Anatomy, Assesment, and Surgery of the Biceps Tendon

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Functional Anatomy

The long head of the biceps (LHB) attaches to its origin at the supraglenoid tubercle of the scapula where it meets the glenoid labrum [1–3]. This origin is fairly broad with a mean diameter of 6.6 mm (range 4.5–12) [4]. The insertion point is located medial to the articular rim of the glenoid and creates a subsynovial recess, which may be positioned variably [2]. Although multiple anatomic variants exist 86% of patients possess typical anatomy [5].

There are four large groups of anatomic variation in the intraarticular portion of the LHB, which are determined by LHB migration during embryonic growth [6]. The Meso group has free movement beneath the rotator cuff, the adherent group has a LHB adherent to the rotator cuff (Fig. 26.1), the split group has a LHB divided intraarticularly, and there is also an absence of the LHB [7].

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The complex vascularization of the proximal LHB is composed of ascending vessels of the anterior humeral circumflex artery [8, 9]. Branches of the brachial and deep brachial arteries supply the more distal aspects of the LHB [8, 9]. In the region where the tendon slides in the groove, 1.2–3 cm from the origin, the tissue is poorly supplied which may contribute to tendon rupture pathology [10].

The intraarticular portion of the LHBTs diameter is 5.1 mm on average (range 3–7 mm) [4] and distally the tendons slide 18 mm inside the

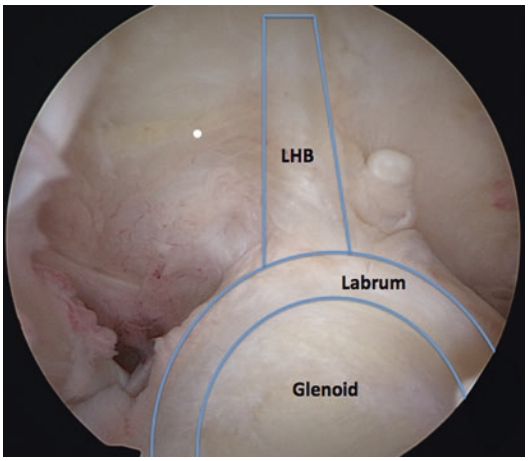

Fig. 26.1 Adherent long head of the biceps tendon pathology demonstrated in an arthroscopic image

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joint to achieve anterior flexion and internal rotation movements [11]. Once the tendon enters the bicipital groove of the hummers, the LHBT twists 30–40° [12]. The bicipital groove is located between the greater and lesser tuberosity of the anterior humerus. The grooves 4 mm depth and opening angle stabilize the LHBT in collaboration with the transvers ligament and biceps pulley [13]. The biceps pulley is composed of the superior glenoid humeral ligament and coracohumeral ligament, which are associated with subscapularis and supraspinatus tendons.

The coracoid apophysis serves as the origin of the short head of the biceps (SHB) as well as other structures. The SHB contributes the medial aspect of the bicep mass. Distally the short and long heads combine to create one muscle belly and they insert in two layers to the radial tuberosity and to the bicipital aponeurosis fanning out over the medial aspect of the forearm flexors. The muscle mass of the biceps confers the flexion function of the elbow as well as supination [14, 15]. As the arm progresses from external to internal rotation, the tendon is displaced medially and superiorly, contacting the lesser tubercle and the transverse ligament [13]. The innervation of the biceps if derived from the musculocutaneous nerve.

Clinical Presentation and Physical Examination

The clinical presentation and physical examination of LHBT pathology is challenging even for experienced clinicians. The physical exam should begin with a detail history followed by a focused and systematic physical examination. A detailed patient history documenting the type of pain, catching, snapping, deformity, weakness and other complaints is key. Understanding mechanism of injury and acuity of injury may offer insight into both acute and chronic pathologies. Many patients with biceps pathology describe anterior shoulder pain that is exacerbated by lifting and or elevated pulling motions. This pain will most often localize to the anterior arm in line with the bicipital groove and intensify with movement. Anterior pain may help to delineate shoulder pathology specific to LHBT pathology. Overhead sports activities are likely in the history of patients we LBHT pathology. Understanding aggravating motions and unstable positions also help to differentiate LBHT pathology from other causes of shoulder pain.

