ANATOMY

The long head of the biceps brachii tendon (LHB) has been long recognised as a common source of shoulder pain. There are unique anatomical and biomechanical features of the tendon, which make it so vulnerable.

The biceps brachii muscle has two tendons. The short head shares common attachment with coracobrachial muscle at the coracoid process. The long head courses proximally in the intertubercular groove (extra-articular portion) inside the shoulder joint over the humeral head to its insertion into the superior glenoid labrum (intra-articular portion) (Figure 1). The proximal, intra-articular portion of the tendon is more richly vascularized and has rich sensory and sympathetic innervation. This portion is also subject to shearing, frictional and compression forces, whereas distal, extra-articular portion is only exposed to tension strain. Another important anatomical structure is a soft-tissue sling, “so-called” biceps pulley, which stabilizes biceps tendon at its entrance to bicipital groove (Figure 2). This biceps reflection pulley is built by fibres of the coracohumeral ligament, superior glenohumeral ligament and subscapularis tendinous slip (Figure 3). Phylogenetic evolution in humans (as we became bipeds) might explain why the bicipital groove moved from mid lateral position on proximal humerus more anteriorly and thus increases medial dislocation forces on LHB. This is one of the reasons that results in pathologic interaction between the biceps tendon and its surrounding tissue.

FUNCTION OF LHB TENDON

The function of the biceps muscle at the elbow has been very well defined as predominantly forearm supinator and weak elbow flexor. Of the muscles of the arm that provide the large deceleration forces in the follow-through phase of throwing, only the biceps brachii traverses both the elbow joint and the shoulder joint. It is not known how much load is within the normal physiological range for the LHB tendon, with calculations and predictions varying from 11 to 55N.

A majority of biomechanical studies were done on cadaveric models investigating contribution of LHB tendon to glenohumeral stability, restraining abnormal translations. The cadaveric testing has limitations in recreating dynamic interplay of different muscles around the shoulder in active movement. There are some in vivo biomechanical studies which use radiographic models to measure the humeral head vertical translations. They found a significant superior translation of the humeral head at different degrees of abduction in patients with LHB rupture.
Another study showed that activation of LHB has significant depression effect on humeral head in different angles of abduction in patients with rotator cuff tears. Intraoperative electrical stimulation of LHB during arthroscopy showed a compression of glenohumeral joint. Interestingly, electromyographic studies show that LHB activates with elbow flexion and extension, rather than with shoulder motion. In spite of well-documented results, there are concerns about accuracy of the radiographic models used. It is difficult to generate true antero-posterior radiographs due to 3-dimensional movement of scapula during arm elevation. The conclusion from in vivo studies is that because of a lack of applicable methods, there is almost no definitive evidence about the actual function of the LHB.

**MOST COMMON LHB PATHOLOGIES**

LHB disorders are common in adult population with an overall incidence between 29% and 66%. LHB pathology is mostly present at its intraarticular portion. Two most common anatomical sites of LHB pathology are its origin known as superior labral tear from anterior to posterior (SLAP) lesion. This is due to the location of superior labrum extending from anterior to posterior (Figure 4), and as it enters the bicipital sulcus (biceps instability), especially in conjunction with subscapularis tears. Proximal biceps tendinitis has typically been characterized as a secondary process due to SLAP or LHB instability, overuse and overload or surrounding shoulder pathology, such as rotator cuff lesions. LHB tendon rupture is also common in individuals older than 50 years with chronic tendinitis and concomitant rotator cuff pathology.

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**Figure 1:** Left shoulder arthroscopy. Long head of biceps insertion.

**Figure 2:** Left shoulder arthroscopy. ↓ = Entrance into the bicipital groove, ✯ = Posterior biceps pulley, Ω = Anterior biceps pulley.

**Figure 3:** Right shoulder arthroscopy. Anterior pulley structure.

**Figure 4:** Right shoulder SLAP lesion. ✯ = detached biceps anchor, ∆ = shaver in-between detached biceps anchor and glenoid.

