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TECHNIQUE

Biceps Transfer Using Subdeltoid Arthroscopy

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ABSTRACT

The diagnosis and treatment of biceps tendon pathology remain controversial. These patients may be more resistant to conservative treatment than those patients with standard subacromial impingement. When conservative treatment fails, surgical options should be explored. Tenotomy and tenodesis of the biceps tendon have been described, although persistent pain, deformity, and muscle cramping have been frequently reported. We describe a novel technique of biceps tenodesis by arthroscopic transfer of the long head of the biceps tendon to the anterior aspect of the lateral conjoint tendon using the subdeltoid space. The soft tissue transfer closely reproduces the native axis of pull of the biceps. It also allows soft tissue healing, which creates the normal "bungee" effect of the superior labrum/biceps anchor complex. This technique also allows the surgeon direct visualization during tenodesis to help prevent overtensioning of the tendon. Because of the early success of the procedure, we continue to use this technique with increasing frequency in appropriately indicated patients to access the anterior aspect of the shoulder extraarticularly.
Keywords: biceps transfer, subdeltoid arthroscopy, biceps tendonitis

INTRODUCTION/HISTORICAL PERSPECTIVE

The long head of the biceps tendon (LHBT) has been implicated as a source of shoulder pain and the surgical treatment of biceps lesions is well accepted. Multiple authors have proposed that the LHBT may play a role in shoulder stability, whereas others consider it a vestigial structure of limited clinical significance.[1–13] Although opinions differ on the function of the biceps within the shoulder, it is well accepted that the biceps tendon can serve as a significant source of pain within the shoulder. Alpantaki et al[14] recently demonstrated that the tendon of the long head biceps is innervated by a network of sensory sympathetic fibers, which may play a role in the pathogenesis of shoulder pain.

Options to surgically address the biceps tendon include tenodesis, tenotomy, and transfer. Techniques for tenodesis have involved a spectrum of open and arthroscopic techniques using bony fixation of the tendon to the proximal humerus. Multiple techniques for fixation have been described including bone tunnels, bone anchors, staples, and interference screws.[3,4,15–25] However, many of these authors have cited high levels of postoperative pain at the tenodesis site (6–40%).

High complication rates have led some authors to advocate alternative procedures. There have been multiple reports of pain relief in patients who have a spontaneous rupture of the LHBT.[26–28] This has led some surgeons to perform simple tenotomies.[2,19,21,29] The procedure has reliable pain relief, although complications such as cosmetic deformity and muscle spasm occur, more commonly in younger patients.[4,17,21,29] Kelly et al[21] reported on 40 patients who had a tenotomy of the biceps tendon as either an isolated procedure or as part of a larger procedure to address concomitant pathologies. Ninety-five percent of patients reported relief of their biceps symptoms; however, there was a relatively high incidence of fatigue discomfort symptoms and a Popeye sign, particularly in the younger patients. These sequelae have led us to pursue other interventions that would remove the biceps from its intra-articular position to the conjoint tendon.

Dines et al[17] described a technique in which the LHBT was transferred to the coracoid in 3 cases. Soft tissue transfer of the long head biceps tendon to the conjoint tendon was originally described by Post and Benca in 1982 in 4 cases.[30] In these patients, an open procedure was used to weave the LHBT through the origin of the conjoined tendon and then onto itself. The concept of transferring the biceps tendon to the conjoined tendon had not resurfaced in the literature until recently in 2005 by Verma et al[1] (Fig. 1). This article will review the indications, technique, and

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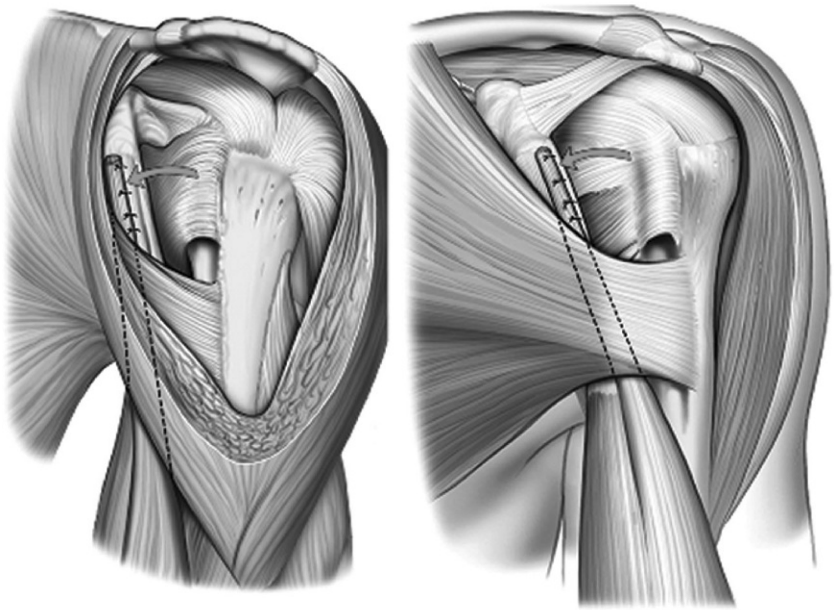

