Technical Note

Arthroscopic Subdeltoid Transfer of the Long Head of the Biceps Tendon to the Conjoint Tendon

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Abstract: Surgical intervention is often recommended for refractory pathology affecting the biceps-labrum complex. Tenodesis of the long head of the biceps tendon (LHBT) is a widely accepted treatment modality; however, the optimal technique remains elusive. Arthroscopic subdeltoid transfer of the LHBT to the conjoint tendon, as described in this technical note, continues to demonstrate excellent clinical results. Its advantages include soft tissue—to—soft tissue healing, an advantageous biomechanical construct, and comprehensive evaluation and decompression of the LHBT including the extra-articular bicipital tunnel. The primary limitation of this procedure is the perceived learning curve for safe navigation within the subdeltoid space.

Historically, the long head of the biceps tendon (LHBT) and the superior labrum were considered independently as pain generators in the shoulder. More recent literature suggests an interdependence of these 2 structures now referred to as the *biceps-labrum complex*.[1-3]

In 2005, Verma et al.[4] described an all-arthroscopic subdeltoid technique for transfer of the LHBT to the conjoint tendon. In the appropriate patient population, this procedure reproducibly relieves pain generated by the biceps-labrum complex and reliably returns patients to function and sport.[5,6] Over the ensuing years, others have described modified versions of this procedure with positive clinical results.[7,8] The following technical note describes our most current procedural technique for the arthroscopic subdeltoid transfer of the LHBT to the conjoint tendon.

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Surgical Technique

The procedure is performed with the patient in the beach-chair position with the arm in a mechanical arm holder (Video 1). A thorough examination with the patient under anesthesia is performed. Arthroscopy fluid can be controlled via gravity inflow or use of a mechanical pump system with single inflow set at a pressure of 30 mm Hg.

Diagnostic Arthroscopy

Four arthroscopic portals are created: a standard posterior portal, a standard anterior rotator interval portal, a standard anterolateral portal, and a pec portal (Video, Fig 1). Diagnostic arthroscopy is then performed. The LHBT is inspected at its anchor to the superior labrum. Biceps chondromalacia—also referenced as a chondral imprint, biceps footprint, or humeral head abrasion—should be documented when present (Fig 2).[9-12] The arthroscopic O'Brien sign (active compression test) is useful for identifying incarceration of the LHBT between the humeral head and glenoid and should be performed before any additional portals are established (Fig 3).[13] The anterior rotator interval portal is established using spinal needle localization to ensure protection of the subscapularis tendon. Tethering the vincula can be identified with 90° of forward elevation and positioning the

Fig 1. Locations of the 4 arthroscopic portals required for the biceps transfer procedure on a right shoulder. Also identified is the location of the percutaneous spinal needle for PDS suture passage and long head of the biceps tendon tensioning. AL, standard anterolateral portal; ARI, standard anterior rotator interval portal; PP, pec portal; SN, spinal needle location; SP, standard posterior portal.

arthroscope to view down the bicipital tunnel. Evaluation of the extra-articular LHBT can be improved with humeral extension given the tendon's relative excursion[14,15] and pulling the tendon into the joint with a probe.

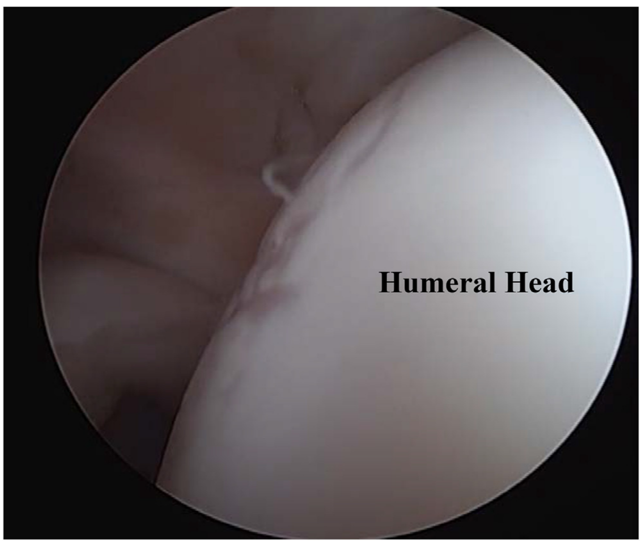

Fig 2. Arthroscopic image of a right shoulder with the patient in beach-chair positioning from the posterior viewing portal demonstrates medial humeral head biceps chondromalacia, which is a result of chronic incarceration of the long head of the biceps tendon between the humeral head and glenoid.