LHB = long head of the biceps, HH = humeral head, G = glenoid, L = labrum, MCHL = medial band of coracohumeral ligament; SGHL = superior glenohumeral ligament, SSC = subscapularis tendon.
Overhead athletes and "dead arm" syndrome

The overhead sports most commonly involved are throwing sports such as baseball (pitchers), volleyball, handball or tennis. However, non-throwing overhead sports including swimming, gymnastics, cross fit and kite surfing have also been shown to produce pathological changes of LHB. One of the mechanisms of injury of the superior labrum together with LHB insertion from the glenoid (SLAP) is torsional "peel-back" mechanism in late cocking phase of throwing. It can be caused by a single traumatic event or by recurrent micro-traumas. The throwers describe this condition as an inability to throw at their preinjury velocity and control because of a combination of pain and subjective unease in the shoulder. The accompanying shoulder biomechanics alterations presented with SLAP lesions are marked internal rotation deficits, as measured with the arm in 90° abducted position, caused by an acquired tight posteroinferior capsule referred to as gleno-humeral internal rotation deficit (GIRD) and scapular dyskinesia. Whether these two conditions are true pathologic or adaptive is not known. Restoration of both conditions with guided physiotherapy usually resolves shoulder pain and improves its function.

LHB tendon rupture

The most common site of tendon rupture is proximal insertion and less often distally near the musculotendinous junction. The underlying cause is intra-articular degenerative process of the tendon due to specific multidirectional force distribution and segmental blood supply. LHB tendon rupture accounts for 96% of all biceps brachii injuries and is most common in patients over 50 years of age. After rupture the muscle belly moves distally (more frequently in men) resulting in a characteristic Popeye deformity. Pain relief after spontaneous long head ruptures is a common finding, which confirms its role as a pain generator.

CLINICAL PRESENTATION OF LHB PATHOLOGY

Physical examination for LHB pathology is one of the most challenging and probably the least reliable entity in shoulder diagnostics. This is due to usually concomitant soft tissue pathology of the rotator cuff or glenoid labrum, and cartilage disease, which interfere at the time of testing. There is also no known pain pattern specific for the biceps tendon.

Several kinds of compression/rotation tests have been proposed for SLAP lesions but they’re also inconsistent and all have proven difficult to validate. Precise patient history with description of the mechanism of injury has been one of the key diagnostic values. In partial biceps tendon tears the Speed’s test had a sensitivity of 50% and a specificity of 67%. Tenderness over the bicipital groove doesn’t add much to examination value and is rather non-specific for biceps tendon injury, especially in obese or heavily muscled subjects.

Shoulder examination should exclude also concomitant scapular dyskinesia and GIRD.

DIAGNOSTICS

The origin and the intra-articular course of the LHB can be best seen with magnetic resonance imaging (MRI) or computer tomography (CT) arthrography. Although care must be taken because of the high incidence of false-positive radiological interpretations of SLAP lesions on MRI scans. In the case of LHB instability due to biceps pulley lesions, diagnostic ultrasound has an advantage, as it is a dynamic examination and can clearly show the upper, unstable part of the tendon.

Arthroscopy is by far the most accurate diagnostic investigation of the proximal biceps pathology. Stability of the LHB can be
easily assessed, as well as the intertubercular part of the tendon by pulling it inside the joint. Difficulty persists in the interpretation of what intraoperative findings represent, such as SLAP II lesions (Snyder classification), and what is normal variation requiring no treatment.

CONSERVATIVE TREATMENT

Comprehensive physiotherapy can be effective in almost all tendons’ pathological conditions unless there is clear evidence of structural disruption with mechanical symptoms due to tendon instability, hourglass deformity or concomitant rotator cuff tear.

Therapy is focused on better periscapular muscle control, muscle strengthening and stretching of the posterior capsule (sleeper stretch) in case of GIRD. Sometimes injection of steroid under ultrasound guidance is needed for persistent tenosynovitis in the bicipital groove.

SURGICAL TREATMENT

Surgical options for all LHB pathology are tenotomy or tenodesis. There is another more anatomical option for SLAP lesion by means of arthroscopic fixation of superior labrum together with biceps back onto the glenoid, using different types of suture anchors. LHB tenodesis includes release of the tendon from its origin and fixation to neighbouring soft tissue or to the humerus along its course. The simplest procedure is tenotomy by releasing the tendon at its origin and leaving it to slip down the groove.