FIGURE 1. Graphic depiction of a subdeltoid arthroscopic transfer of the LHBT to the conjoint tendon. (Please note all figures are of a left shoulder).

postoperative protocol of this procedure as well as provide a glimpse of the early results.

INDICATIONS

Conservative management for biceps tendon pathology includes activity modification, physical therapy, local steroid injections, and oral anti-inflammatory medications. Physical therapy consists of rest, ice, heat, ultrasound, gentle massage, and periscapular muscle strengthening. Local injections into the 2-mm biceps sheath can be performed blindly or with ultrasound guidance. We recommend ultrasound-guided injection to minimize the risk of tendon injury. Although reports of the results of conservative management are limited, patients with a component of biceps tenosynovitis may be more resistant to treatment than those with standard subacromial impingement.[23]

Biceps subluxation can occur in multiple different settings. Biceps instability may be intraarticular or extraarticular, and either of these 2 conditions may or may not have concomitant subscapularis tears. One such scenario is a patient who develops shoulder laxity such as an overhead athlete or swimmer. In this case, the increased shoulder laxity may allow biceps subluxation within the glenohumeral joint causing mechanical symptoms particularly in the posterior joint line. This patient will usually have a positive active compression test as the biceps subluxes posteriorly in the glenohumeral joint. A second intraarticular case involves a patient, commonly an overhead athlete with an unstable biceps anchor or superior labrum (superior labral anterior to posterior tear). In this case, the labrum should be stabilized and the biceps assessed for stability. If unstable, a transfer is performed. From an extraarticular perspective, the biceps may cause anterior shoulder pain due to pathology within the groove. A tear or laxity of the transverse humeral ligament and/or a subscapularis tendon tear destabilizes the biceps pulley complex allowing extraarticular subluxation and should be addressed.

A thorough physical examination of the shoulder may reveal tenderness to palpation over the bicipital groove, a positive Speed's and/or Yerguson's Test, and a positive active compression test.[31] An arthroscopic version of the active compression test has recently been described by the senior author (S.J.O.) to identify biceps pathology intraoperatively and further aid in treatment decisions (Fig. 2).[32] When an unstable superior labral anterior to posterior lesion is present, the torn labrum is visualized becoming entrapped in the glenohumeral joint space. The arthroscopic results should be correlated with preoperative physical examination findings, and treatment decisions can then be made. There are cases in which the arthroscopic active compression test is positive, but the patient had no pain or mechanical symptoms preoperatively related to the biceps. In these situations, no treatment is indicated. The senior author is also currently using a "thrower's test" to evaluate extraarticular biceps pathology. The patient is asked to perform a pitchers throwing motion, whereas resistance is applied to the throwing shoulder. A positive test is indicated by pain in the anterior shoulder signifying an extraarticular biceps subluxation.

When conservative management fails, surgical options include tenotomy, tenodesis, and transfer of

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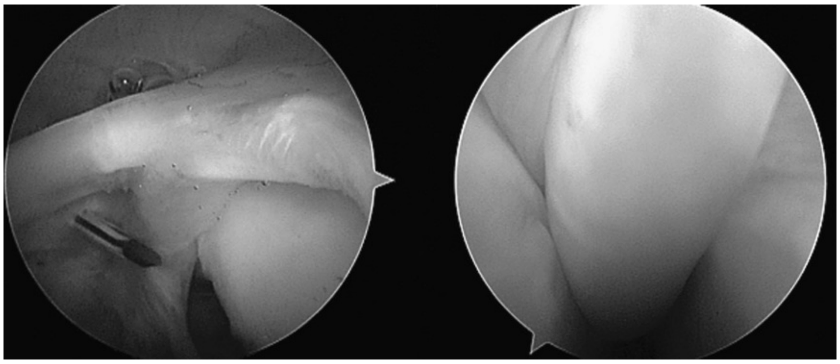

