AAOS
AMERICAN ACADEMY OF
ORTHOPAEDIC SURGEONS

Biceps Tendon and Superior Labrum Injuries: Decision-Making

By F. Alan Barber, MD, Larry D. Field, MD, and Richard K.N. Ryu, MD

An Instructional Course Lecture, American Academy of Orthopaedic Surgeons

Biceps Anatomy and Function

The biceps tendon originates from the labrum and the supraglenoid tubercle of the scapula. The structure is intra-articular yet extrasynovial. It is widest at its origin and progressively narrows as it exits the bicipital groove. The proximal one-third of the biceps tendon has a high degree of innervation, with substance P and calcitonin gene-related peptides present, suggesting a rich sympathetic network[1].

There is a spectrum of pathological conditions of the proximal part of the biceps, including tendinitis, SLAP (superior labrum anterior and posterior) lesions, biceps instability, and partial or complete ruptures. The origin of the long head of the biceps is variable and is approximately 9 cm long[2]. The proximal portion of the long head receives its blood supply primarily from the anterior circumflex humeral artery[3]. The biceps tendon passes posterior to the coracohumeral ligament and beneath the transverse humeral ligament as it courses distally. The capsuloligamentous structures of the rotator interval are responsible for restraining the biceps tendon within its proper anatomic location as it passes into the bicipital groove[4,5]. The coracohumeral ligament and the superior glenohumeral ligament are the two most important structures within the rotator interval for securing the biceps tendon[2]. The superior glenohumeral ligament forms an anterior sling about the biceps. The more distal transverse humeral ligament is not believed to play a primary role in securing the biceps tendon[5].

The exact function of the long head of the biceps tendon in the shoulder is controversial. The angular orientation of the biceps relative to the humeral head appears to be adaptive in nature, and it diminishes the capacity for arm elevation, perhaps placing the biceps at risk for instability. The proximal part of the biceps tendon probably has at least a passive shoulder stabilizing function. Whereas several authors have observed that the proximal part of the biceps tendon has an active stabilizing effect, others have not[6-9]. Cadaveric biomechanical evidence indicates that the contribution of the biceps to glenohumeral stability may depend on the position of the elbow[10].

Problems related to the biceps tendon can be classified as inflammatory, instability, or traumatic[11]. Bicipital tenosynovitis is closely associated with impingement. Neer demonstrated that the biceps tendon is subject to the same mechanical wear beneath the coracoacromial arch as is the rotator cuff[12]. Because the biceps tendon sheath is continuous with the glenohumeral joint, any inflammatory process affecting the intra-articular environment can also affect the biceps. Biceps instability may occur more commonly than would be expected on the basis of clinical and arthroscopic examinations. The biceps tendon passes through an angle of approximately 30° as it exits the shoulder[13]. Medial subluxation or dislocation of the tendon can occur with repetitive wear or trauma to the restraining structures and is commonly associated with rotator cuff lesions, especially subscapularis tears[14] (Fig. 1). Finally, while traumatic biceps tendon lesions including rupture are uncommon, other traumatic disruptions such as SLAP lesions do occur.

Disclosure: The authors did not receive any outside funding or grants in support of their research for or preparation of this work. Neither they nor a member of their immediate families received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, division, center, clinical practice, or other charitable or nonprofit organization with which the authors, or a member of their immediate families, are affiliated or associated.

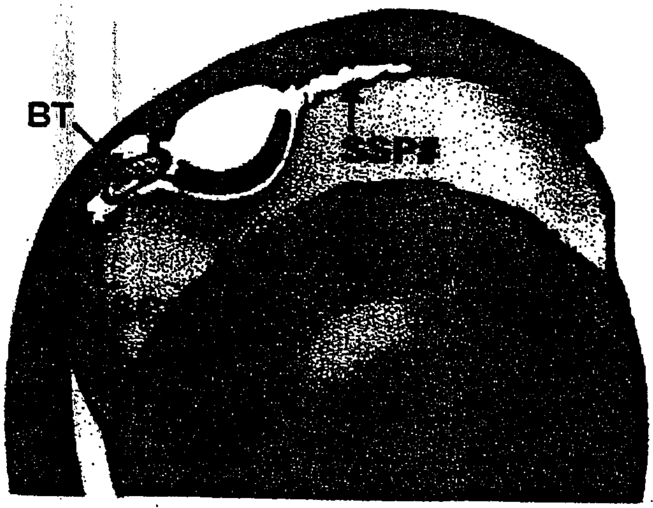

Fig. 1
Medial subluxation or dislocation of the biceps tendon (BT) can occur with repetitive wear or trauma to the superior glenohumeral ligament (SGHL) and is commonly associated with rotator cuff disease, especially subscapularis tears (SSC) as well as supraspinatus (SSP) tears[2].

Biceps Tendinitis and Instability

Biceps tendinitis is a relatively common cause of anterior shoulder pain. The tendinitis can be primary or secondary. Primary bicipital tendinitis is the isolated inflammation of the long head of the biceps tendon in the intertubercular groove, with no associated pathological changes in the shoulder. It has been estimated to represent only 5% of the cases of biceps tendinitis[4]. Secondary biceps tendinitis occurs in conjunction with pathological changes in the adjacent osseous, ligamentous, and muscular structures. This type of tendinitis often results in tendon fraying and even failure as the biceps tendon undergoes wear. As a result of repetitive wear or trauma, the soft-tissue restraints surrounding the biceps tendon can lose their stabilizing function, and medial subluxation or dislocation of the tendon can occur.

Patients with biceps tendinitis or instability present with pain primarily in the bicipital groove. The history and the results of the physical examination are usually compatible with an impingement syndrome, although the pain may be more anterior and may radiate down the biceps itself. Usually, there is no history of trauma. Patients with biceps instability occasionally report popping and an audible or palpable snap during the arc of shoulder motion. Biceps tendon instability is almost always associated with pathological changes in the subscapularis tendon and rarely occurs in the absence of at least some subscapularis tearing.

On physical examination, the most common finding in patients with biceps tendinitis or instability is point tenderness in the bicipital groove. Several provocative tests have been described for isolating a pathological condition of the biceps, including the Yergason test, the Speed test, the biceps instability test, the lift-off test, and the O'Brien active compression test[15-18]. As an adjunct to these provocative tests, selective injections can be very helpful in differentiating the source of shoulder pain. Unfortunately, there is no single physical finding that is conclusive evidence of a symptomatic pathological condition of the biceps. Coexisting impingement and rotator-cuff-related symptoms may make the diagnosis difficult.