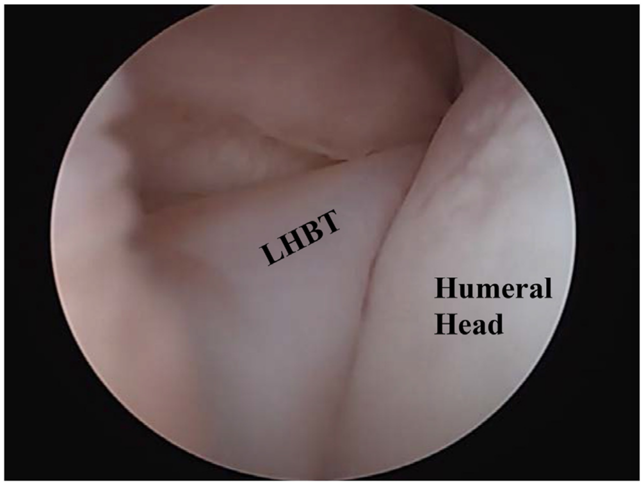

Fig 3. An arthroscopic image of a right shoulder with the patient in beach-chair positioning from the posterior viewing portal demonstrates incarceration of the long head of the biceps tendon between the humeral head and the glenoid as visualized during a positive arthroscopic O'Brien sign.

Tenotomy of the LHBT

The LHBT is released from its intra-articular insertion using either radiofrequency ablation device or arthroscopic scissors. Any remaining LHBT stump is debrided. Tagging the LHBT before tenotomy is unnecessary in this procedure.

Identifying the Conjoint Tendon for LHBT Transfer

The arthroscope is moved into the subacromial space via the posterior portal, and a thorough subacromial bursectomy is performed using a standard anterolateral working portal in line with the anterior margin of the acromion.[5,16] If acromioplasty is indicated, the coracoacromial ligament should be left in continuity to serve as a pathway to the coracoid process.

The arm is repositioned into 90° of forward flexion, 20° of abduction, and 90° of elbow flexion open the subdeltoid space (Fig 4). A cautery device is used to trace the anterior aspect of the coracoacromial ligament medially to the coracoid process. The subdeltoid bursa is lightly debrided to allow fluid extravasation into the deltoid space. The coracoid process is followed distally to identify the conjoint tendon, which is then traced further distally. The radiofrequency probe is used to release the clavipectoral fascia from the superficial margin of the conjoint tendon to insufflate the subdeltoid space with saline solution. The anterior rotator interval cannula is repositioned into the subdeltoid space and used for outflow.

The conjoint tendon can be traced distally to identify the pectoralis major tendon as it crosses the surgical field. The upper border of the pectoralis major tendon is then traced laterally to its insertion on the humerus. Once the conjoint tendon has been thoroughly exposed

Fig 4. The following intraoperative image shows a right shoulder with the patient in beach-chair positioning, with the arm positioned in 90° of forward flexion, 20° of abduction, and 90° of elbow flexion to allow the humeral head to fall posteriorly, opening up the subdeltoid space for the biceps transfer procedure.

as a medial landmark, a mechanical shaver is used to probe open the subdeltoid space and debride bursa. Frequently, there is a small perforating vessel connecting the deltoid and the distal lateral aspect of the bicipital tunnel approximately 1 cm proximal to the pectoralis major tendon, which should be cauterized.

Preparing the LHBT for Transfer

After exposure of the subdeltoid space, the arthroscope is moved into the anterolateral portal for the duration of the case. A pec portal is then created under spinal needle localization viewing from the anterolateral portal. The goal of the pec portal is to enter the subdeltoid space just proximal to the proximal margin of the pectoralis major tendon and allow for further work within the subdeltoid space to include identification of the LHBT, coagulation of the ascending branch of the anterior humeral circumflex vessels, manipulation of the LHBT, and its suture fixation to the conjoint tendon. After spinal needle localization, a skin-only incision is made in line with Langer lines, and a flexible canula is placed.