FIGURE 2. The intraarticular portion of the LHBT is visualized on the left. On the right, the arthroscopic active compression test is performed, and the LHBT subluxes posteriorly and becomes trapped in the glenohumeral joint.

the LHBT. The senior author routinely performs this procedure in patients younger than 60 years, with a viable biceps tendon, who have isolated biceps pathology or concomitant rotator cuff tears. Kelly et al found that patients older than 60 years had no side-to-side difference in strength, any fatigue discomfort symptoms, and minimal incidence of a Popeye sign when compared with the age group younger than 60 years. This has led the author to recommend LHBT transfer in younger, more active patients who have been refractory to conservative treatment modalities.[21]

TECHNIQUE

Once on the operating room table, the patient is placed in a modified beach chair position. Preoperatively, a thorough examination under anesthesia is performed to evaluate passive range of motion and any underlying instability. A standard posterior portal is then established and diagnostic arthroscopy is performed. An accessory portal is then created in the anterior triangle. The LHBT and its anchor to the superior labrum are then inspected. A probe is used to displace the tendon inferiorly to allow visualization of the entire intraarticular portion. Fraying of the base of the biceps is a soft sign of biceps instability in the intraarticular segment. An arthroscopic active compression test is then performed with the arm forward flexed with maximum internal rotation to evaluate for intraarticular instability.[32] Using data from the patient's history, physical examination, examination under anesthesia, and direct LHBT inspection, a decision to proceed with transfer, tenotomy, or tenodesis can be made.

In the appropriate patient, after the integrity of the biceps tendon has been confirmed, the surgeon may proceed with the LHBT transfer procedure (Fig. 1). Next, the LHBT is released (Fig. 3). The remaining stump is then debrided using a mechanical shaver, and any other concomitant intraarticular pathology is addressed at this time. A subacromial decompression is performed using a radiofrequency probe and mechanical shaver when clinically indicated by impingement signs and symptoms and usually confirmed by the presence of an impingement lesion. Visualization of the subacromial space and bicipital groove is then possible. If indicated, an acromioplasty is performed during this part of the case.

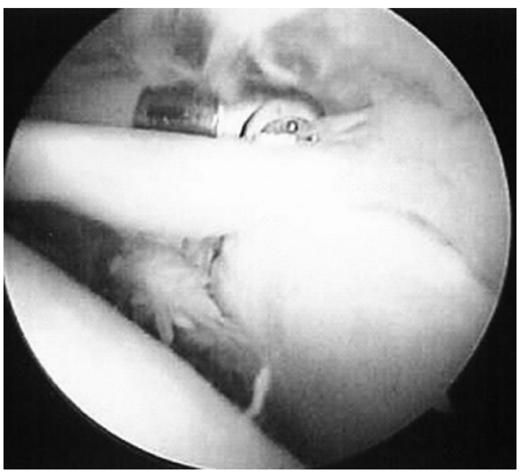

FIGURE 3. The LHBT is divided with electrocautery from its origin.

FIGURE 4. 90-90-15 position for subdeltoid arthroscopy. Note that the humeral head has fallen posteriorly due to gravity to allow the space to open.

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Arthroscopic entry into the subdeltoid space is now performed. The arm is positioned in 70 to 90 degrees of forward flexion, 90 degrees of elbow flexion, and 15 to 30 degrees of lateral abduction with respect to the sagittal plane (Fig. 4). This allows the humeral head to fall posteriorly via gravity and opens the subdeltoid space. The subdeltoid space is bordered medially by the conjoint tendon, inferiorly by the pectoralis major tendon, laterally by the LHBT, and superiorly by the greater tuberosity. The camera is placed in the posterior portal, and an anterolateral portal is created at the anterior third of the acromion. This portal will be used for working during the initial exposure. The surgeon meticulously performs a counterclockwise debridement of the subdeltoid space when viewing from anteriorly at a left shoulder (Fig. 5). With the aid of an arthroscopic shaver and radiofrequency device, the fascia and subdeltoid bursa are released. The first step is to divide these tissues and "tunnel" medially to the coracoid process, which may be palpated medially with an instrument. With this technique, the surgeon should be able to identify the coracoid and the conjoint tendon. At this time, a coracoid portal is also made. A knife is used to make a portal incision through skin only to avoid neurovascular injury. All portals are made via spinal needle localization and creation with a blunt cannula placed over a guide wire. This portal is approximately 2 cm distal to the tip of the coracoid process and in line with the conjoint tendon. We refer to this as the "coracoid portal" because the tip of the coracoid is the anatomic landmark for needle localization through the