Inspection of the upper extremity with comparison of the contralateral limb should be conducted first during the physical examination. It is crucial to maintain a high index of suspicion for subtle atrophy, deformity, swelling and ecchymosis while comparing the injured limb to the pain free extremity. In the case of marked deformity such as a “Popeye’s” deformity inspection alone may be sufficient to diagnose complete rupture of the LHBT.

The patient’s limbs should then be palpated for tenderness. Tenderness of the LHBT is best palpated with the patients arm placed in 10° of external rotation so the bicipital groove faces anteriorly (Fig. 26.2). Tendinitis localized to the bicipital groove is not typical in patients presenting with acute injury. However, partial rupture or full rupture of the biceps tendon may be suspected in patients with preexisting tendinitis. Structures adjacent to the bicipital groove should be palpated for tenderness as well, as the differential diagnosis for anterior shoulder pain includes acromioclavicular joint pathologies (Fig. 26.3), adhesive

Fig. 26.2 Tenderness of the long head of the biceps tendon can be palpated with the patients arm placed in 10 degrees of external rotation so the bicipital groove faces anteriorly

Fig. 26.3 Physical examination manuver demonstrating test to illicit pain in acromioclavicular joint pathologies

capsulitis, subacromial impingement, and coracoid impingement.

The neurovascular examination bilaterally of the upper extremities should be employed to assess motor strength, movement, and sensation. Both active and passive range of motion should be measured and recorded.

The structures above and below the area of pain should be inspected and palpated as the source of pain may be referred from the cervical spine or the elbow.

Pathologies

Biceps Tendonitis

Biceps tendonitis is characterized by anterior shoulder pain. Patients who regularly participate in repetitive lifting, pulling, reaching, and throwing motions in their work or during sport activities are likely to develop biceps tendonitis. Biceps tendonitis is more common in older individuals and may be associated with comorbid shoulder pathologies. Inflammation and painful motions in the shoulder are common and pain should be elicited on palpation of the bicipital groove with the patients arm held in 10° of internal rotation.

Rupture and Tears

Proximal rupture of the biceps may cause a sudden and painful popping sensation that the patient reports on examination. A retraced muscle belly may be clearly visible bulging over the anterior proximal portion of the arm, commonly known as the "Popeye" deformity. In patients without acute traumatic injuries, the biceps tendon rupture is usually preceded by a history of shoulder pain that quickly resolves after a painful audible snap occurs. Partial tears do not present with Popeye deformity but a patient may report a traumatic injury during motion followed by pain and even bruising. It may be difficult to differentiate biceps tendon tear from tendonitis based on history and physical examination alone.

Distal biceps avulsions are another rare pathology more commonly seen in older individuals. These injuries are most often acute traumatic injuries where the biceps is torn form its distal insertion on the radial tuberosity. Most often this is caused by eccentric overload in the dominant extremity and the patient may report pain in the anticubital fossa. There may be an audible pop at the time of injury. Distal biceps avulsions may present with proximal displacement of the biceps muscle belly that has been referred to as the "Reverse Popeye" sign.

Entrapment of the Biceps Tendon

Entrapment of the LHBT occurs due to inflammation and hypertrophy of the LHBT inside the joint. The increased biceps tendon diameter prevents the tendon from sliding in the bicipital groove due to physical blockade caused by the transverse ligament and or biceps pulley [16] who's functions are to stabilize the biceps in the bicipital groove thereby preventing a bowstring effect. Patients present with anterior shoulder pain and pain on forward motion of the shoulder especially with elbow extension. This pathology is often associated with rotator cuff rupture [16].

Superior Labral Anterior to Posterior Tears (SLAP)

SLAP tears are a common pathology in effecting the integrity of the glenoid labrum and the LHBT at their attachment point overlying the glenoid labrum. These injuries are often caused by repetitive overhead activities such as in throwing athletes. The presenting symptoms include but are

not limited to non-specific deep shoulder pain, anterior shoulder pain, popping or clicking, weakness or muscle fatigue. The culprit traumatic injury associated with SLAP tears is often asymptomatic for a period of time know as the "Lag Time".