The conjoint tendon is further exposed, with special care not to injure underlying neurovascular structures. Although the musculocutaneous nerve is not typically within the working field, a blunt probe or switching stick should be used to elevate the conjoint tendon to ensure the nerve is not in danger because it enters the undersurface of the coracobrachialis muscle between 31 and 82 mm distal to the coracoid tip, at a mean of 56 mm.[17] If the musculocutaneous nerve is identified, care must be taken to protect against inadvertent injury. The underlying axillary vessels and their branches are not routinely visualized.

The LHBT is then palpated within zone 2 of the bicipital tunnel beneath its constraining sheath. The ascending branches of the anterior humeral circumflex vessels run along the lateral border of the bicipital tunnel and should be cauterized. Radiofrequency ablation device is then used to open the bicipital sheath along its lateral border and create an aperture from which the LHBT can be retrieved (Fig 5). The LHBT is withdrawn through the pec portal, and a FiberLink suture (Arthrex, Naples, FL) is passed around the proximal aspect of the LHBT for control and traction.

Percutaneous LHBT Alignment and Tensioning

A spinal needle is passed percutaneously, proximal to the coracoid process in line with the conjoint tendon. The typical entry point for the spinal needle is just medial to the coracoid tip and just off the anterior aspect of the clavicle (Fig 6). Once the spinal needle is in appropriate position, a PDS suture is passed through the spinal needle and retrieved out of the pec portal to shuttle the traction suture on the LHBT. This enables the LHBT to be pulled in a collinear fashion with the conjoint tendon and should be tensioned with the elbow flexed to 90°.

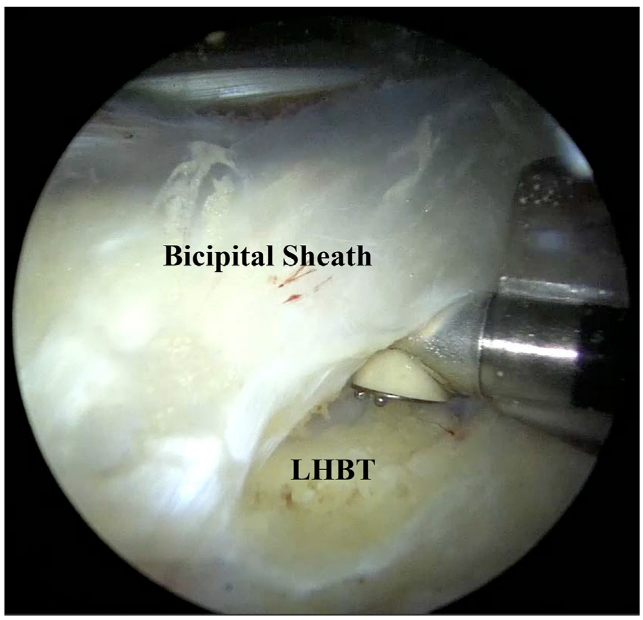

Fig 5. Arthroscopic image of a right shoulder with the patient in beach-chair positioning viewed from the anterolateral portal demonstrates the use of radiofrequency ablation to open the bicipital sheath along its lateral border by creating an aperture from which the long head of the biceps tendon (LHBT) can be retrieved for eventual transfer to the conjoint tendon.

Fig 6. Arthroscopic image of a right shoulder with the patient in beach-chair positioning with a view from the anterolateral portal demonstrates passage of a spinal needle percutaneously, proximal to the coracoid process, just off the anterior border of the clavicle in line with the conjoint tendon, which allows shuttling of a long head of the biceps tendon traction suture for appropriate tensioning during suture passage.