Radiographic evaluation is usually not helpful and almost always reveals normal findings in cases of primary bi-

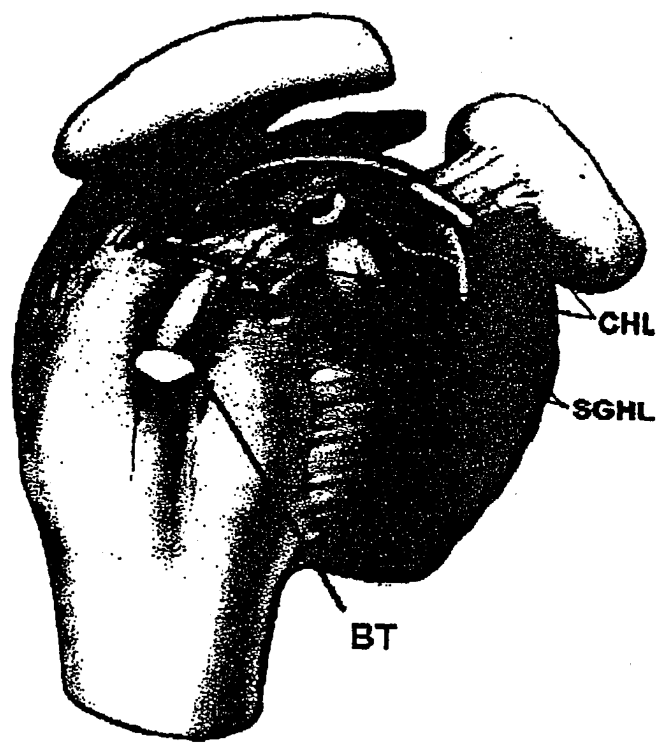

Fig. 2
The biceps tendon (BT) makes a 30° to 40° turn into the bicipital groove as it exits the shoulder and is stabilized by a pulley system[2]. CHL = coracohumeral ligament and SGHL = superior glenohumeral ligament.

ceps tendinitis. Secondary causes, such as an avulsion fragment from the tuberosity, suggest a biceps dislocation, and a large anterior acromial spur may suggest an impingement syndrome. Additional radiographic views can be used to evaluate the bicipital groove. Ultrasonography has become a useful tool for evaluation of the biceps and the rotator cuff in some centers[19]. However, ultrasonography is heavily operator-dependent and can be limited by osseous anatomy.

Magnetic resonance imaging is an excellent tool for evaluating the biceps tendon and the superior labral complex. A magnetic resonance imaging arthrogram continues to be the most appropriate noninvasive diagnostic study available for confirming a pathological condition of the biceps. Oblique and sagittal images can demonstrate subluxation and dislocation of the long head of the biceps tendon. Edema associated with bicipital tendinitis produces an increased signal intensity on T2-weighted images. Biceps tendon ruptures are relatively easy to detect on magnetic resonance imaging as well.

Boileau et al. described an hourglass-shaped biceps tendon that causes typical tendinitis symptoms[20]. It can be seen on arthrography. It results from an inflamed, thickened intra-articular segment, which can block tendon excursion during shoulder motion because the thickened part cannot traverse the bicipital groove. This so-called shoulder trigger finger can cause anterior shoulder pain and a loss of 10° to 20° of passive elevation as a result of mechanical locking, but it is difficult to recognize clinically. A thickened tendon can disrupt the pulley and destabilize the biceps over time. The treatment is excision of the thickened part of the biceps and tenodesis if necessary.

When a pathological condition of the biceps is suspected but confirmation proves elusive, arthroscopic evaluation is the most accurate means of verifying the diagnosis. During the arthroscopy, it is imperative that the tendon be inspected thoroughly, and this requires pulling the biceps into the joint to completely visualize the portion within the bicipital groove. Testing for instability of the biceps tendon should be done.

Instability of the Biceps Tendon

The biceps tendon makes a 30° to 40° turn into the bicipital groove as it exits the shoulder and is stabilized by a pulley system[2] (Fig. 2). This pulley system is made up of the coracohumeral ligament and the superior glenohumeral ligament along with both supraspinatus and subscapularis tendon fibers (Fig. 1). Progressive disruption of the pulley leads to biceps instability with medial subluxation, which in turn leads to progressive damage of the pulley itself. The biceps can dislocate immediately on top of the subscapularis, under the subscapularis if the subscapularis tendon is torn, or even laterally[21]. A clear understanding of the anatomy of the rotator interval is necessary to appreciate the variations of biceps instability in association with rotator cuff lesions.

The coracohumeral ligament arises from the coracoid process and separates into two bands. It invests the biceps at this critical angle as it exits the joint[7]. The superior glenohumeral ligament travels from the labrum to the humeral head. It becomes a u-shaped sling that supports the biceps tendon at this critical exit angle[5]. Also, rotator cuff fibers reinforce the pulley system. The transverse humeral ligament appears to be much less important to biceps stability. In fact, its more distal location means that the critical angle of biceps passage occurs more proximally and any subluxation would likely occur more proximally. The description of progressive damage to the pulley system by Habermeyer et al. has been labeled "pulley lesions."[2] These lesions can be traumatic or degenerative, and the pulley is susceptible to rotator cuff degeneration as is the biceps tendon itself.

Damage to the pulley system often occurs in a series of steps and is usually initiated by an articular-sided supraspinatus tear, which then leads to a tear of the superior glenohumeral ligament[13,14]. The tear of the superior glenohumeral ligament in turn allows subtle subluxation of the long head of the biceps, which can, in turn, cause a partial articular subscapularis tear. Progressive subluxation of the long head of the biceps causes more damage to the subscapularis tendon (Fig. 1). This cycle of progressive subluxation leading to subscapularis damage can ultimately lead to medial dislocation of the biceps and even anterosuperior instability with the occurrence of labral lesions. The possibility of a subscapularis tear occurring in conjunction with biceps instability cannot be overemphasized. Recognition of these tears is important as they often cause substantial anterior shoulder pain along with the biceps instability.

Nonoperative Treatment of Bicipital Tendinitis and Biceps Instability

The initial treatment of primary and secondary bicipital tendinitis is nonoperative. Initially, rest and nonsteroidal anti-inflammatory drugs are recommended. Subacromial steroid injections can help to treat both primary and secondary tendinitis[3]. Injections into the glenohumeral joint can reduce intra-articular biceps irritation. Finally, injections into the bicipital sheath anteriorly, with care taken to avoid the biceps tendon itself, can be of benefit[3]. Once the symptoms begin to decrease, gentle range-of-motion exercises are begun. When a patient has secondary bicipital tendinitis due to impingement syndrome, treatment should be directed toward the rotator cuff lesion. Exercises can be advanced as dictated by the status of the rotator cuff.

Nonoperative treatment of biceps instability is limited and should be directed toward the management of the rotator cuff lesions. Intra-articular injections are sometimes beneficial for older, sedentary patients. Younger, more active individuals almost always require surgery to address the rotator cuff lesions and the biceps instability.