FIGURE 6. Subdeltoid arthroscopy portal placement. A, Anterolateral portal is used for viewing while working in the subdeltoid space. B, Pectoralis portal is used for working. C, Conjoint portal is used for suture tying during transfer. D, Anterior, accessory portal is used for inflow. Note in this setup, we have 2 inflows to allow greater insufflation of the space.

anterior deltoid. The surgeon then sweeps laterally, and the pectoralis major tendon can be identified anteriorly and inserted laterally to the LHBT within the bicipital groove. A "pectoralis portal" is then created through the deltoid entering the space at the superolateral margin of the pectoralis major tendon. Again we refer to this as the "pectoralis portal" because the superolateral margin of

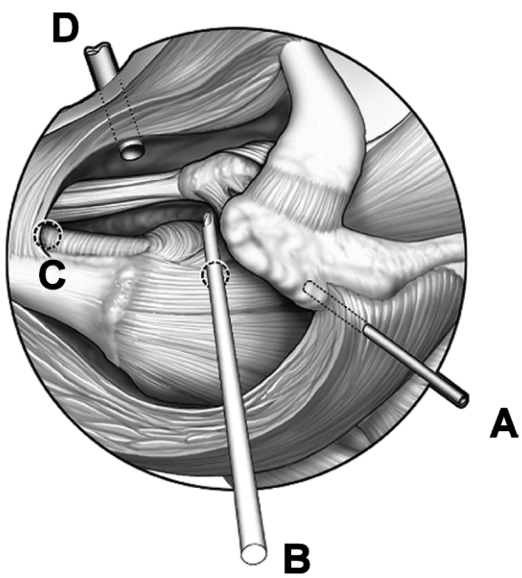

FIGURE 5. Graphic depiction of developing the subdeltoid space. A, Posterior portal is used for viewing. B, Anterolateral portal is used for tunneling medially. C, Site is used for the pectoralis portal. D, Conjoint portal is used for suture tying during transfer.

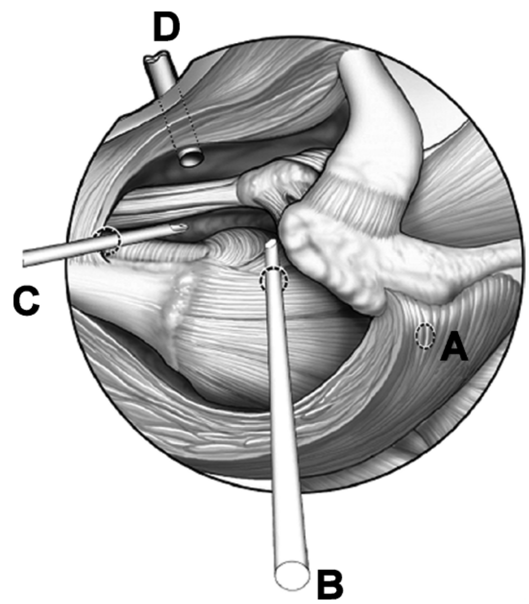

FIGURE 7. Graphic depiction of working in the subdeltoid space. A, Posterior portal is not used for this portion of the case. B, Anterolateral portal is used for viewing medially. C, Pectoralis portal is used for working. D, Conjoint portal is used for suture tying during transfer.

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the pectoralis major tendon is the anatomic landmark for spinal needle localization through the deltoid. The camera is then placed in the anterolateral portal, and the pectoralis portal is used for working (Figs. 6 and 7). The pectoralis portal allows viewing from "below up" to release the bicipital hood if needed. Two inflow cannulas are placed in the conjoint and anterior portals, respectively. This allows for appropriate insufflation of the surgeon's working space. The remaining bursal attachments are divided, and the surgeon should now have a "room with a view" in the subdeltoid space.