LHBT Transfer Suture Repair

With an assistant holding traction on the LHBT, a no. 2 suture is passed at the distal most aspect of the two tendons using a modified figure-of-eight configuration allowed the LHBT to be "log rolled" onto the superficial surface of the conjoint tendon. We use a self-passing and self-retrieving device (Scorpion Suture Passer; Arthrex). The device jaws are opened around the LHBT and then through the conjoint tendon from the deep surface to the superficial surface. The same limb is then reloaded and repassed through the LHBT in a similar fashion. Pulling tension on the inferior limb rolls the tendon onto the superficial surface of the conjoint tendon (Fig 7). The suture is tied with an arthroscopic knot-tying technique, securing the LHBT to the conjoint tendon. This process is repeated moving proximally for a total of 4 sutures spaced roughly 5 to 10 mm apart (Fig 8). Once the final suture is secured, the traction suture is retrieved out of the anterior portal and the excess LHBT is cut proximal to the most proximal suture and pulled out of the anterior portal. The elbow is then moved through full range of motion (ROM) while visualizing the transfer repair to ensure adequate fixation.

Bicipital Tunnel Decompression

A bicipital tunnel decompression is performed with radiofrequency ablation to completely unroof the bicipital tunnel in zones 1 and 2 (Fig 9). Special care is taken to avoid injury to the subscapularis tendon. Additional stenosis and synovitis of the bicipital groove can be resected with a mechanical shaver.

Rehabilitation Protocol

After the surgery, patients are discharged home the same day. The arm is immobilized in a sling for 4 weeks. Patients are allowed to come out of the sling for distal ROM, as well as active and active-assisted shoulder and elbow ROM against gravity only. For the first 4 weeks, they are instructed not to lift anything heavier than a cell phone in the affected upper extremity. Formal physical therapy begins after the 2-week postoperative visit. Patients can return to most activities of daily living unrestricted at 4 weeks after surgery and to sport in 3 to 4 months after surgery.

Discussion

The LHBT plays a well-established role in shoulder pathology and is a commonly recognized pain generator.[18,19] The current surgical options for biceps tendon pathology include tenodesis, tenotomy, and transfer. Arthroscopic transfer of the LHBT to the conjoint tendon was first described in 2005,[4] and both short-term and midterm outcome studies for the procedure demonstrate excellent clinical results.[5,6,20] Successful variants of the procedure have been described in the literature since then.[7,8] Independently, both biceps

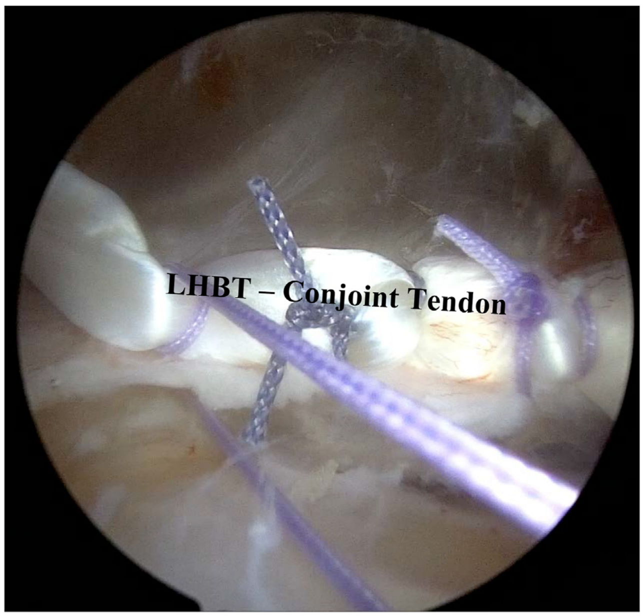

Fig 7. The following arthroscopic image, as viewed from the anterolateral portal, demonstrates a modified figure-of-eight suture technique, where the tensioning of the bottom limb of the suture pulls the long head of the biceps tendon (LHBT) anterior and medial relative to the conjoint tendon in a "log roll" technique.