Operative Treatment of Biceps Tendinitis and Instability

The most important aspect of treating a pathological condition of the biceps tendon is to determine its cause, define the degree of structural compromise, and detect associated pathological conditions, such as rotator cuff disease and impingement, that need to be addressed concomitantly. Surgical intervention for biceps tendinitis is generally indicated if the patient continues to have symptoms after three months of conservative management or if there is biceps instability.

The surgical options available include tendon débridement, a release of a constricted synovial sheath, a tenodesis, or a tenotomy.

Biceps Débridement

A simple débridement of the tendon in association with an arthroscopic subacromial decompression is appropriate for the treatment of mild tendon fraying. If the patient has a partial tear, involving <50% of the tendon, and an inactive lifestyle, a simple débridement and decompression may be sufficient. In younger active patients, partial tears should be treated more aggressively, with any tear involving >25% of the tendon being managed with tenodesis. Tenotomy should be avoided in younger active patients, whereas it is a reasonable option for more sedentary patients. A so-called Popeye deformity may develop after a tenotomy, but it will not develop after a tenodesis.

Biceps Decompression

Biceps tendon decompression can relieve the symptoms of primary biceps tendinitis through a tenosynovial release. A release of the transverse humeral ligament, sparing the coracohumeral ligament, and an arthroscopic or open release of the bicipital tendon sheath in the absence of other pathological entities will decrease symptoms. This surgical option is applicable only for inflammation of an otherwise intact tendon in the absence of other substantial pathological entities. If the tenosynovitis is severe and unrelenting, and occurs above as well as below the bicipital groove, a tenotomy in a less active patient or a subpectoral tenodesis in a more active individual is recommended.

Tenotomy

There is controversy about the choice of tenotomy or tenodesis[22]. Tenotomy is currently a more popular option for the treatment of a diseased biceps tendon[23,24], but the decision regarding treatment of an inflamed but otherwise intact biceps tendon is not an easy one. Associated pathological entities and surgery may render the decision regarding whether to perform a tenotomy and a tenodesis moot because the prolonged immobilization necessary after an arthroscopic rotator cuff repair, into which a tenotomy can be easily incorporated, reduces the benefits of a tenodesis.

Tenotomy has obvious advantages. It is technically very easy to perform, rehabilitation is simple, and there is no need for immobilization. The disadvantage of a tenotomy is the potential for a residual Popeye deformity caused by retraction of the biceps muscle distally. In addition to this deformity, cramping and weakness with vigorous use of the biceps may be encountered. In many cases, one can predict the possibility of deformity by carefully inspecting the proximal end of the biceps. In cases of chronic inflammation in which the biceps origin is substantially thickened, simple tenotomies rarely lead to deformity because the proximal end of the biceps is too large to pass through the bicipital groove.

Clinical studies of simple tenotomies have revealed that pain relief is achieved and the satisfaction rate usually exceeds 90%, but the Popeye deformity occurs in up to 70% of patients and as many as 40% of patients experience fatigue or soreness with resisted elbow flexion. In several studies, patients over sixty years of age did not experience this fatigue[25,26]. Osbahr et al. noted no significant difference in terms of the cosmetic result, pain relief, or muscle spasms between tenodesis and tenotomy, but the patients who were treated with a tenodesis were younger than those who were treated with a tenotomy[27]. Walch et al. reviewed the outcomes of 307 patients who had had a biceps tenotomy because of an irreparable rotator cuff tear or because they were unwilling to undergo the lengthy rehabilitation associated with an arthroscopic rotator cuff repair[23]. Eighty-seven percent were satisfied, although a subacromial decompression was often performed as well. Preoperative fatty infiltration of the rotator cuff muscles and a high-riding humeral head were prognostic of a poor outcome.

Tenodesis

Tenodesis can be performed either open or arthroscopically, with use of soft-tissue or osseous fixation, and above or below the bicipital groove. The advantages of a biceps tenodesis are a better cosmetic result and restoration of strength, whereas the disadvantages include a more difficult operation, the possible need for costly implants, a longer rehabilitation, a period of immobilization, and the possibility of the tenodesis failing. Several alternatives for arthroscopic fixation are available. The tendon can be secured with use of an interference screw in a bone tunnel or with suture anchors in the bicipital groove, or by suturing it to the rotator interval[28,29]. Suturing the biceps remnant to the conjoint tendon has also been described[30]. An open subpectoral approach in which a keyhole type of fixation is achieved can be utilized. Investigators comparing the mechanical strength values following tenodesis fixation techniques concluded that the interference screw and bone tunnel technique provides the greatest initial fixation strength[31].

Tenodesis for treatment of disease of the long head of the biceps is usually performed in conjunction with the treatment of concomitant rotator cuff disease. Isolated biceps tenodesis has historically been uncommon, and the results have been modest at best, perhaps reflecting neglected underlying pathological conditions such as an impingement phenomenon. Studies in which a biceps tenodesis was done in conjunction with a decompression have uniformly revealed satisfactory results[32], although Walch et al. reported no difference in the success rates of tenodeses done with and without an accompanying decompression[23].

