostic and occasionally therapeutic. The rehabilitation program should focus on achieving and maintaining full range of motion while strengthening the rotator cuff and scapular stabilizing muscles. Although these measures are useful, most patients with SLAP tears will continue to have symptoms and go on to require surgical intervention. This particularly true for the type III lesion secondary to the mechanical irritation produced by the labral fragment.

The primary goal of any surgical intervention for a SLAP lesion is to stabilize the biceps anchor and address coexistent pathology. Setup and positioning is the same as describe previously. As with all labral pathology, the most important steps are the exam under anesthesia to detect any evidence shoulder instability and a thorough arthroscopic evaluation to evaluate the stability of the biceps complex. Positioning for a type III lesion can be performed readily in the beach chair, although lateral decubitus should be used if one suspects the tear extends to the posterior labrum to facilitate repair if needed. In this case, the exam under anesthesia demonstrated full passive range of motion and no glenohumeral instability.

Standard portal positions are utilized. After establishing the posterior portal, the anterior portal is then established through the rotator cuff interval with the help of a spinal needle for localization. A small cannula is useful here to assist with atraumatic reinsertion of devices. Be cognizant that the entire extent of the labrum requires evaluation. This is done with the assistance of switching sticks to alternate between viewing and working portals to examine the entire labrum. The labrum should be carefully probed for concealed pathology. The probe is then used to test the integrity and stability of the biceps anchor and to pull the bicep tendon into the joint for inspection. Once the scope is placed back in the posterior portal, a 4.5 mm full-radius motorized shaver working through the anterior cannula is used to gently debride the torn labrum taking care to not compromise the integrity of the anchor. A thermal ablation device can also be useful, but contact with articular surfaces should be avoided to prevent iatrogenic injury. All instruments are then removed, the shoulder is suctioned, and the portal sites are closed.

With debridement alone, postoperative rehabilitation is relatively aggressive. Sling is used for the first 1–2 weeks in our clinic for comfort. Early passive range of motion with pendulum swings and gentle assisted external rotation should be started in the first 2–3 days. Formal physical therapy should be started within the first 1–2 weeks as well to assist in the goals of full range of motion and pain control. Once painless range of motion is achieved, progression into strengthening can begin. A throwing program should be incorporated for return to play once range of motion and strength return.

Outcome

Debridement of isolated type III SLAP lesions typically results in better outcomes than type II and type IV injuries [17]. Snyder et al. report good results with debridement alone in a review of 140 shoulder surgeries. Over an 8-year time frame, the majority of repeat MR arthrograms demonstrated type III were healed [4]. Literature would also suggest that outcomes and return to play are dependent upon the presence of concomitant instability. Glasgow and Cordasco et al. have noted a dramatic reduction in outcomes and the durability of debridement procedures in the setting of glenohumeral instability, highlighting the importance of an accurate history and examination under anesthesia [18, 19]. Cordasco et al. reported 89% good to excellent results at 1 year, 63% excellent results at 2-year follow-up; however, return to competition at 2 year follow-up was only 44% when instability was associated with the labral tear [18]. These results are based primarily on patient reported pain, but there is little to no data supporting progression to instability following debridement of labral lesions [18].

Clinical Pearls and Pitfalls

- Address all associated pathology such as rotator cuff injuries, AC joint disorders, and subtle instability.
- Beware of type III SLAP tears with traumatic vague shoulder pain with mechanical symptoms.
- Avoid over aggressive debridement of the superior labral complex to avoid instability of the biceps anchor.
- During arthroscopic debridement, the viewing and working portals should be liberally switched to achieve a complete evaluation of the entire labrum.
- Consider lateral decubitus positioning if a labral lesion is suspected to extend posteriorly.

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Chapter 16
Type 4 SLAP Tear in 21-Year-Old Minor League Centerfielder

James M. Paci and Lucas King

Case Presentation

The patient is a healthy 21-year-old, right-hand dominant male minor league baseball centerfielder. The athlete sustained an injury to his right shoulder after diving to catch a fly ball. He throws righty and switch hits. The patient was able to complete his game and was evaluated after the game by his team athletic trainer. The athlete was treated conservatively with rest, activity modification, NSAIDs, and an athletic training room-based rehab program focusing on joint range of motion, periscapular strengthening and mobility, and core training. He ultimately failed conservative management and was referred for further evaluation.