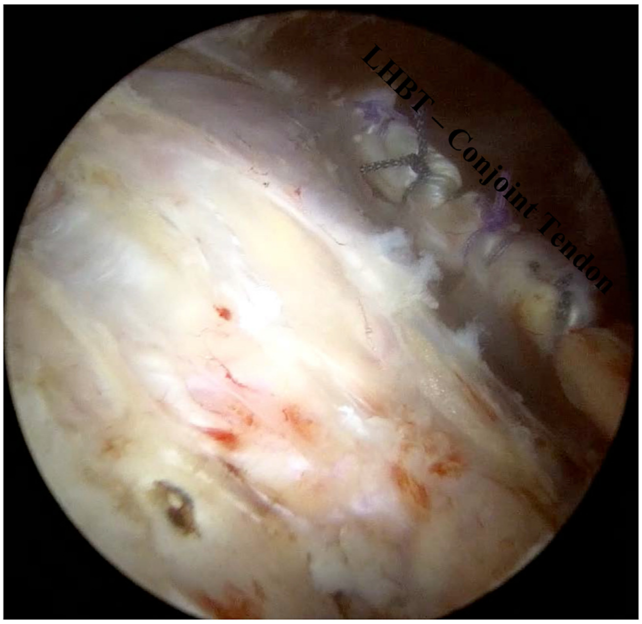

Fig 8. Arthroscopic image in a right shoulder in beach chair positioning viewed from the anterolateral portal demonstrating the completed biceps transfer construct with four sutures spaced roughly 5 to 10 mm apart and a complete bicipital tunnel decompression.

tenodesis and biceps transfer procedures have demonstrated good clinical outcomes. Although numerous studies have compared outcomes of biceps tenotomy to tenodesis, few have compared clinical results of biceps transfer to biceps tenodesis. However, one such study recently demonstrated that among high-level athletes who underwent either biceps tenodesis or biceps transfer, 73% of biceps transfer patients returned to their preoperative level of play, whereas 53% of biceps tenodesis patients returned to their preoperative level of play.[6]

Several tenodesis techniques have been described in the literature, but all traditionally include bony fixation of the LHBT to the proximal humerus. Animal studies indicate that bony tenodesis techniques, regardless of fixation type, experience their most robust healing reaction at the cortical surface compared to bone tunnels.[21,22] Furthermore, tendon-to-tendon healing has been shown to occur in a potentially regenerative manner, whereas tendon-to-bone healing proceeds through an inflammatory process.[21-23] Additionally, bone tunnels in the setting of biceps tenodesis act as a stress riser that can cause fracture of the humerus after surgery.[21,24,25] In fact, a database study cites the risk of humerus fracture at a non-negligible 1.4% of all biceps tenodesis procedures.[24] These findings suggest that bone tunnels are unnecessary for adequate tendon-to-bone healing and introduce the avoidable risk of fracture that does not exist in a purely soft tissue-to-soft tissue biceps transfer procedure.

All bony tenodesis procedures—whether via cortical button, interference screw, or suture anchors—carry with them the additional cost associated with hardware use. In contrast, the biceps transfer procedure utilizes suture only. In one study, the average material cost for biceps tenodesis hardware fixation was $514.32 compared to just $32.05 for soft-tissue fixation.[26] Importantly, this study also found no differences in healing as determined by ultrasound evaluation and clinical examination.[26] Another study similarly demonstrated equal biomechanical properties when comparing pull-out strength of intraosseous suprapectoral tenodesis to transfer to the conjoint tendon.[27] Pull-out strength was greater in the transfer specimens, although this was not statistically significant. Thus the biceps transfer procedure has the advantage of at least equal biomechanical strength and healing potential and can be achieved at a fraction of the cost compared to bony fixation.

There are technical aspects of the above-described arthroscopic subdeltoid biceps transfer that one is not afforded with traditional shoulder arthroscopy and bony tenodesis procedures. Studies have demonstrated that glenohumeral arthroscopy does not fully evaluate the biceps labral complex.[2] Taylor et al.[2] demonstrated that traditional arthroscopy visualizes just 55% of the length of the LHBT relative to the proximal margin of the pectoralis major tendon. This is a distinct advantage of subdeltoid arthroscopy—where complete visualization of the bicipital tunnel is achieved.[16] Additionally,

