Disorders of the long head of biceps tendon

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Disorders of the long head of the biceps (LHB) tendon can exist in conjunction with several other shoulder pathologies. Currently, the function of the LHB tendon remains unresolved. It is clear, however, that this tendon can be a significant source of shoulder pain and dysfunction. We have reviewed the anatomy, pathophysiology, classification, diagnosis, and treatment of disorders involving the LHB tendon. We also have reviewed the literature to help make treatment decisions.

Anatomy

The LHB tendon originates from the superior labrum and the supraglenoid tubercle. The exact location of labral attachment varies, but is usually in the posterior portion of the superior labrum\textsuperscript{18,60}.

The intra-articular portion of the LHB tendon is partially stabilized by the biceps reflection pulley, which consists of the superior glenohumeral ligament (SGHL), the coracohumeral ligament, and deep fibers of the subscapularis and supraspinatus tendons\textsuperscript{64} (Fig. 1). The superior glenohumeral ligament runs spirally along the LHB tendon adjacent to the coracohumeral ligament\textsuperscript{3} (Fig. 2). The pulley stabilizes the LHB tendon as the tendon makes a 30° to 40° turn while exiting the glenohumeral joint.\textsuperscript{32} The LHB tendon travels deep to the coracohumeral ligament and through the rotator interval before exiting the glenohumeral joint.

The extra-articular portion of the LHB tendon travels in the bicipital (intertubercular) groove before attaching to the biceps muscle belly. The bicipital groove is approximately 4 mm in depth with a medial wall angle of approximately 56\textdegree.\textsuperscript{17}

The biceps vinculum is a loose membranous tissue consisting of fat, arteries, and veins that loosely attaches the biceps tendon to the periosteum of the bicipital groove.\textsuperscript{30} The transverse humeral ligament is a broad band of tissue from the greater to the lesser tuberosity overlying the LHB tendon. The ligament is formed by a continuation of superficial fibers of the subscapularis that cross the bicipital groove and attach to the greater tuberosity. The deeper fibers of the subscapularis insert on the lesser tuberosity.\textsuperscript{3,29} Longitudinal fibers of the supraspinatus tendon and the coracohumeral ligament also contribute to the ligament.\textsuperscript{29}

The LHB tendon is innervated by a large neuronal network of thinly myelinated sensory neurons. The innervation is most dense at the tendon origin.\textsuperscript{2} The vascular supply to the LHB tendon is supplied by the thoracoacromial artery via osteotendinous branches and the brachial artery via musculotendinous branches. A zone of hypovascularity is found 1.2 to 3 cm from the tendon origin.\textsuperscript{16} This zone of hypovascularity correlates with the portion of the tendon that starts intra-articularly and courses through the biceps pulley, ending near the proximal bicipital groove.\textsuperscript{16}

Function

The function of the LHB tendon is controversial. Electromyography analysis has shown that the LHB tendon serves as a glenohumeral joint stabilizer in the unstable

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Biomechanical studies showed the LHB tendon was a dynamic depressor of the humeral head, but this has not been demonstrated clinically. Kuhn et al demonstrated that the biceps is an important restraint to external rotation of the abducted arm.

Classification

Disorders involving the LHB tendon can be classified in 3 broad subgroups: (1) inflammation, (2) instability, or (3) traumatic. A number of authors have further subclassified biceps tendon lesions according to anatomic location, pathologic process, and the status of the biceps tendon. Burkhead et al and Walch et al classified lesions of the LHB by the anatomic location of the pathology. Lesions at the origin affect the biceps anchor at the attachment to the supraglenoid tubercle and superior labrum. Rotator interval lesions consist of biceps tendinitis, isolated tendon ruptures, and subluxation. Habermeyer et al also classified biceps pathology by the status of the biceps sling, which provides information about where the LHB tendon will sublux. An isolated lesion of the SGHL is group 1, lesions of the SGHL and partial articular sided tears of the supraspinatus tendon (PASTA) are group 2 (results in lateral LHB tendon subluxation), deep surface tears of the subscapularis and SGHL are group 3 (results in medial LHB tendon subluxation), and group 4 is when there is tearing of the deep surface of the subscapularis tendon, PASTA, and SGHL (LHB tendon can sublux or dislocate medial or lateral).