In the case of a complete biceps

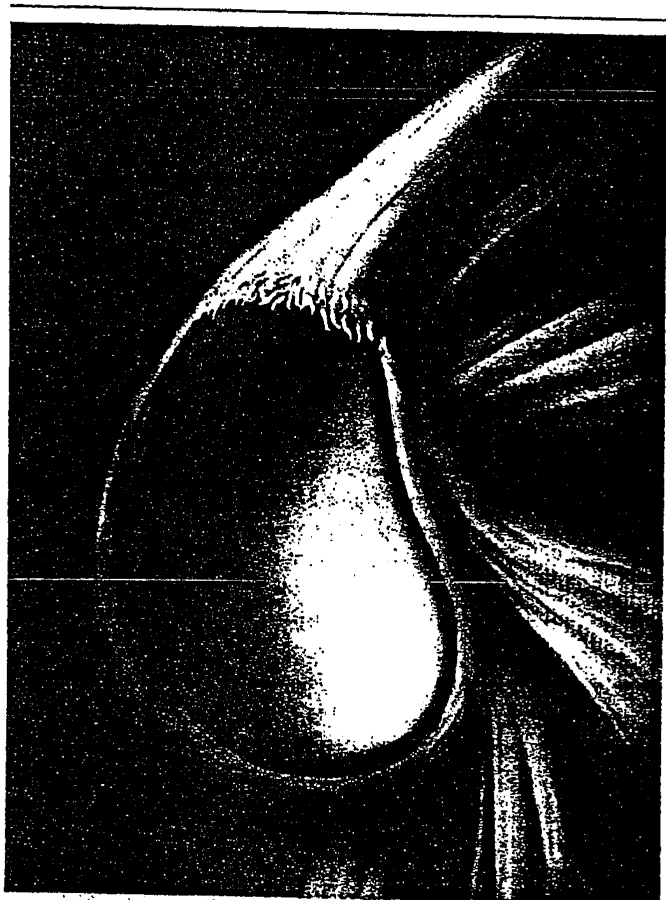

Fig. 3-A

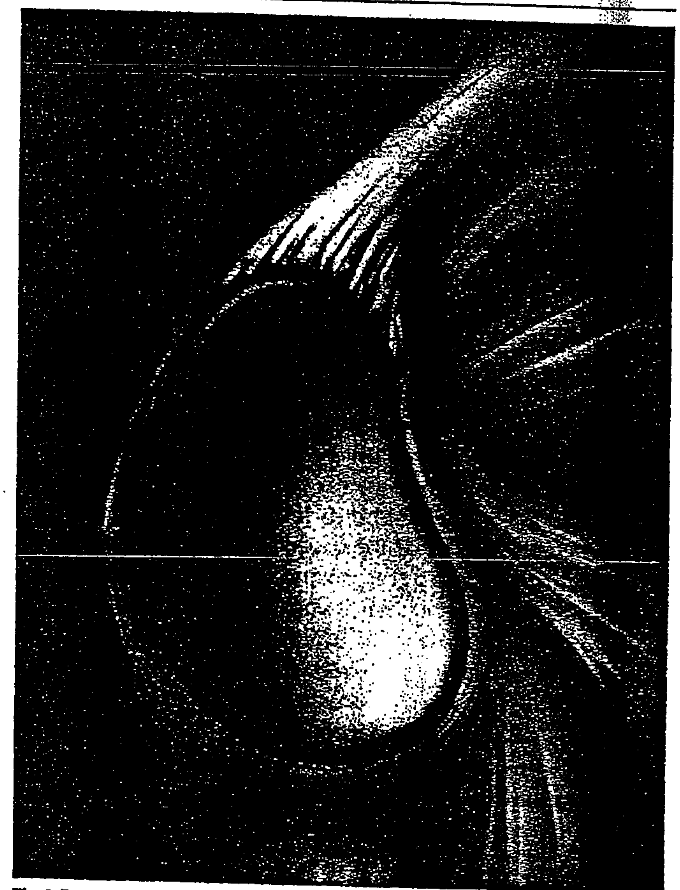

Fig. 3-B

Figs. 3-A through 3-D The classification system for SLAP lesions. **Fig. 3-A** A type-1 SLAP lesion consists of degenerative fraying on the inner margin of the superior aspect of the labrum. **Fig. 3-B** With a type-2 SLAP lesion, the biceps attachment and the adjacent superior aspect of the labrum have pulled off the superior glenoid tubercle.

rupture, tenodesis is appropriate for a younger active patient and can be accomplished through an open subpectoral approach. Technically, reestablishing the proper resting length to the tenodesed biceps tendon is critical if strength and a good cosmetic appearance are to be restored. The subpectoral approach helps the surgeon to find the ruptured proximal stump and permits direct visualization so that the musculotendinous portion of the biceps can be lined up with the pectoralis insertion site to reproduce the optimal resting length. Furthermore, with any open approach, a keyhole-type fixation technique in which the stump of the tendon is fixed and delivered into the humeral shaft helps to avoid the need for costly implants. Older patients with lower functional demands have tolerated benign neglect well[35]. Isolated pathological involvement of the biceps is uncommon, and if a rupture occurs the presence of associated rotator cuff disease should be considered.

Biceps Instability

Subluxation or dislocation of the biceps tendon is almost invariably associated with rotator cuff tearing, particularly of the subscapularis, and pathological involvement of the rotator interval[2]. It is important to determine the direction of the instability, which is most commonly medial, and the instability is usually fixed rather than dynamic. The superior portion of the subscapularis tendon is usually torn and must be addressed in addition to the biceps disease. The treatment options for biceps instability include tenotomy, tenodesis, or reconstruction of the stabilizing structures that support the biceps tendon. The indications for tenotomy and tenodesis parallel those for patients with moderate-to-severe tendinitis and are the more common choices.

Tenodesis of the biceps, in conjunction with a subscapularis repair, is appropriate if a patient is young and active, whereas a tenotomy is an appropriate intervention for a less active patient even when the subscapularis is being repaired. Not treating the unstable biceps definitively leads to rupture of the subscapularis repair. These anterior superior tears that include the biceps and subscapularis often also involve the supraspinatus. Furthermore, careful evaluation of the subcoracoid space is recommended as subcoracoid impingement may have led to the cumulative injury to the rotator interval structures[34,35]. Reconstruction of the stabilizing structures in the rotator interval

Fig. 3-C

Fig. 3-D

Fig. 3-C A type-3 SLAP lesion is a superior labral bucket-handle tear. **Fig. 3-D** A type-4 SLAP lesion is a superior labral bucket-handle tear that extends into the biceps tendon.

with attention paid to the superior glenohumeral ligament and the coracohumeral ligament, and the creation of a sling around the tendon can be performed. However, recurrent instability can be a problem, and a stenosed, painful tendon may result.

Overview of Surgical Treatments of the Biceps Tendon

Both tenodesis and tenotomy can yield good results[22]. Interestingly, several authors have found that acromioplasty alone relieved anterior shoulder pain despite a preoperative diagnosis of biceps tenosynovitis[36]. While there is much controversy regarding operative management of a symptomatic biceps tendon, we typically sacrifice the biceps tendon only when there is a substantial partial tear, extensive tenosynovitis, or tendon instability. The decision to perform a tenodesis or tenotomy is usually based on several factors. Tenotomy is routinely carried out in sedentary patients and in those for whom the cosmetic result is not a concern. However, tenodesis is almost always performed in younger, more active patients or any patient for whom the cosmetic result is an issue, particularly those with thin arms.

The SLAP Injury

Superior glenoid labrum injuries were apparently first defined as SLAP (superior labrum anterior and posterior) tears by Snyder et al. in 1990[37]. While the recognized varieties of SLAP injuries have expanded over time, the challenge is to differentiate between the labral variations that are clinically relevant lesions and those that are normal variations or simply the effects of aging.

SLAP lesions can be created by various mechanisms of injury including a biceps traction overload caused by the long head of the biceps acting as a decelerator of the arm during the follow-through phase of throwing, arm acceleration during the late cocking phase, a tight posterior aspect of the capsule, falling on the outstretched arm creating shearing forces on the superior biceps labral complex[38], sudden forced abduction and external rotation of the shoulder, and passive disruption during a motor-vehicle accident when the shoulder-lap belt restrains the ipsilateral chest wall, causing the shoulder to roll around the seat belt.