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7_16,

Table 16.1 Range of motion of shoulders

	Forward flexion	Abduction	External rotation @90°	Internal rotation @90°	External rotation @Neutral
Right shoulder	180	180	105	5	50
Left shoulder	180	180	90	45	50

Diagnosis/Assessment

Upon evaluation by the treating physician, the patient complained of throwing-related shoulder pain with mechanical clicking and pain with overhead activities.

On physical examination, the patient was 6 ft 1 in., weighing 180 pounds.

Pertinent exam findings include range of motion (Table 16.1).

Based on the above table, it was determined that the patient had a total arc of motion loss of 25°, attributed totally to loss of internal rotation. There was a total internal rotation loss of 40° and an increase in external rotation of only 15°.

The patient had 5/5 manual tested strength in all planes of rotator cuff muscle testing. Baseline pain was located to his anterior shoulder. However, he had no tenderness to palpation within the bicipital groove or over the acromioclavicular joint. He had negative Neer and Hawkins impingement testing and a negative crossarm adduction test. He was found to have a positive O'Brien's test with negative apprehension and relocation testing and a negative posterior load and shift. Anterior stability, posterior stability and sulcus were graded 1+. His neurovascular examination was benign, with no evidence of axillary nerve impingement.

Plain x-rays of his right shoulder were obtained and showed no bony abnormalities or evidence any pathologic process present. An MRI arthrogram was performed with a concern for superior labral pathology and revealed a type IV SLAP lesion with extension into the proximal biceps, as well as evidence of fraying of the anterior inferior labrum.

Management

Initial treatment of a type IV SLAP lesion is nonoperative. Patients should be treated with a minimum of 6 weeks of physical therapy or athletic training room treatment. The goal of early nonoperative management is to decrease pain; normalize range of motion to what would be expected in an overhead athlete, increased ER by 7–15° with commensurate loss of IR; and to improve periscapular dynamics and strength. Upon normalization of range of motion and if a negative O'Brien's test is achieved, a formal throwing program can be started, in conjunction with continued therapy. If the athlete is unable to achieve normalization of range of motion or they continue to have mechanical symptoms and positive provocative testing, i.e., O'Brien's testing, after at least 6 weeks of conservative care, surgery may be indicated.

Surgical options for treatment of a type IV SLAP lesions include biceps tenotomy or tenodesis, repair of the SLAP lesion, or a combination of these. Choosing which procedure to perform is dependent upon the age of the patient, their activity goals, and the percentage of biceps involvement. In younger patients who are overhead athletes with less than 50% involvement, debridement and SLAP repair is preferred. If this repair fails, it can easily be revised to a tenodesis in the future. In older patients, non-overhead athletes, and in cases of greater than 50% biceps tendon involvement, a primary biceps tenodesis is preferred. Additionally, tenodesis is favored for patients with bicipital groove pain or evidence of an unstable biceps tendon. At the time of surgical intervention, it is pertinent to address any other concomitant injuries. One must be meticulous to address rotator cuff tears, capsulolabral tears, biceps tendinopathy, any loss of expected range of motion, and internal impingement lesions which are common in this patient demographic.

In our practice, type IV SLAP lesions in older patients, non-overhead athletes, or those tears with greater than 50% involvement of the biceps tendon, a biceps tenodesis is performed. Our preferred technique in this population, without any bicipital groove symptomology, is an all arthroscopic intra-articular tenodesis placed at the proximal extent of the groove. The biceps is secured using a Loop-n-Tack technique (VIDEO: https://www.youtube.com/watch?v=pe71Q6ufdrM) using a FiberLink suture and a 4.75 mm Peek SwiveLock suture anchor (Arthrex, Inc., Naples, FL) to secure the tenodesis to the bone. The superior labrum is examined after the tenodesis to determine whether a superior labral repair is necessary. In younger patients and overhead athletes, we recommend erring on the side of biceps debridement or SLAP repair as opposed to tenodesis. Revision to a tenodesis can always be performed if the repair fails.