Lafosse et al classified LHB disorders by arthroscopic findings related to LHB instability (both direction and extent), macroscopic lesions of the LHB, and status of the adjacent rotator cuff tendons. Direction of tendon instability was seen as anterior, posterior, or anteroposterior. Extent of instability was graded as none, subluxation (defined by translation of less than one-third of the LHB without passing over the pulley insertion sites of the greater and or lesser tuberosities), and dislocation. LHB tendon lesions were graded as grade 0 (normal tendon), grade I (minor lesion with fraying or erosion involving <50% of the diameter of the tendon), grade II (major lesion fraying or erosion involving >50% of the tendon diameter), grade III (tearing of the deep surface of the subscapularis tendon, PASTA, and SGHL (LHB tendon can sublux or dislocate medial or lateral)).

### Pathology

The LHB tendon may be affected by tendinopathy, dislocation, and partial or complete tears. Disorders of the LHB tendon are associated with rotator cuff tear in up to 90% of cases. Glenohumeral arthritis is also commonly associated with LHB tendon pathology. LHB tendinopathy is characterized by chronic inflammation, fibrotic degeneration, a decrease in the number of axons in the distal portion of the tendon, and an increase in the calcitonin gene-related peptide and substance P within associated nerve roots and blood vessels. Hypertrophic tendinopathy may result in entrapment of the tendon within the glenohumeral joint. The resultant “hourglass biceps” may be unable to slide through the bicipital groove, causing locking of the shoulder, which has been likened to the trigger finger in the hand. In addition, inflammation and hypertrophy or stenosis of the bicipital groove, or both, are thought to incarcerate the LHB tendon, which may produce
atraumatic superior labrum anteroposterior (SLAP) lesions and abrasions on the humeral head.\textsuperscript{13}

Rupture of the LHB tendon may be partial thickness or complete. LHB tendon rupture typically occurs in the hypovascular zone 1.2 to 3 cm from the tendon origin.\textsuperscript{16} Partial-thickness rupture is often seen in association with tendinopathy and contributes to shoulder pain and dysfunction, with or without concomitant rotator cuff tear. Complete rupture of the diseased LHB tendon may actually relieve the symptoms. Complete ruptures may cause biceps muscle retraction, leading to the “Popeye” deformity. Hypertrophic tendinopathy may prevent the muscle retraction in this scenario.

The LHB tendon may be painfully unstable medially or posterolaterally. Medial instability is associated with a subscapularis tear, whereas posterolateral instability is associated with a supraspinatus tear.\textsuperscript{44} Complete LHB tendon dislocation is only seen medially.\textsuperscript{34,49} Medial dislocation occurs underneath or into the substance of the subscapularis tendon\textsuperscript{49} (Fig. 5). The deep fibers of the subscapularis tendon must be disrupted for medial LHB tendon dislocation, although the anterior fibers of the subscapularis may remain intact.\textsuperscript{29}

Injury to the biceps reflection pulley has been shown to be necessary for LHB tendon dislocation in either direction.\textsuperscript{3,11,29,58} The biceps reflection pulley is injured by increased shear load at forward flexion with internal or neutral arm rotation.\textsuperscript{11} Although the transverse humeral ligament was historically thought to contribute to biceps tendon stability, this function has come into question. The transverse humeral ligament may actually remain intact, even in the setting of complete LHB tendon dislocation.\textsuperscript{49}

**Diagnosis**

Physical examination is unreliable in the diagnosis of LHB tendon pathology. Anterior shoulder tenderness may indicate LHB tendon pathology. The belly press, Speed’s, and Yergason’s tests have only moderate specificity.\textsuperscript{34,37} The bear hug and upper cut tests are highly sensitive but have low specificity.\textsuperscript{37} In patients with rotator cuff tears, the physical examination is even less reliable in the detection of LHB tendon disorders.\textsuperscript{27}

Holtby and Razmjou\textsuperscript{34} performed a prospective diagnostic study (Level of Evidence [LOE] I) to determine the accuracy of the Speed’s and Yergason’s tests to detect biceps pathology by using arthroscopy as the gold standard. The authors reported 32% sensitivity, 75% specificity, 56% accuracy, 50% positive predictive value, 58% negative predictive value, 1.28 positive likelihood ratio, and 0.91 negative likelihood ratio for the Speed’s test. For the Yergason’s test, they reported 43% sensitivity, 79% specificity, 63% accuracy, 60% positive predictive value, 65% negative predictive value, 2.05 positive likelihood ratio, and 0.72 negative likelihood ratio. These results indicated that neither clinical examination maneuver is very good at identifying biceps pathology, but when the result one of these tests is positive, then it is quite reliable that some shoulder pathology is present. The weakness of this study was that the authors combined arthroscopic findings of SLAP tears and biceps pathology, leaving no information about which pathology (SLAP tears or LHB tendinitis) these tests correlate more accurately with clinically.