Instability

Shoulder instability and subluxation is associated with biceps degeneration due to chronic tendinitis. Instability or subluxation may cause palpable snapping of the tendon felt during painful arcs of motion such as during the throwing motion. Superior Labrum Anterior to Posterior (SLAP) tears can present with a similar clinical picture, however SLAP tears are prone to locking and catching symptoms over snapping.

Calcific Tendonitis

This condition is more common in women and mainly affects patients ages 30–60. It is associated with subacromial impingement. Risk factors include hypothyroidism and diabetes. The history will most generally show atraumatic pain, with catching and crepitus in addition to a decreased range of motion and mechanical blocking.

The differential diagnosis of shoulder complaints incudes the various conditions mentioned above as well as many others. Pathology of the biceps can be secondary to acute traumatic injury, overuse, vascular disruptions, impingement and other causes. There are many maneuvers that are sensitive for detecting pathology in the shoulder joint but due to overlapping elicitation of pain with similar maneuvers the tests are not specific [17, 18].

Tests

Although, many physical exam maneuvers are available to the experienced clinician, this chapter focuses on those that are common and most contributory to general examination of the LHBT. No maneuver has been shown to dependably diagnose LHBT pathology alone and they should be used in cohort with a detailed anamnesis of the patient and imaging studies. Generally the biceps tendon may be ruptured in three locations, both the proximal and distal insertions as well as in the muscle belly. Full rupture of the distal insertion of the biceps tendon is a relatively strait forward diagnosis as it most often presents with "Popeye" sign, ecchymosis, positive uppercut test (pain on flexion and supination against resistance) with associated radiological findings. However, diagnosing rupture of the proximal insertion of the LHBT becomes a challenging diagnosis, as it is an intra-articular pathology that articulates directly with the glenoid labrum and is encompassed by many surrounding tissues. These challenging diagnoses and the diagnosis of other LHBT pathology require the use of the maneuvers described below in order to direct the use of imaging technologies and patient treatment.

Yergasons Test

This test provokes pain and tenderness over the bicipital groove with forearm supination against resistance. The examiner "shakes the patients hand" with the forearm in neutral position, the elbow is flexed 90° and tight to the body. The patient resists supination, while the examiner palpates the bicipital groove [19] (Fig. 26.4). Pain elicited by this test indicates either a LHBT tear, Labral tear or both, but may be more suggestive of a biceps tear as the biceps is the primary flexor of the forearm and is also a supinator. This test

Fig. 26.4 The examiner is performing Yergason's test

may also illicit pain due to tendinopathy or tendinitis of the LHBT [20].

O'Brien's Test

This test is provocative of pain originating at the attachment of the superior labrum. With the elbow fully extended and the arm adducted to cross the midline, the patient raises their arm against resistance with their thumb pointing upwards and then downwards (Fig. 26.5a, b). Pain elicited with the thumb in the upwards position is more specific to LHBT pathology while the downward position may be more specific for labral tears. These maneuvers are sensitive for SLAP tear, biceps tendinitis and rupture but are not specific [20].

Speed's Test

Pain elicited in the bicipital groove by Speed's test indicates a LHBT tear, Labral tear or both [21]. With the hand extended in full supination and 90° flexion of the shoulder with a strait elbow the patient resists forward flexion (Fig. 26.6).

Upper Cut Test

The elbow is flexed to 90°, the shoulder is neutral and the forearm is supinated. The patient raises their fist to their chin against resistance (Fig. 26.7). Shoulder pain or anterior pop indicates a positive test. Utilization of the speed and upper cut tests in together was shown to be superior to either test alone [20, 22].