The arthroscope is advanced through the anterolateral portal to view the bicipital sleeve and provide access for release of the bicipital sleeve. While viewing from the anterolateral portal, the overlying pectoralis major tendon is visualized, and the biceps should be released to this level. An aperture is made in the bicipital hood at the junction of the pectoralis major tendon, and the LHBT is then delivered into the subdeltoid space (Fig. 8).

At this point, the biceps tendon is removed extracorporally through the pectoralis portal and tagged with 2 ethibond Thompson traction stitches. A small skin incision is placed directly anterior to the superior aspect of the coracoid. The tendon is then placed back into the subdeltoid space, and the traction sutures are brought through this superior aperture and held for transfer (Fig. 9).

The LHBT is then tensioned in line with the conjoint tendon. The elbow is flexed to 90 degrees, and the transfer is tensioned by pulling on the tagging sutures until the biceps is moderately bowstrung. A looped suture retriever is then passed from one of the lateral portals reducing the LHBT to the conjoint while the superior tensioning is held, and the reduction is held in place by an assistant. A spectrum or other suture-passing device is then used to pass a loop-ended No. 0 polydioxanone suture through the biceps and the conjoint tendon. The loop is passed through one of the lateral portals, and No. 2 Tevdek suture (Deknatel DSP, Fall River, Mass) is shuttled back through the anterior conjoint portal cannula. The other end of the No. 2 Tevdek is then retrieved out through the conjoint portal cannula, and the LHBT is then sutured in place using arthroscopic knot-tying techniques. A critical technical point is to suture the LHBT to the lateral aspect of the anterior surface of the conjoint tendon (Fig. 10). This will avoid coracoid impingement as well as protect from injury to the musculocutaneous nerve. In this manner, 3 or 4 sutures can be placed to secure the transferred long head biceps tendon. Finally, the excess portion of

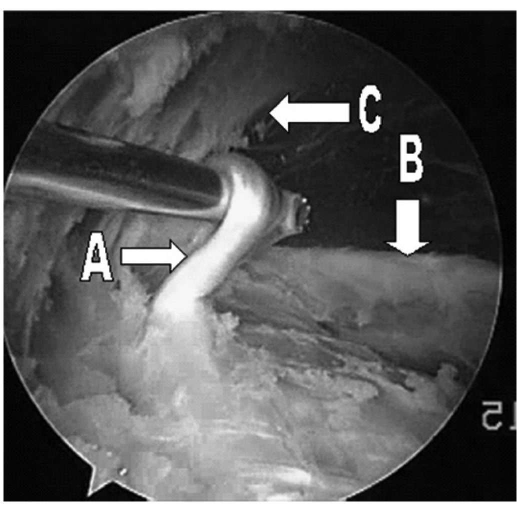

FIGURE 8. An aperture is made in the bicipital sheath to allow delivery of the LHBT into the subdeltoid space. A, LHBT. B, Conjoint tendon. C, Pectoralis major tendon.

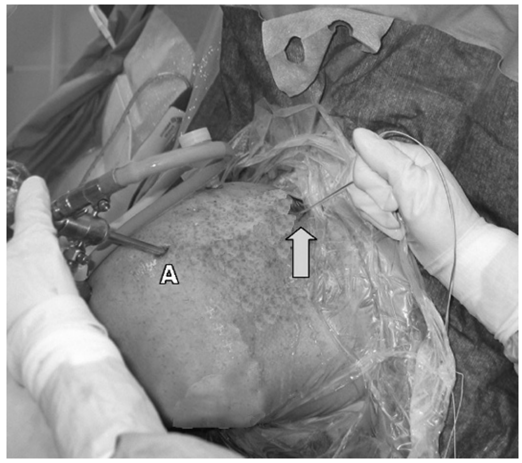

FIGURE 9. Viewing from the anterolateral portal (A), a superior aperture (arrow) is made to allow for tensioning of the transfer. Note that shoulder edema has distorted the preoperative landmarks. This aperture is actually anterior to the coracoid and clavicle.