Any classification system should provide a logical method for evaluating the injury that can positively affect the treatment algorithm. The classification system now includes many more types than had been initially described[37]. A type-1 SLAP lesion has fraying on the inner margin of the superior aspect of the labrum (Fig. 3-A) and probably rep-

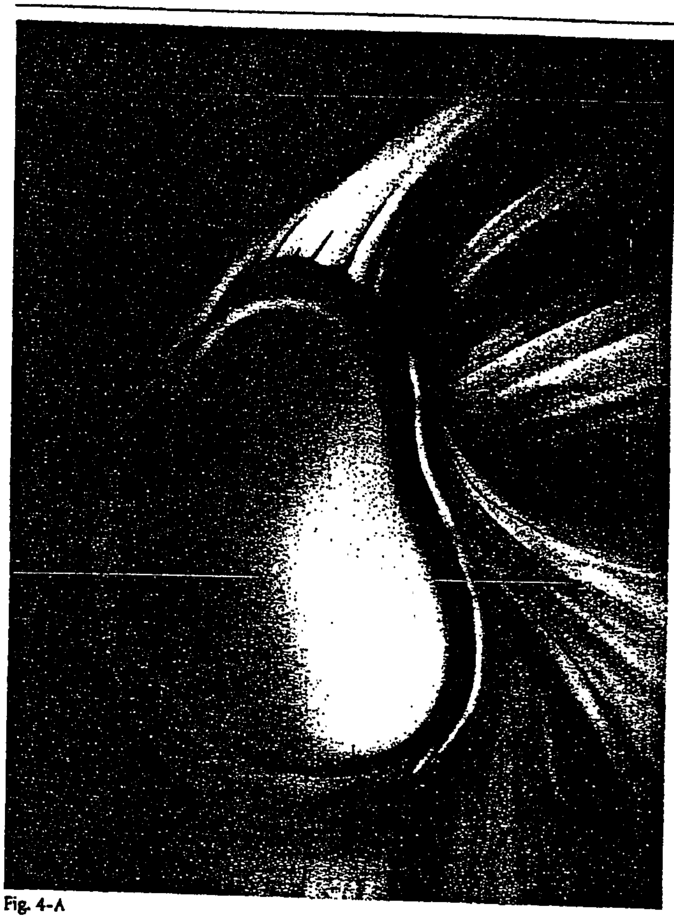

Fig. 4-A

Fig. 4-B

Figs. 4-A, 4-B, and 4-C The SLAP classification system was expanded to include injuries associated with dislocation. **Fig. 4-A** A type-5 SLAP lesion is a Bankart lesion that extends superiorly to the biceps attachment. **Fig. 4-B** A type-6 SLAP lesion has an anterior or posterior labral flap with a type-2 biceps elevation.

resents normal degenerative changes associated with increased age and the retreat of blood supply from the superior aspect of the labrum. This may be confused with a meniscoid superior part of the labrum, which is a normal variant.

A type-2 SLAP lesion is the most common clinically relevant abnormality. It occurs when the superior labral attachment of the biceps tendon pulls off the superior glenoid tubercle (Fig. 3-B). Burkhart and Morgan further defined the type-2 SLAP lesion according to three subtypes based on the anatomic location of this elevation: anterior, posterior, and combined anterior and posterior[39]. The most common of these subtypes is the anterior lesion, which involves a labral avulsion from the anterosuperior quadrant of the glenoid. The posterior subtype involves the posterosuperior quadrant of the glenoid and is most commonly seen in throwing athletes. The combined (anterior and superior) subtype is the least common. When traction is applied to the biceps tendon of a patient with a labral separation from the posterosuperior quadrant of the glenoid, the force on the tendon shifts from an anterior-horizontal to a posterior-vertical position. This force is transmitted to the labrum at the base of the biceps tendon and results in the detached labrum sliding medially or peeling off the posterior-superior aspect of the glenoid; this has been called the "peel-back" phenomenon[39].

A type-3 SLAP lesion is a superior labral bucket-handle tear often extending from anterior to posterior at the biceps insertion (Fig. 3-C). In contrast to the type-2 lesion, the biceps-labral attachment is not elevated from the glenoid. In a type-4 SLAP lesion, the bucket-handle tear extends into the biceps tendon, splitting the tendon attachment (Fig. 3-D). Additional SLAP lesions (types 5 through 10) have also been described[40-42] (Figs. 4-A through 5-C).

Maffet et al. expanded this classification system to include should[er] instability injuries. Their type-5 SLAP lesion is a Bankart lesion exte[nd]ing superiorly to the biceps attachm[ent] (Fig. 4-A). A type-6 SLAP lesion ha[s a] labral flap with a type-2 biceps elev[a]tion (Fig. 4-B), and a type-7 SLAP lesion is a lesion of the middle glen[o]humeral ligament extending to the [bi]ceps attachment (Fig. 4-C). Powell e[t] al.[41] further expanded this classification system to include a type-8 lesion, which is a type-2 SLAP lesion with posterior labral extension (Fig. 5-A) a type-9 lesion, which is a type-2 SL[AP]

Fig. 4-C
A type-7 SLAP lesion is a separation of the biceps attachment that extends into the middle glenohumeral ligament.

lesion with circumferential labral tearing (Fig. 5-B); and a type-10 lesion, which is a type-2 SLAP lesion with a posterior-inferior labral separation (Fig. 5-C). An additional variation of labral disease includes a type-2 SLAP injury with articular cartilage avulsions and loose bodies as described by Choi and Kim[42].

Approximately half of clinically relevant SLAP lesions are type 2. Also, except in series dealing principally with shoulder instability, the overall prevalence of SLAP tears is very low[37,43-45]. In the original study in which SLAP lesions were defined[38], they accounted for only 4% of 700 cases in a consecutive series of shoulder arthroscopic procedures, and a review of 2375 patients in another series of consecutive shoulder arthroscopic procedures demonstrated a 5.9% prevalence of SLAP lesions[43-45].

Clinical Presentation

Clinically relevant SLAP lesions are most often found after trauma, in swimmers, or in long-time overhead-throwing athletes[37,39,40]. The patients describe clicking and popping often associated with anterior shoulder pain and reduced function, including decreased throwing or serving velocity or slower swimming speed. The symptoms may appear suddenly or gradually. The dead-arm syndrome is characterized by the inability to throw at the preinjury velocity[46].

The key elements to be considered in differentiating a clinically relevant superior labral injury from normal variations or changes due to aging include the patient, the mechanism of injury, the findings of the clinical examination, and the findings of appropriate imaging studies. Demonstrated improvement after surgical treatment confirms the diagnosis.

Proper patient selection is critical. A SLAP lesion should be anticipated prior to surgery so that it is not an unexpected finding at arthroscopy. True type-2 SLAP injuries are seldom associated with substantial glenohumeral arthritis or rotator cuff tears. When degenerative changes are found, the labral abnormality is likely to be part of a degenerative process.

Clinically relevant SLAP injuries are most often found in the dominant arm of a man less than forty years of age who has participated in high-performance overhead activities for many years, a patient with a specific history of shoulder trauma, or a patient with shoulder instability. A fall on an outstretched hand or a prior motor-vehicle accident during which the patient was wearing a shoulder-lap belt is also suggestive of a SLAP injury[12,47].