Surgical treatment of LHB tendon is often recommended after failed conservative treatment in cases of isolated symptomatic pathology, such as SLAP II (or higher stages of Snyder classification), partial tears, hourglass deformity or in concomitant rotator cuff lesions, with biceps instability and tendinitis and finally at the time of shoulder arthroplasty.

Treatment of SLAP lesions is very specific in this group. Since its description in 1985, several biomechanical studies of type II lesions have investigated various repair techniques of suture anchor placement and optimal suture loop constructs without any clear advantage for specific repair type. SLAP repair residual symptoms are recently more studied and include persistent discomfort, loose hardware, persistent rotator cuff defects, articular cartilage injuries, persistent synovitis and low rates of return to sport.

Surgical trends in the treatment of SLAP lesions over the last few years have revealed a decreased rate of labral re-fixation, while the rate of biceps tenodesis and tenotomy has increased. This was found for SLAP tears with and without rotator cuff repair. Many biomechanical comparisons of different tenodesis techniques were published in favour of a bony fixation over soft tissue fixation. Most of them show superiority of interference screw fixation. On the other hand, newly developed intraosseous techniques like ABIT (arthroscopic biceps intraosseous tenodesis), or author’s preferred intraosseous cortical-bridge fixation, has shown higher failure loads compared with interference screws due to better absorption and restoration of energy of the construct.

Tenotomy vs Tenodesis

Tenotomy of LHB, as the quickest and well tolerated surgical option, has been reported to have complications, such as cosmetic deformity (Popeye deformity), cramp-like arm pain, decrease in elbow flexion strength, and fatigue discomfort. It seems that only male sex is a patient-related factor, which correlates with occurrence of Popeye deformity in 45% of these patients. Other patient-related factors such as age, involvement of the dominant arm, body mass index, elbow flexion strength and cramp-like arm pain are not correlated with deformity.

Tenodesis related complications have been described as intraoperative, such as neurovascular (musculocutaneous nerve entrapment) and humeral fractures. Post-operative complications include implant failure, bio-absorbable screw reaction, tenodesis failure due to biceps tendon rupture and persistent pain. Hsu et al found that tenodesis had a 25% incidence of cosmetic deformity.

There is no consensus on the ideal treatment of LHB pathology in the literature. Majority of the clinical studies compare tenotomies and tenodesis in concomitant rotator cuff repairs rather than isolated procedures. Few of them compare biceps strength and endurance, but rather contain

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subjective follow-up evaluation after tenotomy or tenodesis. In a recent clinical study done by Zhang et al, equal subjective results were found for tenotomy and tenodesis with suture anchors in patients older than 55 years with reparable rotator cuff tears at average follow-up of 2 years. A postoperative study on strength and endurance after tenotomy and tenodesis, done by Wittstein et al demonstrated subjective outcomes similar for both procedures, but decreased supination torque in the tenotomy group relative to the non-operative side and tenodesis.

ATHLETE’S PERFORMANCE AFTER SURGERY
Overhead athletes have a more difficult time recovering from SLAP repair compared with other athletes. Studies showed 73% of all athletes were able to return to their previous level of play, but only 63% in the subgroup of overhead athletes. The numbers are even lower for baseball pitchers where less than 50% were able to return to play. Risk of revision surgery has a significant association with age (older than 20 years) and throwing activity. Biceps tenodesis shows similar results in a recent study among baseball players where position players have an 80% rate of return to play whereas pitchers have only 16% rate of return to play. The results for both techniques are even worse in concomitant rotator cuff lesions where debridement or even repair is necessary.

SUMMARY
LHB tendon is the common source of pain in the shoulder with an overall incidence of up to 66% in the adult population. Its role in glenohumeral kinematics remains poorly understood. There are consistently more reports on biceps tendon injuries in overhead/throwing athletes. Biomechanics of throwing exposes the tendon to extreme shearing, compression and traction forces. Improper training, sports technical deficiencies along with overuse and overload are the most important related factors for potential LHB injury. Tenodesis has become a good surgical solution for all types of isolated and combined LHB pathologies for all nonoverhead/ nonthrowing athletes and for almost all overhead/throwing athletes, except pitchers in baseball. Treatment of the SLAP lesion in professional pitchers in baseball is still nowadays the most challenging task as both SLAP repair and biceps tenodesis have unsatisfactory success rates.
References


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