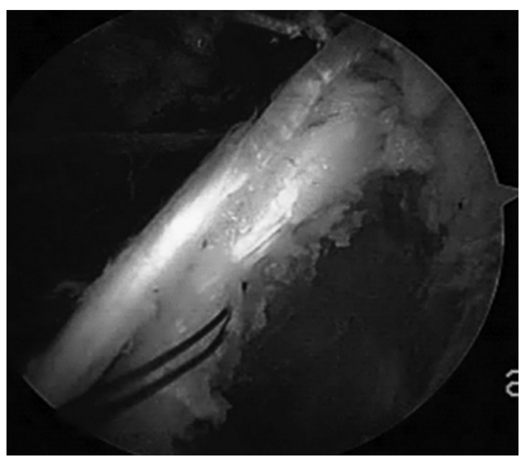

FIGURE 10. The long head of the biceps is sutured to the lateral aspect of the anterior surface of the conjoint tendon to avoid coracoid impingement.

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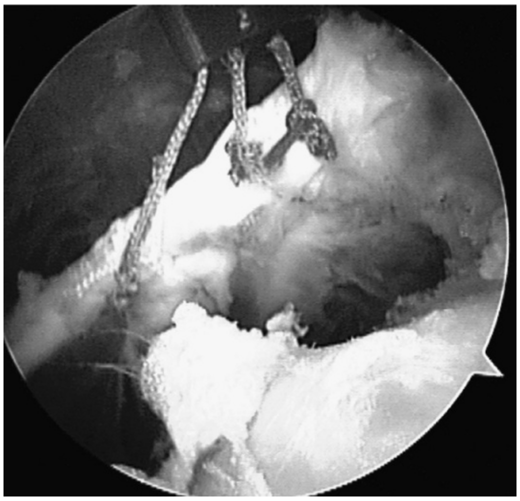

FIGURE 11. Completed biceps transfer.

tendon is cut and removed along with the tagging sutures through the superior aperture, thus completing the transfer (Fig. 11). The elbow is put through a full range of motion while visualizing the repair. Although this tensioning technique was empirically derived, it seems to give a repair that balances the tendon when the elbow is brought through full range of motion.

RESULTS

The senior author has performed approximately 170 of these transfers to date. Although there is a learning curve to become proficient in this technique, after approximately 30 procedures, our operative time was consistently under 1 hour. Eighty percent of patients reported good to excellent results with a minimum 2 years of follow-up.[33] This group included those patients with concomitant pathology. When the isolated group was analyzed, there were 92% good to excellent results. Ninety-five percent of patients had no pain in the bicipital groove at rest or with activity. There was no statistically different strength difference between the surgically treated and contralateral biceps muscle. Drakos et al[33] reported that 12.5% of patients had fatigue discomfort symptoms, and 5% had a Popeye sign.

Postoperative Management

Postoperatively patients are placed in a sling full time for the first 3 days, and then only at night and in crowds for the remainder of the first 2 weeks. Patients are allowed and encouraged to come out of the sling for active and active-assisted shoulder and elbow range of motion immediately postoperatively. They are not allowed to lift anything heavier than a pen, knife, fork, or spoon. Formal physical therapy is started 2 weeks after surgery. They are allowed complete activities of daily living at 4 weeks, full throwing and swimming as tolerated at 3 months, and unrestricted activity including lifting at 4 to 5 months.

Complications

There are few, but important potential complications with this technique. When releasing the LHBT from the bicipital groove, it is necessary to create an aperture over the tendon sheath. The hood extends distally to the superior aspect of the pectoralis major tendon. During the delivery of the LHBT into the subdeltoid space, care should be taken to avoid injury to the overlying pectoralis major tendon. If visualization of the tendon is difficult, a retractor can be placed across the overlying deltoid using a small stab incision to retract it anteriorly and increase the working area of the space. Failure to release the hood will result in an acute angle as the tendon is transferred to the conjoint tendon. Second, the tendon should be placed anteriorly along the lateral aspect of the conjoint tendon to avoid coracoid impingement that could occur with posterior placement.

Neurovascular injury is also a potential complication. The musculocutaneous nerve usually enters the coracobrachialis an average of 49 mm distal to the coracoid process, but may have a more proximal site of insertion in 5% of patients.[34] This relationship should be kept in mind particularly when suture is passed through the conjoint tendon. Furthermore, the ascending branch of the anterior humeral circumflex artery traverses from distal to proximal within the lateral aspect of the bicipital groove. If violated, this branch may lead to a postoperative hematoma. If visualized intraoperatively, it should be cauterized.