In a similar study, Kibler et al\textsuperscript{37} (LOE II) examined the accuracy of Yergason’s, Speed’s, uppercut, bear hug, belly press, O’Brien’s, anterior slide, and dynamic labral shear tests for identification of LHB tendon pathology. The authors reported that the bear hug (sensitivity, 0.79) and upper cut (sensitivity, 0.73) tests were most sensitive, and the belly press (specificity, 0.85) and Speed’s (specificity, 0.81) tests were most specific for biceps tendon pathology. In addition, the upper cut test was most accurate (0.77) and had the highest positive likelihood ratio (3.38). Further regression analysis found that the combination of Speed’s and the upper cut tests were significantly better at
detecting biceps pathology ($P = .021, R^2 = 0.400, 80\%$ predictability). What makes these data stronger than the results of the study by Holtby and Razmjou\(^3\) is that they separated out the findings of biceps lesions and SLAP tears.

The available evidence from LOE I and II studies shows that the combined use of the Speed’s test and the upper cut test is recommended for the clinical detection of LHB tendon pathology.

Magnetic resonance imaging (MRI), with or without contrast, can be used in the detection of LHB tendon disorders. Interobserver reliability is low in the detection of LHB tendon tears.\(^5\) Noncontrast MRI may detect LHB tendon tears with only 52\% sensitivity.\(^5\) MRI arthrography may raise the sensitivity to 90\%.\(^6\) Computed tomography arthrogram can also be a useful diagnostic tool to evaluate the status of the LHB tendon. Although sensitivity of this modality has been poor (31\% to 46\% sensitive), it was very specific for biceps pathology (95\% to 99\% specific), with a positive predictive value of 96\% and negative predictive value 88\%.\(^1\)^\(^5\)^\(^2\)^\(^0\)

Ultrasound imaging may reliably detect complete rupture and dislocation of the LHB tendon but poorly detects partial-thickness tears of the LHB tendon.\(^3\) Armstrong et al\(^4\) correlated ultrasound findings to arthroscopy and found it was 100\% specific and 96\% sensitive for subluxation or dislocation and 50\% sensitive and 100\% specific for identifying pathology with 100\% positive predictive value and 71\% negative predictive value. These results indicate that normal ultrasound findings do not guarantee normal biceps anatomy.

Arthroscopy is the gold standard for detection of LHB tendon disorders. A thorough arthroscopic examination of the LHB tendon includes using an arthroscopic probe to pull the extra-articular portion of the biceps into the glenohumeral joint to allow complete visualization of the tendon. A segment of the LHB tendon that is extra-articular may be affected by tendinopathy or partial-thickness tearing and can only be examined by probing the tendon into the joint (Fig. 6). Surgeons should look for an abrasion of the cartilage of the humeral head near the bicipital groove, which may be a sign of biceps pathology.\(^1\)

**Treatment**

Isolated LHB lesions are relatively uncommon; therefore, it is important to properly recognize and treat associated shoulder pathology such as rotator cuff dysfunction, scapular dyskinesia, adhesive capsulitis, or glenohumeral joint arthritis. We review the nonoperative and operative treatment options for the LHB. We also have reviewed the current literature to aid in clinical decision making.

**Nonsurgical**

Management of patients with symptoms related to inflammation or abnormalities involving the LHB tendon should begin with nonoperative treatment, including activity modification, nonsteroidal anti-inflammatory medication, and physical therapy directed at associated underlying shoulder disorders as well as scapulothoracic mechanics. An injection of steroid with local anesthetic may be beneficial, either intra-articularly into the glenohumeral joint or directly into the bicipital tendon sheath within the bicipital groove. Subacromial injection may also be used for concomitant impingement symptoms. No published studies have specifically evaluated the nonoperative treatment of LHB disorders.

Several studies\(^1\)^\(^2\)^\(^4\)^\(^7\)^\(^6\)^\(^5\) report the results after nonsurgical treatment of complete LHB ruptures. Traumatic or spontaneous ruptures of the LHB are commonly associated with cosmetic deformity of the biceps muscle, Popeye deformity, and biceps muscle spasm, particularly in thin patients. Patients typically report resolution of biceps muscle...
pain and spasm after 6 to 8 weeks, with little residual dysfunction related to the LHB. Carroll and Hamilton\textsuperscript{14} reviewed the nonoperative treatment results of 100 patients after rupture of the LHB tendon in a case series (LOE IV) and found no residual disability at final follow-up.