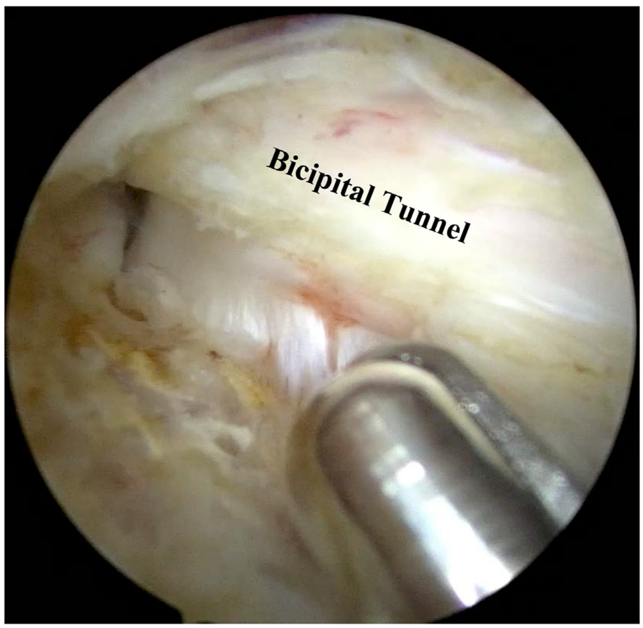

Fig 9. Arthroscopic image in a right shoulder in beach chair positioning viewed from the anterolateral portal demonstrating a completed bicipital tunnel decompression with unroofing of the bicipital sheath in zones 1 and 2.

Table 1. Pearls and Pitfalls

Pearls	
	Positioning the operative shoulder in 90° of forward flexion, 20° of abduction, and 90° of elbow flexion will better expose the subdeltoid space.
	Trace the anterior aspect of the coracoacromial ligament medially to identify the coracoid process.
	Reposition the anterior rotator interval cannula into the subdeltoid space to assist with outflow.
	A small perforating vessel at the distal lateral aspect of the bicipital tunnel approximately 1 cm proximal to the pectoralis major tendon should be identified and cauterized.
	The pec portal should be created under spinal needle localization with a skin-only incision to avoid damage to the cephalic vein.
	When retrieving the LHBT from the bicipital tunnel, cauterization of the ascending branch of the anterior humeral circumflex vessels along the lateral border of the tunnel is essential.
Pitfalls	
	Disregard for the musculocutaneous nerve at the undersurface of the conjoint tendon can lead to inadvertent damage during suture fixation of the tendon transfer.
	In cases of anomalous anatomy or revision surgery, special care should be taken to avoid neurovascular structures when in the subdeltoid space.

LHBT, long head of the biceps tendon.

decompression of the bicipital tunnel can be performed in subdeltoid arthroscopy, which allows the surgeon to address extra-articular biceps lesions in addition to intra-articular lesions.[2,28] Extra-articular lesions have been shown to be an important pain generator in biceps-labral pathology.[1,2,15,28,29]

Although there are technical factors, costs, and complications unique to each procedure that must be considered when determining the appropriate surgical interventions, the advantages of the above-described biceps transfer procedure are multifold. For one, it offers a biomechanically sound construct in a regenerative healing environment. It demonstrates equal, if not superior, clinical results and return-to-play rates compared to bony tenodesis. There is no significant cost or complication associated with hardware use. Finally, the addition of subdeltoid arthroscopy allows the surgeon to address all intra- and extra-articular biceps tendon pathology.

Table 2. Advantages and Disadvantages

Advantages	
	Biomechanically sound construct with soft tissue-to-soft tissue healing
	Allows comprehensive evaluation and decompression of the LHBT including the extra-articular bicipital tunnel
	Lower implant cost compared to bony tenodesis
Disadvantages	
	Subdeltoid arthroscopy is challenging and has a steep learning curve
	Slightly longer operative time compared to traditional biceps tenodesis techniques

LHBT, long head of the biceps tendon.

There are risks unique to the biceps transfer procedure. The pectoralis major tendon must be carefully avoided when releasing the bicipital tunnel. The LHBT must be transferred along the lateral aspect of the conjoint tendon to avoid injury to the musculocutaneous nerve and to prevent coracoid impingement. In rare instances of anomalous anatomy, one must take special care to avoid injury to the axillary artery and the surrounding neurovascular structures. Limitations of the biceps transfer procedure include the lack of randomized controlled studies comparing clinical outcomes of the procedure to the current standards of care and a steep learning curve for surgeons who are unfamiliar with subdeltoid arthroscopy. Pearls and pitfalls of the described technique are presented in Table 1, and advantages and disadvantages are listed in Table 2.

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