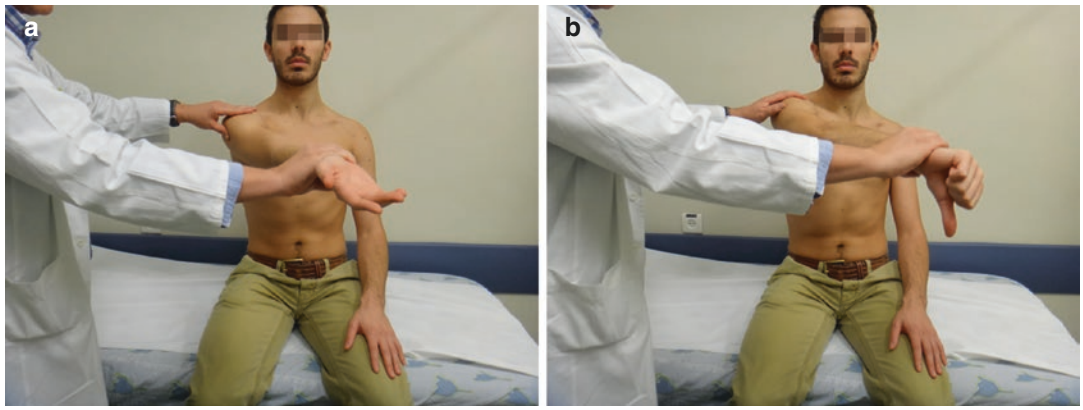

Fig. 26.5 (**a**) The examiner is performing O'Brien's test first with the upward position and then in the (b) downward position

Fig. 26.6 The examiner is performing Speed's test

Fig. 26.7 The examiner is performing the uppercut test

Jobe's Empty Can Test

Due to its intimate location at the rotator cuff interval the long head of the biceps may be involved in impingement and rotator cuff pathologies. Impingement and rotator cuff tests can be positive in the presence of biceps pathology. The empty can test [23] evaluates the strength of the supraspinatus tendon. It is performed with each shoulder in 90° of abduction and 30° of forward flexion and internal rotation so the thumb is pointed to the floor (Fig. 26.8). This test is performed both passively and against active resistance. Weakness or inability to maintain this position passively may demonstrate supraspinatus tear or rotator cuff impingement [24].

Dislocation and subluxation of the medial biceps tendon are caused by disturbance to the biceps pulley anatomy. This pathology is often seen together with subscapularis tears [25]. A click may be palpated with the arm abducted at 90° and guided into external rotation. Palpation may demonstrate full dislocation of the tendon with the tendon displaced and located anterior to the lesser tuberosity [26, 27].

Horn Blowers Sign

This test evaluates the infraspinatus and teres minor [28]. The patient's arm is abducted to 90°, with external rotation of the shoulder to 90° and the palm facing forward. If the patient can maintain the position passively the examiner adds active resistance to the dorsal aspect of the hand anteriorly and caudally [29].

Lift Off Test and Belly Press Test

To examine the subscapularis muscle two main tests are employed. In the lift off test [30] the patient places the dorsal aspect of their hand in the small of the back or on their buttock and try to lift their hand against resistance without breaking their wrist. In the belly press test [31] the patient places their palm on their umbilicus and try to lift their arm off their abdomen against the examiners resistance without breaking their wrist or internally rotating their shoulder [32] (Fig. 26.9).

Biceps Load Test

The patient's arm is held in 90° abduction of the shoulder with 90° flexion of the elbow and external rotation [33, 34]. Then the patient draws the arm into external rotation until the end of their range of motion. The patient flexes against resistance in this position. Pain elicited by this test may indicate a LHBT tear, Labral tear or both [33, 35].

Hawkins-Kennedy Test

The patient's humerus is flexed forward to 90° and the examiner internally rotates the shoulder

Fig. 26.8 The examiner is performing Jobe's empty can test

Fig. 26.9 The examiner is performing the belly press test

[36]. This test may reproduce pain due to impingement and has relatively high sensitivities for bursitis and rotator cuff abnormalities [36–38]. The bicipital groove is also provoked in this test as it becomes in direct contact with the acromion.