Three patients were noncompliant with postoperative protocols in their first 6 weeks and ruptured their transfer. One patient was resuspended, whereas the other 2 patients developed Popeye signs. One patient developed breast asymmetry, which resolved spontaneously at 3 months. One pitcher developed scar tissue, which necessitated a scar debridement procedure. We have had no neurologic injury, compartment syndromes, or infections. These sequelae are all theoretically possible, and meticulous surgical technique as well as strict adherence to postoperative protocols are needed to ensure a positive result.

DISCUSSION

The results of biceps tenodesis in the literature are mixed. Dines et al[17] reported on 20 shoulders, 17 of which underwent tenodesis and 3 underwent open transposition of the tendon to the coracoid for symptomatic long head biceps lesions. Of these, there were 6 failures that required revision surgery. No distinction was made between patients who underwent tenodesis or transposition. The authors concluded that persistent

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impingement played a key role in the cases that failed and that this pathology must be carefully considered and addressed at the time of surgery. Similarly, Becker and Cofield[15] evaluated 50 shoulders at an average follow-up of 13 years. Satisfactory results were noted in only 50% of patients at long-term follow-up. The authors concluded that biceps tenosynovitis is only rarely present in isolation and should be considered as part of the spectrum of shoulder pain. In all cases, concomitant rotator cuff pathology should be considered. In contrast, Post and Benca[30] reported 17 patients at an average of 42 months of follow-up. Thirteen underwent tenodesis and 4 patients underwent open transfer to the coracoid. At final follow-up, 94% of patients had good or excellent results.

In our experience, traditional tenodesis has been associated with a significant complication rate. A number of patients required takedown of the tenodesis because of persistent pain or the development of regional pain syndrome. We believe that arthroscopic transfer described earlier may provide improved results over traditional bony tenodesis for multiple reasons. First, transfer more closely reproduces the native axis of pull of the biceps muscle and allows the long head and short head to share load. Second, the transfer allows for soft tissue healing, which may be more favorable than soft tissue to bone as it recreates the normal "bungee" effect of the superior labrum/biceps anchor complex. Finally, this technique provides the surgeon with direct visualization during tensioning and suturing to help prevent overtensioning of the tendon. Another advantage of this technique is its simplicity. The technique is performed in an avascular plane without the use of implants and adds only 10 to 15 minutes to the operative time once the subacromial decompression is completed. In addition, the technique will help avoid the cosmetic deformity and muscle cramping that may occur with isolated tenotomy.

Accurate diagnosis and treatment of LHBT pathology remains a controversial and challenging subject. When conservative treatment fails, surgical options include debridement, tenotomy, or tenodesis. In addition, we feel that this new procedure, arthroscopic transfer of the long LHBT, provides an improved technique for arthroscopic tenodesis. Although further studies are yet to determine the long-term efficacy, this procedure may ultimately provide better outcomes than conventional techniques.

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REFERENCES

1. Verma NN, Drakos M, O'Brien SJ. Arthroscopic transfer of the long head biceps to the conjoint tendon. *Arthroscopy*. 2005;21:764.
2. Andrews JR, Carson WG Jr, McLeod WD. Glenoid labrum tears related to the long head of the biceps. *Am J Sports Med*. 1985;13:337–341.
3. Curtis AS, Snyder SJ. Evaluation and treatment of biceps tendon pathology. *Orthop Clin North Am*. 1993;24:33–43.
4. Eakin CL, Faber KJ, Hawkins RJ, et al. Biceps tendon disorders in athletes. *J Am Acad Orthop Surg*. 1999;7:300–310.
5. Glousman R, Jobe F, Tibone J, et al. Dynamic electromyographic analysis of the throwing shoulder with glenohumeral instability. *J Bone Joint Surg Am*. 1988;70:220–226.
6. Gowan ID, Jobe FW, Tibone JE, et al. A comparative electromyographic analysis of the shoulder during pitching. Professional versus amateur pitchers. *Am J Sports Med*. 1987;15:586–590.
7. Itoi E, Kuechle DK, Newman SR, et al. Stabilising function of the biceps in stable and unstable shoulders. *J Bone Joint Surg Br*. 1993;75:546–550.
8. Kumar VP, Satku K, Balasubramaniam P. The role of the long head of biceps brachii in the stabilization of the head of the humerus. *Clin Orthop Relat Res*. 1989;244:172–175.
9. Levy AS, Kelly BT, Lintner SA, et al. Function of the long head of the biceps at the shoulder: electromyographic analysis. *J Shoulder Elbow Surg*. 2001;10:250–255.
10. Neviaser TJ. The role of the biceps tendon in the impingement syndrome. *Orthop Clin North Am*. 1987;18:383–386.
11. Pagnani MJ, Deng XH, Warren RF, et al. Role of the long head of the biceps brachii in glenohumeral stability: a biomechanical study in cadavera. *J Shoulder Elbow Surg*. 1996;5:255–262.
12. Rodosky MW, Harner CD, Fu FH. The role of the long head of the biceps muscle and superior glenoid labrum in anterior stability of the shoulder. *Am J Sports Med*. 1994;22:121–130.
13. 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;77:366–372.
14. Alpantaki K, McLaughlin D, Karagogeos D, et al. Sympathetic and sensory neural elements in the tendon of the long head of the biceps. *J Bone Joint Surg Am*. 2005;87:1580–1583.
15. Becker DA, Cofield RH. Tenodesis of the long head of the biceps brachii for chronic bicipital tendinitis. Long-term results. *J Bone Joint Surg Am*. 1989;71:376–381.