Surgical Management

After both regional and general anesthesia had been established, the patient underwent a careful examination under anesthesia of both the injured, throwing shoulder and the nondominant shoulder. Loss of expected internal rotation of 25° was verified. The patient was then placed in the lateral decubitus position with an axillary roll placed, all bony prominences well padded, and the operative extremity placed in inline suspension. The joint was the insufflated with normal saline with epinephrine. A standard posterior portal was then established followed by a rotator interval anterior portal, and a diagnostic arthroscopy was performed. The biceps tendon tear had less than 50% tendon involvement, so a labral repair rather than tenodesis of the biceps was indicated. An arthroscopic shaver was then used to debride the partially torn biceps and unstable labrum tissue to a stable base (Fig. 16.1). Working through a 4.5 mm cannula, the superior labral tear was mobilized from the 10:30 to 12:30 position. Next, the superior glenoid neck was debrided to bleeding bone in order to enhance the biologic healing response (Fig. 16.2). A superolateral portal was then established with spinal needle localization. This portal was placed medial to the rotator cable and through the muscular portion of the supraspinatus to avoid tendon injury. Using a curved suture passer, two horizontal mattress sutures were

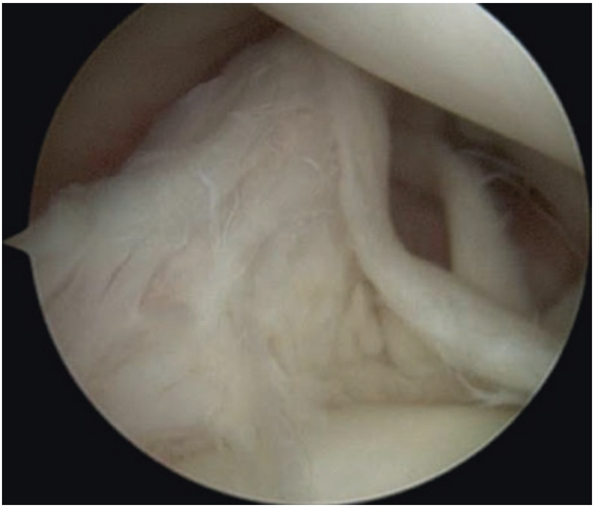

Figure 16.1 Intraoperative view of right shoulder through the posterior portal showing a Type IV SLAP lesion

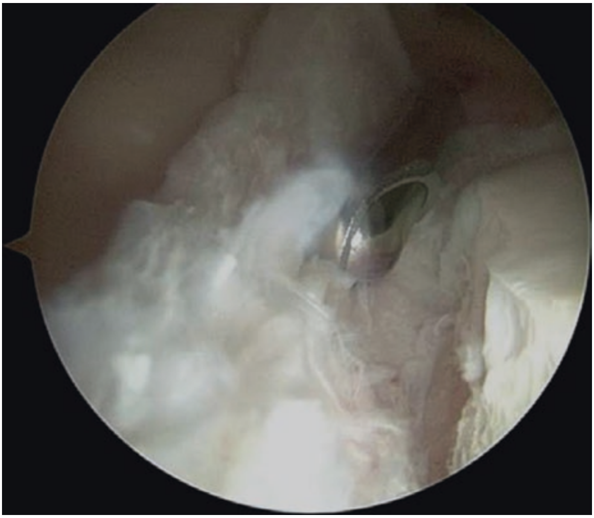

Figure 16.2 View from posterior portal of arthroscopic shaver debriding unstable superior labrum to a stable base in addition to reaching bleeding bone