Selective Injection

The use of selective injections in cohort with the various maneuvers described above may clarify the clinical picture of a patient presenting with LHBT pathology [39]. Selective injections help to differentiate LHBT pathology from other causes of shoulder pain as well as pain referred from surrounding structures such as the cervical spine [40]. Ultrasound (US) guided injection is essential to ensuring accurate delivery of the analgesic to the proper location and to ensure the safety of the injection, preventing rupture of the LHBT. The injection can be delivered to the subacromial reign to alleviate the symptoms of impingement. If impingement is ruled out after subacromial injection and anterior pain remains, injection to the bicipital groove can further clarify pathology. If reduction of pain is seen after bicipital groove injection, this suggests LHB pathology. An examiner can further perform intra-articular injection when evaluating a suspected intra-articular origin of pain including SLAP tear or adhesive capsulitis.

Imaging

The use of imaging studies in relation to the physical exam can help in the evaluation and treatment of biceps tendon pathology. As with the use of all imaging technologies it is important to consider the advantages, exposure risks, costs, and accessibility of each imaging modality. Plain radiographs are ubiquitous, easily accessible and supply immediate results. Therefore, it essential that the clinician adopt a systemic approach in order to fully evaluate and utilize the plain film in the assessment and evaluation of each patient. Shoulder pain is often evaluated with three orthogonal plane film views. The anteroposterior (AP), scapular Y view (Trans scapular view), and axillary views are commonly taken. The bicipital groove view [13] (Fig. 26.10) can be useful in specific circumstances. This view serves to measure the depth and width of the groove as well as the slope of its medial wall in degenerative cases and instability of the LHB [13].

Fig. 26.10 This image is an X-ray demonstrating the bicipital groove view

Additional films in alternate radiographic views can be taken based on an examiners clinical suspicion. Though the majority of pathologies in the shoulder are related to soft tissue injuries, CT scans can be employed to obtain superior imaging of the bony anatomy as well as auxiliary testing for those patients with contraindications to MRI. Ultrasound (US) imaging plays a role in the diagnosis of shoulder pathologies, as it is a non-invasive, low cost, and low exposure technique. Specifically, US can demonstrate tendon or muscle rupture and inflammation in addition to assistance in localizing the LHBT in the humeral groove (Fig. 26.11a, b).

US can be used a tool to help excluded pathology as it can show the rotator cuff musculature dynamically. US aids in localization of pain by giving real time feedback upon palpation of underling anatomical structures with the US probe. The viewer can visualize subluxation and dislocation of the biceps tendon with external rotation in real time. US can help to diagnose rupture or partial rupture as well as hourglass

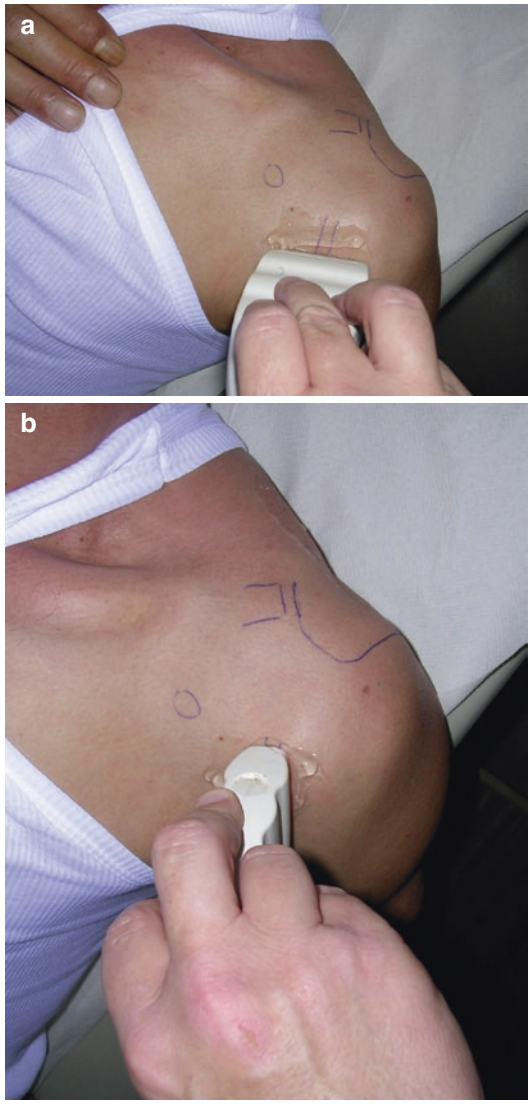

Fig. 26.11 The examiner is demonstrating ultra sound imaging technique for viewing the long head of the biceps tendon