Physical Examination

Several tests have been proposed for the diagnosis of a clinically relevant SLAP injury. However, these tests often provide inconsistent results and are not consistently diagnostic[18,48-54]. The modified O'Brien test, the crank test, the anterior slide test, the Jobe relocation test, the biceps load test, and the pain provocation test are advocated by some and dismissed by others[54]. A positive Speed test and a loss of internal rotation that has not resolved following a short course of physical therapy have been said to indicate a SLAP lesion[39]. Despite the concerns about the reliability of these tests, they do play a role in the physical examination of the shoulder. However, no single test should be completely relied upon.

Diagnostic imaging also provides inconsistent results. Plain radiographs reveal osseous problems. The superior aspect of the glenoid labrum can be seen on a gadolinium-enhanced magnetic resonance imaging scan, but correct interpretation requires special expertise. The variability of the normal superior aspect of the labrum reduces the diagnostic value of this test. However, the presence of a sublabral ganglion cyst is very suggestive of a SLAP lesion[55].

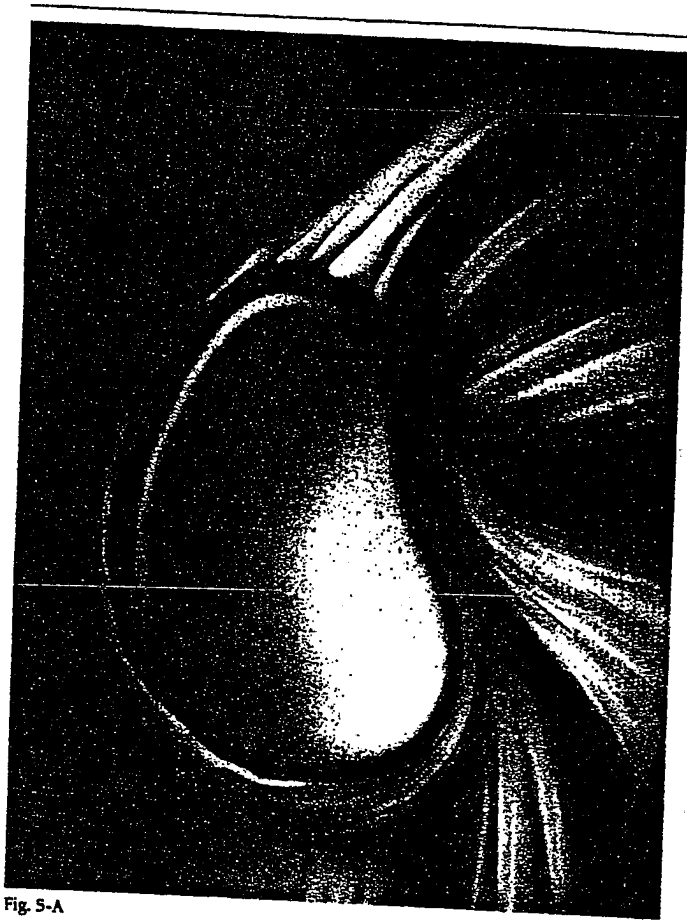

Fig. 5-A

Fig. 5-B

Figs. 5-A, 5-B, and 5-C Additional types of SLAP lesions have been identified. **Fig. 5-A** A type-8 SLAP lesion is a type-2 lesion with posterior labral extension. **Fig. 5-B** A type-9 SLAP lesion is a type-2 lesion with circumferential labral tearing.

Nonoperative Treatment

The initial treatment of a SLAP lesion should include rest, anti-inflammatory medication, stretching, and strengthening to address muscular imbalances. Decreased internal rotation is often found in athletes who throw overhead. A reduction in shoulder rotation to <180° or a loss of internal rotation suggests a tight posterior aspect of the capsule. Scapular dyskinesis or weakness of the scapular stabilizers may result in scapular winging and asymmetrical arm motion. Stretching to attain full motion (internal rotation) should be performed prior to surgical intervention. If symptoms persist after three months of nonoperative treatment, surgery may be indicated.

Surgical Treatment

The arthroscopic treatment of a SLAP lesion depends on the type of lesion. A type-1 SLAP lesion is treated with débridement of the area of labral fraying. A type-2 lesion should be treated with reattachment of the superior aspect of the labrum to achieve a stable biceps-superior labral anchor. A type-3 SLAP lesion requires removal of the bucket-handle tear. A type-4 lesion requires débridement of any flap or bucket-handle tear and repair of the associated biceps tear or a biceps tenodesis. Types-5, 6, and 7 SLAP lesions are associated with shoulder instability, which should be corrected at the same time as the SLAP lesion is repaired and any flap should be débrided. For types 8, 9, and 10, the labrum should be reattached and any flap should be débrided. The goal of surgical repair is to securely reattach the biceps-labral complex and to eliminate the peel-back and drive-through signs.

Half of all SLAP lesions that require surgery are type 2. While various techniques have been used in the past, suture anchors are currently the preferred method of biceps-labral fixation. An anterior type-2 SLAP lesion requires one suture anchor placed either beneath or slightly anterior to the biceps tendon origin. In this location, a mattress suture (or two simple sutures) can fix both sides of the biceps origin. A posterior or combined type-2 SLAP lesion requires a suture anchor posterior to the biceps origin to fully stabilize the posterior-superior aspect of the labrum.

The initial step in a repair of a SLAP lesion is to carefully probe and assess the biceps and the superior labrum injury and to débride any degenerative tissue. After the superior aspect of the labrum has been elevated to expose the glenoid neck, this area is débrided to prepare it for biceps-labral reattachment. Roughening the bone surface to

Fig. 5-C
A type-10 SLAP lesion is a type-2 lesion with a posterior-inferior labral separation.

eate a bleeding bed, rather than de-
orticating the superior glenoid tuber-
le is sufficient. The appropriate suture
nchor or anchors are inserted into the
uperior glenoid articular cartilage
argin at an angle (usually 45°) that
ces the anchor into the bone with-
t cutting out either medially or lat-
lly. Once the anchor is in place, the
tures are passed through the labral
sue and either a simple or a mattress
ch is used.

toperative Treatment

AP repairs are often followed by stiff-
s in the postoperative period, as the
air can substantially decrease mo-
n including internal and external ro-
on and translation[36]. Thus, a sling is
d for only three weeks, and the pa-
t is encouraged to remove the sling
perform rotation movements to
ch the capsule during this period.
use of the sling is discontinued, pendulum exercises with elbow flexion and extension are recommended and should be performed. At six weeks, strengthening of the rotator cuff, scapular stabilizers, biceps, and deltoid muscle is initiated. Throwing athletes begin an interval-throwing program at four months on a level surface. Stretching (of the posterior aspect of the capsule) and strengthening are continued, and throwing from the mound begins at six months. A return to full activity is permitted at seven months. Non-throwing athletes may return to their sports at four months.