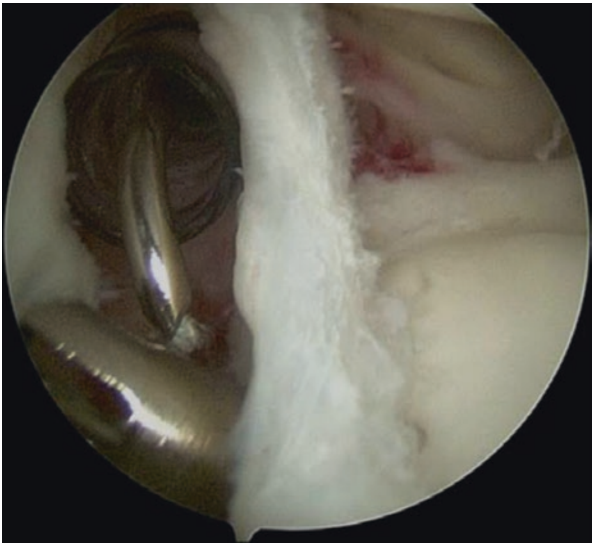

FIGURE 16.3 Horizontal mattress sutures placed through the anterior portal and retrieved through the superolateral portal

passed using #2 FiberStick sutures working from the anterior portal and grasping from the superolateral portal (Fig. 16.3). From the superolateral portal, pilot holes were made at the 10:30 and 12 o'clock positions for 2.9 mm PushLock Short PEEK suture anchors (Arthrex, Inc., Naples, FL). The posterior anchor was placed first followed by the 12:00 anchor incorporating the biceps base using a horizontal mattress suture for the final stabilization (Fig. 16.4). While this case did not warrant additional anchors, often, anchors are needed posterior to the 10:30 position as the SLAP tear can extend beyond that position. One should take caution with anchor placement anterior to biceps origin as this can over constrain the shoulder. Finally, due to his glenohumeral internal rotational deficit with associated loss of total arc of motion, a posterior inferior capsular release was performed from the 9 o'clock to 6 o'clock position. After closure the patient was placed in a shoulder abduction brace.

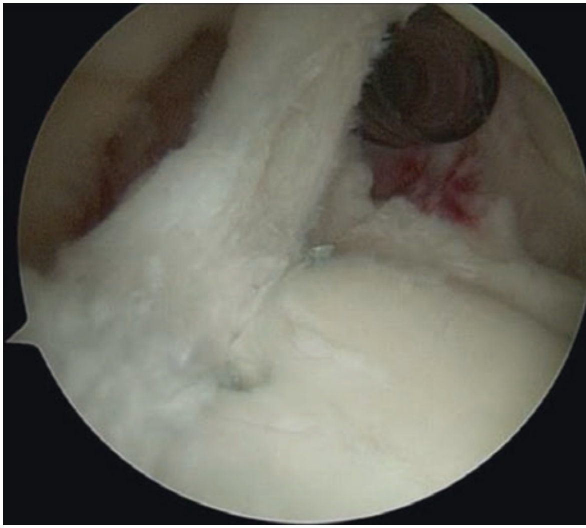

FIGURE 16.4 Final image of SLAP lesion repair which includes two anchors placed at 10:30 and 12 o'clock positions

The rehabilitation process after a type IV SLAP repair takes approximately 6–9 months in the overhead thrower. Postoperative rehabilitation progresses through multiple phases and an interval throwing program prior to return to unrestricted baseball activities. Generally speaking, an interval hitting program begins around 12 weeks post-op and an interval throwing program at 16–20 weeks post-op as long as functional goals are met.

Phase I encompasses the first 6 weeks postoperatively. The goals of phase I are to protect the repair, promote dynamic stability, and prevent any of the negative effects of immobilization such as stiffness. The patient is kept immobilized in a sling for 4 weeks but is allowed out of the sling for range of motion exercises including wrist and elbow movement and physical therapy. While there should not be any active range of motion during the first 4 weeks, passive range of motion is slowly advanced until week 4, at which time active assist range of motion is started.

Phase II lasts from weeks 7 to 12, and its main objective is to gain full active range of motion, which is usually achieved by week 10. It is also important to gradually restore strength and balance of the shoulder at this time. Only when the patient attains full range of motion and strength, can he start a hitting or throwing program. Once adequate motion and strength are achieved, an interval hitting program may be started, usually around 12 weeks post-op.