appearance of the biceps tendon where the tendon is entrapped and cannot slide freely in the bicipital groove. Fluid can be seen on US around the biceps tendon, which may be secondary to primary bicipital biceps tendonitis or secondary to adhesive capsulitis, osteoarthritis, rotator cuff pathology or other mechanisms [41, 42].

Both Magnetic Resonance Imaging (MRI) and MRI arteriogram are regularly employed to visualize the biceps tendon and pathology of the shoulder joint. Axial and sagittal oblique views may provide superior visualization of the biceps tendon to other views. Unfortunately, even though MRI is a useful tool for non-invasive soft tissue inspection, the findings often correlated poorly with those seen directly by arthroscopy [43, 44]. Contrast materials improve the sensitivity and specificity of biceps pathology diagnoses aided by MRI [45, 46].

Classification

To the best of our knowledge there are no widely used classification systems solely employed for the description of isolated biceps tendon tears. Tears may be described according to the severity of the tear, location in relation to surrounding structures, and with regard to the length, width, and thickness. Multiple classification systems exit to classify SLAP tears, which include LHBT involvement. These classification systems include the original Snyder Classification [47] (types 1–4) and the Maffet Sub-Classification [48] (which adds types 5–7) as described below.

Type 1: Degenerative fraying of the superior labrum with intact biceps anchor.

Type 2: Detachment of the superior labrum and biceps tendon from the glenoid rim.

Type 3: Bucket-handle tear of labrum with intact biceps anchor.

Type 4: Bucket-handle tear of labrum extended into the biceps tendon.

Type 5: SLAP tear with anterior inferior extension.

Type 6: Anterior or posterior flap tear with the bucket handle tear.

Type 7: SLAP with extension to the glenohumeral ligament.

Nonsurgical Treatment

Although outcomes of operative procedures may be very good and reliable, nonsurgical treatment of biceps tendon pathology is the first and preferred treatment modality [49]. Tendinitis of the biceps tendon should first be treated with rest,

modification of activity, non-steroidal anti-inflammatory medication and physical therapy. Physical therapy should be targeted at both the biceps tendon pathology and contaminant pathologies. Bicipital sheath steroid injections may offer adequate pain relief for symptomatic patients. This procedure can be performed under US [50]. Once a patient has failed a comprehensive course of conservative management or if a patient presents with marked injury requiring surgical interventions, invasive procedures may be considered.

Surgical Treatment

There are many effective procedures available for treatment of biceps pathology. In order to choose the optimal procedure a patients age, activity level, and expectations must always be taken into account. Decompression and or debridement are often suitable to treat minor tendon tears or fraying of the biceps tendon [51]. Biceps tenotomy usually consists of intra-articular dissection of the LHBT. Tenotomy of the biceps is more suitable of patients without physical demands or when an athlete requires a hasty return to activity [52]. The advantages and disadvantages of tenotomy must also be considered. Although tenotomy is a relatively simple surgical technique and does not require immobilization the procedure causes distal displacement of the muscle belly often with fatigue and muscle cramping [53, 54].

Tenodesis is a popular treatment for young active patients with tearing, subluxation, dislocation, or hourglass deformity [55]. However tenodesis is not a preferred procedure in individuals with full thickness biceps tendon rupture unless the patient prefers tenodesis due to cosmetic reasons, such as in a body builder. This procedure begins with detachment of the LHBT followed by reattachment of the tendon on the humerus. Tenodesis is often performed simultaneously with procedures to remedy concurrent shoulder pathology such as rotator cuff tears. Biceps tenodesis often is able to prevent atrophy while preserving muscle strength, function and cosmetic appearance [56, 57]. This technique does not require significant post surgical immobilization or prolonged rehabilitation. However, compared to tenotomy, tenodesis is a more challenging procedure and necessitates longer rehabilitation and immobilization for the patient. Fixation failure is a possible complication [12].