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16. 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: 429–435.

17. Dines D, Warren RF, Inglis AE. Surgical treatment of lesions of the long head of the biceps. *Clin Orthop Relat Res*. 1982:165–171.

18. Froimson AI, I Oh. Keyhold tenodesis of biceps origin at the shoulder. *Clin Orthop Relat Res*. 1975;112:245–249.

19. Gill TJ, McIrvin E, Mair SD, et al. Results of biceps tenotomy for treatment of pathology of the long head of the biceps brachii. *J Shoulder Elbow Surg*. 2001;10: 247–249.

20. Huffman G, Wolf E. Results in patients with symptomatic degeneration of the long head of the biceps brachii tendon. *Arthroscopy*. 2003;19:5.

21. Kelly A, Drakos M, Fealy S, et al. Arthroscopic release of the long head of the biceps tendon: functional outcome and clinical results. *Am J Sports Med*. 2005;33: 208–213.

22. Kim SH, Yoo JC. Arthroscopic biceps tenodesis using interference screw: end-tunnel technique. *Arthroscopy*. 2005;21:1405.

23. Neviaser R. Lesions of the biceps and tenonitis of the shoulder. *Orthop Clin North Am*. 1980;11:343–348.

24. Neviaser TJ, Neviaser RJ, Neviaser JS. The four-in-one arthroplasty for the painful arc syndrome. *Clin Orthop Relat Res*. 1982;163:107–112.

25. Patton WC, McCluskey GM 3rd. Biceps tendinitis and subluxation. *Clin Sports Med*. 2001;20:505–529.

26. Caroll RE, Hamilton LR. Rupture of the biceps brachii. *J Bone Joint Surg Am*. 1968;49:1016.

27. Claessens H, Snoeck H. Tendinitis of the long head of the biceps brachii. *Acta Orthop Belg*. 1972;58:124–128.

28. Phillips BB, Canale ST, Sisk TD, et al. Ruptures of the proximal biceps tendon in middle-aged patients. *Orthop Rev*. 1993;22:349–353.

29. Osbahr DC, Diamond AB, Speer KP. The cosmetic appearance of the biceps muscle after long-head tenotomy versus tenodesis. *Arthroscopy*. 2002;18:483–487.

30. Post M, Benca P. Primary tendinitis of the long head of the biceps. *Clin Orthop Relat Res*. 1989;246:117–125.

31. O'Brien SJ, Pagnani MJ, Fealy S, et al. The active compression test: a new and effective test for diagnosing labral tears and acromioclavicular joint abnormality. *Am J Sports Med*. 1998;26:610–613.

32. Verma NN, Drakos M, O'Brien SJ. The arthroscopic active compression test. *Arthroscopy*. 2005;21:634.

33. Drakos MC, Verma NN, Gulotta LV, et al. Arthroscopic biceps tendon transfer: functional outcome and clinical results. Presented at: American Academy of Orthopedic Surgeons Annual Meeting; 2006; Chicago, IL.

34. Bach BR Jr, O'Brien SJ, Warren RF, et al. An unusual neurological complication of the Bristow procedure. A case report. *J Bone Joint Surg Am*. 1988;70:458–460.

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