Overview

While the anatomy of the biceps tendon and the restraining structures within the rotator interval have been well defined, biceps function and the importance of the long head of the biceps are not clearly understood at this time. Pathological involvement of the biceps, when encountered, is usually associated with rotator cuff disease and possibly an impingement process. Functionally, some humeral head stability may be imparted through the biceps tendon. While careful clinical examination along with diagnostic testing can accurately identify a pathological condition of the biceps, arthroscopy is an extremely valuable tool with which to establish the accurate diagnosis and treatment of biceps disease.

Options for the surgical treatment of pathological biceps conditions include decompression, débridement, tenotomy, and tenodesis. Several factors must be considered in this decision. The most important factors to be taken into account when choosing between tenodesis and tenotomy are the activity expectations of the patient, the importance of the cosmetic result, patient compliance, associated pathological entities requiring a surgical procedure that may allow easy incorporation of a tenodesis, and the patient's age. Those over the age of sixty appear to tolerate a tenotomy with the fewest side effects.

There are various techniques for arthroscopic tenodesis, including interference screw fixation to bone, suture anchor fixation, and suture fixation to adjacent tissue. The interference screw technique yields the best initial fixation, although soft-tissue fixation can also lead to a satisfactory result and is easier to perform. An open subpectoral tenodesis is the appropriate choice for patients with a retracted ruptured tendon or for those with biceps disease extending distal to the bicipital groove.

The SLAP lesion at the attachment of the biceps tendon to the superior aspect of the glenoid labrum is uncommon. A clinically relevant SLAP lesion is found during about 5% of all shoulder arthroscopies and may be confused with a normal anterior labral variation. Clinical examinations and imaging tests for the diagnosis of SLAP lesions are often unreliable, and the ultimate diagnostic confirmation is made with arthroscopy. Surgical treatment is focused on the reattachment of the unstable biceps-labral complex.

F. Alan Barber, MD
Plano Orthopedic and Sports Medicine Center, 5228 West Plano Parkway, Plano, TX 75093

Larry D. Field, MD
Mississippi Sports Medicine and Orthopaedic Center, 1325 East Fortification Street, Jackson, MS 39202

Richard K.N. Ryu, MD
533 East Micheltorena Street, Suite 204, Santa Barbara, CA 93103

Printed with permission of the American Academy of Orthopaedic Surgeons. This article, as well as other lectures presented at the Academy's Annual Meeting, will be available in March 2008 in *Instructional Course Lectures*, Volume 57. The complete volume can be ordered online at www.aaos.org, or by calling 800-626-6726 (8 A.M.-5 P.M., Central time).

References

1. Curtis AS, Snyder SJ. Evaluation and treatment of biceps tendon pathology. Orthop Clin North Am. 1993;24:33-43.

2. Habermeyer P, Magosch P, Pritsch M, Scheibel MT, Lichtenberg S. Anterosuperior impingement of the shoulder as a result of pulley lesions: a prospective arthroscopic study. J Shoulder Elbow Surg. 2004; 13:5-12.

3. Burkhead WZ Jr, Arcand MA, Zeman C, Habermeyer P, Walch G. The biceps tendon. In: Rockwood CA Jr, Matsen FA III, Wirth MA, Lippitt SB, editors. The shoulder. Vol 2. 3rd ed. Philadelphia: Saunders; 2004. p 1059-119.

4. Favorito PJ, Harding WG 3rd, Heidt RS Jr. Complete arthroscopic examination of the long head of the biceps tendon. Arthroscopy. 2001;17:430-2.

5. Pfahler M, Branner S, Refior HJ. The role of the bicipital groove in tendopathy of the long biceps tendon. J Shoulder Elbow Surg. 1999;8:419-24.

6. Pagnani MJ, Deng XH, Warren RF, Torzilli PA, O'Brien SJ. Role of the long head of the biceps brachii in glenohumeral stability: a biomechanical study in cadavera. J Shoulder Elbow Surg. 1996; 5:255-62.

7. Itoi E, Kuechle DK, Newman SR, Morrey BF, An KN. Stabilising function of the biceps in stable and unstable shoulders. J Bone Joint Surg Br. 1993;75:546-50. Erratum: J Bone Joint Surg Br. 1994;76:170.

8. Warner JJ, McMahon PJ. The role of the long head of the biceps brachii in superior stability of the glenohumeral joint. J Bone Joint Surg Am. 1995;77:366-72.

9. Yamaguchi K, Riew KD, Galatz LM, Syme JA, Neviaser RJ. Biceps activity during shoulder motion: an electromyographic analysis. Clin Orthop Relat Res. 1997;336:122-9.

10. Gowan ID, Jobe FW, Tibone JE, Perry J, Moynes DR. A comparative electromyographic analysis of he shoulder during pitching. Professional versus amateur pitchers. Am J Sports Med. 1987;15: 586-90.

11. Yamaguchi K, Bindra R. Disorders of the biceps tendon. In: Iannotti JP, Williams GR Jr, editors. Disorders of the shoulder: diagnosis and management. Philadelphia: Lippincott, Williams and Wilkins; 1999. p 159-90.

12. Neer CS 2nd. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. J Bone Joint Surg Am. 1972; 54:41-50.

13. Bennett WF. Visualization of the anatomy of the rotator interval and bicipital sheath. Arthroscopy 2001;17:107-11.

14. Bennett WF. Arthroscopic repair of isolated subscapularis tears: a prospective cohort with 2- to 4-year follow-up. Arthroscopy. 2003;19: 131-43.

15. Yergason RM. Supination sign. J Bone Joint Surg Am. 1931;13:160.

16. Bennett WF. Arthroscopic repair of anterosuperior (supraspinatus/subscapularis) rotator cuff tears: a prospective cohort with 2- to 4-year follow-up. Classification of biceps subluxation/instability. Arthroscopy. 2003;19:21-33.

17. Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle. Clinical features in 16 cases. J Bone Joint Surg Br. 1991; 73:389-94.

18. O'Brien SJ, Pagnani MJ, Fealy S, McGlynn SR, Wilson JB. The active compression test: a new and effective test for diagnosing labral tears and acromioclavicular joint abnormality. Am J Sports Med. 1998;26:610-3.

19. Iannotti JP, Ciccone J, Buss DD, Visotsky JL, Mascha E, Cotman K, Rawool NM. Accuracy of office-based ultrasonography of the shoulder for the diagnosis of rotator cuff tears. J Bone Joint Surg Am. 2005;87:1305-11.

20. Boileau P, Ahrens PM, Hatzidakis AM. Entrapment of the long head of the biceps tendon: the hourglass biceps — a cause of pain and locking of the shoulder. J Shoulder Elbow Surg. 2004; 13:249-57.