Phase III encompasses weeks 13 through 20 and builds upon the previous weeks. The goals during this time are to improve strength, power, and endurance in the shoulder while at the same time maintaining full range of motion. Care is taken during this phase to respect the expected shoulder motion, including increased dominant ER and decreased IR. Once full range of motion and adequate strength are achieved and the patient has negative provocative testing, including O'Briens Active Compression Test, an interval throwing program is initiated.

Along with a formal interval throwing program, phase IV involves further strengthening, range of motion exercises, and endurance improvement. There should not be any pain or tenderness at this point, and shoulder strength should be at about 75–80% of contralateral strength at the end of phase IV.

In order to advance into phase V and return to sport unrestricted sports activities, the patient will need to meet certain criteria. This includes, full functional range of motion, full shoulder strength, shoulder dynamic stability, negative provocative testing, and no pain when performing a 180-foot long toss. Pitchers and catchers must complete an additional phase II of their interval throwing programs prior to return. A continued stretching and strengthening program, including the Thrower's Ten + Two program, is maintained after return to sport.

Outcome

After a successful partial biceps debridement and knotless repair of his type IV SLAP tear and posterior-inferior capsular release, the patient began his rehabilitation program.

During phase I of his rehabilitation, which started within a few days of surgery, the focus was passive range of motion and isometric strengthening, while limiting biceps activation. He was able to progress as expected from phase I to phase II of his program, initiating active strengthening and throwers ten exercises, without complication in week 7. Full and painless range of motion was achieved by week 10, with achievement of full total arc of motion with an external rotation shift of 7–10°. At this point the focus of his rehabilitation was maintenance of motion and increasing active shoulder strength and endurance. Achieving adequate motion and ample strength, the patient was initiated on an interval hitting program and progressed to phase III of his program at week 13.

Throughout phase III, the patient was able to maintain his full range of motion while increasing strength and endurance. By week 20, he had full strength in his right shoulder and was advanced to phase IV of his program. He was cleared to DH upon completion of his hitting program, but not yet playing in the outfield. An interval throwing program was provided starting in week 20. He advanced through the program without any significant difficulties. Once finished with the throwing program, our patient was able to return to play in the outfield without complication and successfully returned to his minor league baseball career.

Clinical Pearls and Pitfalls

- Complete a detailed physical exam to elucidate biceps tendon pathology, rotator cuff pathology, and range of motion deficits in internal rotation, external rotation, and total arc of motion.
- MRI arthrogram with ABER view is key for diagnosis of SLAP tear.
- Beware of internal rotation deficit associated with loss of total arc of motion after rehabilitation; consider a posterior capsular release if warranted at the time of surgical intervention to help improve range of motion. In the case of an associated Bennett's osteophyte, be sure to debride the osteophyte.

- The cutoff for repair or tenodesis of the bicep is 50% tendon involvement; Err on the side of repairing the SLAP in a younger patient as tenodesis can always be performed at a later date if the repair fails, and repair allows you to regain the patient's normal anatomy.
- Avoid over-constrainment of the bicep as well as the superior anterior labrum; do not place any anchors anterior to the 12:30 position in the absence of instability.
- After biceps tenodesis, be sure to reassess the superior labrum and repair it if unstable (ie Slapodesis).
- Always perform a careful evaluation under anesthesia to confirm any range of motion deficits prior to surgery and prior to any capsular interventions.
- In the overhead athlete, we prefer an intra-articular biceps tenodesis at the exit of the bicipital groove as opposed to a subpectoral biceps tenodesis due to the fracture risk associated with subpectoral biceps tenodesis

Further Reading

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4. Sears BW, Spencer EE, Getz CL. Humeral fracture following subpectoral biceps tenodesis in 2 active, healthy patients. J Shoulder Elb Surg. 2011;20(6):e7–e11.

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N.N. Verma, E.J. Strauss (eds.), *The Biceps and Superior Labrum Complex*, DOI 10.1007/978-3-319-54934-7,