Procedures for SLAP tears include debridement, SLAP repair, and tenotomy or tenodesis. The optimal procedure for SLAP repair is most often chosen based on the classification of the SLAP tear. Type I lesions are most often treated with debridement. In patients with Type II SLAP tears arthroscopic debridement and reattachment of the biceps tendon to the superior glenoid rim is common. In type III SLAP tears the bucket handle tear is excised and the biceps anchor may be repaired in the case of anchor instability. Surgical intervention for type IV SLAP tears depends upon the degree of biceps tendon involvement. In cases with minimal biceps involvement the biceps anchor may be left intact and the pathological portion resected. In cases of extensive biceps tendon involvement age is an important factor in considering reattachment of the labrum and biceps tendon to the glenoid rim or biceps tenodesis. However, arthroscopic biceps screw arthrodesis performed at the articular margin is the preferred procedure and results in a low surgical revision rate, a low rate of residual pain, and significant improvement in objective shoulder outcome scores [58].

LHBT entrapment resulting in hourglass deformity of the biceps tendon is usually treated with isolated biceps tenotomy or tenodesis. Choosing the optimal operative procedure is based on a patient's age, expectations, contaminant pathology, surgeon preference and skills. In both tenotomy and tenodesis it is important that the intraarticular area of hypertrophy of the biceps tendon is excised to resolve the mechanical block. Tenodesis is the preferred technique in LHBT entrapment with hourglass deformity [16].

Postoperative Rehabilitation

The postoperative rehabilitation protocols for biceps tenodesis begin with immediate initiation of pendulum exercises. Both active and passive exercises are begun 7–10 days postoperatively.

Finally, active exercises are begun 6 weeks post surgery with regular rehabilitation follow up visits. All rehabilitation protocols should be individualized to fit the needs, recovery trajectory, range of motion progress and pain level of the patient. However, in the case of biceps tenodesis the patient often has undergone simultaneous procedures for contaminant pathology. The additional surgical procedures should be taken into account when designing postoperative rehabilitation protocols and goals for each patient.

In biceps tenotomy care must be taken not to extend the elbow beyond 45° for the first 3 weeks. It is also important to exclude active biceps flexion for the first 6 weeks. As always, managing patient expectations and encouraging communication between the patient and clinician is vital to successful surgical procedures and postoperative rehabilitation.

Questions

1. Please find the false statement about biceps tendon pathologies
   A. Distal tendon rupture of biceps is less common than proximal rupture
   B. Biceps tendonitis is characterized by anterior shoulder pain
   C. 'Reverse Popeye sign' is specific for proximal tendon avulsions
   D. It may be difficult to differentiate partial biceps tendon tear from tendonitis based on history and physical examination alone
   E. Entrapment of the biceps tendon is usually associated with rotator cuff tendon rupture
   C.

2. In which patients do the authors recommend tenodesis instead of tenotomy only?
   A. Elderly patients with rotator cuff tear
   B. Patients with shoulder pain due to arthritis
   C. Adhesive capsulitis
   D. Rotator cuff rupture
   E. Young athletic patients
   E. Although studies do not show any superiority of tenodesis vs tenotomy, tenodesis is recommended in young patients who participate in sports. The incidence of muscle spasm and cramping may be reduced in tenodesis patients as compared to tenotomy patients. Cosmetic appearance is another indication for tenodesis.

What is new?

What if a patient does not pursue any treatment for his/her biceps tendon rupture?

Chronic rupture of the long head of the biceps tendon: comparison of 2-year results following primary versus revision open subpectoral biceps tenodesis, Archives of Orthopaedic and Trauma Surgery, May 2016, Euler SA.

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