21. Bennett WF. Subscapularis, medial, and lateral head coracohumeral ligament insertion anatomy. Arthroscopic appearance and incidence of "hidden" rotator interval lesions. Arthroscopy. 2001;17:173-80.

22. Berlemann U, Bayley I. Tenodesis of the long head of biceps brachii in the painful shoulder: improving results in the long term. J Shoulder Elbow Surg. 1995;4:429-35.

23. Walch G, Edwards TB, Boulahia A, Nové-Josserand L, Neyton L, Szabo I. Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: clinical and radiographic results of 307 cases. J Shoulder Elbow Surg. 2005; 14:238-46.

24. Wolf RS, Zheng N, Weichel D. Long head biceps tenotomy versus tenodesis: a cadaveric biomechanical analysis. Arthroscopy. 2005;21:182-5.

25. Kelly AM, Drakos MC, Fealy S, Taylor SA, O'Brien SJ. Arthroscopic release of the long head of the biceps tendon: functional outcome and clinical results. Am J Sports Med. 2005;33:208-13.

26. Gill TJ, McIrvin E, Mair SD, Hawkins RJ. Results of biceps tenotomy for treatment of pathology of the long head of the biceps brachii. J Shoulder Elbow Surg. 2001;10:247-9.

27. Osbahr DC, Diamond AB, Speer KP. The cosmetic appearance of the biceps muscle after long-head tenotomy versus tenodesis. Arthroscopy. 2002;18:483-7.

28. Boileau P, Krishnan SG, Coste JS, Walch G. Arthroscopic biceps tenodesis: a new technique using bioabsorbable interference screw fixation. Arthroscopy. 2002;18:1002-12.

29. Romeo AA, Mazzocca AD, Tauro JC. Arthroscopic biceps tenodesis. Arthroscopy. 2004; 20:206-13.

30. Verma NN, Drakos M, O'Brien SJ. Arthroscopic transfer of the long head biceps to the conjoint tendon. Arthroscopy. 2005;21:764.

31. Ozalay M, Akpinar S, Karaeminogullari O, Balcik C, Tasci A, Tandogan RN, Gecit R. Mechanical strength of four different biceps tenodesis techniques. Arthroscopy. 2005;21:992-8.

32. Klepps S, Hazrati Y, Flatow E. Arthroscopic biceps tenodesis. Arthroscopy. 2002;18:1040-5.

33. Mariani EM, Cofield RH, Askew LJ, Li GP, Chao EY. Rupture of the tendon of the long head of the biceps brachii. Surgical versus nonsurgical treatment. Clin Orthop Relat Res. 1988;228: 233-9.

34. Richards DP, Burkhart SS, Campbell SE. Relation between narrowed coracohumeral distance and subscapularis tears. Arthroscopy. 2005; 21:1223-8.

35. Burkhart SS, Brady PC. Arthroscopic subscapularis repair: surgical tips and pearls A to Z. Arthroscopy. 2006;22:1014-27.

36. Neviaser RJ. Lesions of the biceps and tendinitis of the shoulder. Orthop Clin North Am. 1980; 11:343-8.

37. Snyder SJ, Karzel RP, Del Pizzo W, Ferkel RD, Friedman MJ. SLAP lesions of the shoulder. Arthroscopy. 1990;6:274-9.

38. Clavert P, Bonnomet F, Kempf JF, Boutemy P, Braun M, Kahn JL. Contribution to the study of the pathogenesis of type II superior labrum anterior-posterior lesions: a cadaveric model of a fall on the outstretched hand. J Shoulder Elbow Surg. 2004;13:45-50.

39. Burkhart SS, Morgan CD. The peel-back mechanism: its role in producing and extending posterior type II SLAP lesions and its effect on SLAP repair rehabilitation. Arthroscopy. 1998;14:637-[illegible]

40. Maffet MW, Gartsman GM, Moseley B. Superior labrum-biceps tendon complex lesions of the shoulder. Am J Sports Med. 1995;23:93-8.

41. Powell SE, Nord KD, Ryu RK. The diagnosis, classification, and treatment of SLAP lesions. Oper Tech Sports Med. 2004;12:99-110.

42. Choi NH, Kim SJ. Avulsion of the superior labrum. Arthroscopy. 2004;20:872-4.

43. Snyder SJ, Banas MP, Karzel RP. An analysis of 140 injuries to the superior glenoid labrum. J Shoulder Elbow Surg. 1995;4:243-8.

44. Handelberg F, Willems S, Shahabpour M, Huskin JP, Kuta J. SLAP lesions: a retrospective multicenter study. Arthroscopy. 1998;14:856-62.

45. Kim TK, Queale WS, Cosgarea AJ, McFarland EG. Clinical features of the different types of SLAP lesions: an analysis of one hundred and thirty-nine cases. Superior labrum anterior posterior. J Bone Joint Surg Am. 2003;85:66-71.

46. Burkhart SS, Morgan CD, Kibler WB. Shoulder injuries in overhead athletes. The "dead arm" revisited. Clin Sports Med. 2000;19:125-58.

47. Ruotolo C, Nottage WM, Flatow EL, Gross RM, ...nton GS. Controversial topics in shoulder arthros...py. Arthroscopy. 2002;18(2 Suppl 1):65-75.

Liu SH, Henry MH, Nuccion SL. A prospective ...uation of a new physical examination in predict... glenoid labral tears. Am J Sports Med. 1996; ...721-5.

Kibler WB. Specificity and sensitivity of the ante... slide test in throwing athletes with superior glen... labral tears. Arthroscopy. 1995;11:296-300.

Stetson WB, Templin K. The crank test, the ...ien test, and routine magnetic resonance imaging scans in the diagnosis of labral tears. Am J Sports Med. 2002;30:806-9.

51. McFarland EG, Kim TK, Savino RM. Clinical assessment of three common tests for superior labral anterior-posterior lesions. Am J Sports Med. 2002; 30:810-5.

52. Jobe CM. Superior glenoid impingement. Current concepts. Clin Orthop Relat Res. 1996; 330:98-107.

53. Kim SH, Ha KI, Ahn JH, Kim SH, Choi HJ. Biceps load test II: A clinical test for SLAP lesions of the shoulder. Arthroscopy. 2001;17:160-4.

54. Mimori K, Muneta T, Nakagawa T, Shinomiya K. A new pain provocation test for superior labral tears of the shoulder. Am J Sports Med. 1999;27:137-42.

55. Westerheide KJ, Karzel RP. Ganglion cysts of the shoulder: technique of arthroscopic decompression and fixation of associated type II superior labral anterior to posterior lesions. Orthop Clin North Am. 2003;34:521-8.

56. Panossian VR, Mihata T, Tibone JE, Fitzpatrick MJ, McGarry MH, Lee TQ. Biomechanical analysis of isolated type II SLAP lesions and repair. J Shoulder Elbow Surg. 2005;14:529-34.