Mariani et al.\textsuperscript{47} in a retrospective case-control study (LOE III), compared the results of patients who had rupture of the LHB and were treated with or without biceps tenodesis. There was no difference in outcome for pain and shoulder or elbow range of motion. They did find a statistically significant difference ($P < .0001$) between groups for patient satisfaction, with 78% of patients in the surgery group reporting being much better at an average follow-up of 13 years compared with no patients reporting being much better (1% stated they were better, 37% the same, and 53% worse) in the nonsurgery group at an average follow-up of 4.6 years. In addition, patients in the nonoperative group had an 8% decrease in elbow flexion strength and a 21% decrease in forearm supination strength at final follow-up.

Deutch et al\textsuperscript{21} monitored 11 patients (mean age, 59 years) for an average of 1.7 years (range, 0.5-3.5 years) to determine residual pain and disability after rupture of the LHB treated nonoperatively (LOE IV). The authors reported continued complaints of pain or disability, or both, at the final follow-up. They found a 23% decrease in supination, 29% decrease in pronation, and 29% decrease in elbow flexion strength as measured by strain gauge dynamometers and compared with the contralateral unaffected side. The authors concluded that LHB rupture may not be completely benign with nonoperative treatment, resulting in possible continued painful symptoms and dysfunction, especially in younger patients.

### Surgical

Surgical treatment options for LHB tendinitis that remains symptomatic despite nonoperative treatment consists of tenotomy or tenodesis in conjunction with addressing any additional concomitant shoulder pathology, including impingement syndrome, rotator cuff tears, and labral pathology. The ideal surgical treatment for LHB pathology continues to remain an area of significant controversy.\textsuperscript{25,35,52}

Many surgical techniques have been reported for arthroscopic and open biceps tenotomy and tenodesis. Tenotomy or tenodesis of the LHB tendon is indicated when there is partial tearing (>25% to 50% of the tendon diameter), longitudinal tears that result in poor tendon gliding in the bicipital groove (symptomatic catching), medial subluxation of the tendon, disruption of the biceps sling, or in the setting of a subscapularis tear.\textsuperscript{12,52,56,65}

Several authors\textsuperscript{25,35,40} have attempted to answer the question of which surgical treatment is better—tenotomy or tenodesis—and provide evidence to support one rather than the other. Frost et al.\textsuperscript{25} in a systematic review (LOE IV), hypothesized that there would be no difference in outcome between tenotomy and tenodesis for treatment of pathology involving the LHB tendon. This review analyzed the results of 5 studies that evaluated the results of tenotomy, 8 that examined tenodesis, and 6 that reported results of both. Overall, tenodesis resulted in good or excellent results in 40% to 100% of patients, with a failure rate of 5% to 48%. Tenotomy resulted in 65% to 100% good or excellent results, with a failure rate of 13% to 35%. The comparative studies did not show any significant differences between the groups, other than the Popeye sign being present in 3% to 70% of the tenotomy patients. The authors concluded that the available evidence shows there is little difference in outcomes using tenodesis or tenotomy; however, well-designed, prospective, randomized controlled trials comparing these procedures should be performed to provide stronger evidence for treatment decisions.

Hsu et al\textsuperscript{35} conducted a systematic review (LOE IV) to determine if there were any significant differences in the incident of cosmetic deformity or load-to-tendon failure, or both, between tenotomy and tenodesis. They included 8 studies in the final analysis. Postoperative bicipital pain was present in 17% of patients in the tenotomy group and in 24% in the tenodesis group. The corresponding odds ratio (1.5) and relative risk (1.4) reflected that bicipital pain was more common in the tenodesis group. The average Constant score was 66.9 for the tenotomy group and 76.1 for the tenodesis group, and the average University of California, Los Angeles (UCLA) score was 33 for the tenotomy group and 28 for the tenodesis group. In the tenotomy group, 41% of patients had biceps muscle belly deformity at final follow-up compared with only 25% in the tenodesis group. The corresponding odds ratio was 2.15 and the relative risk was 1.7 for the tenotomy group to be more likely to have a Popeye muscle deformity at final follow-up.

Again, evidence-based recommendations are limited due to the lack of high-quality studies in the current literature. On the basis of what is available, tenotomy is recommended for older patients with sedentary lifestyle, obese arms, or those not concerned with cosmesis, and tenodesis is recommended for young (<40 years) active patients with high physical demands, thin arms, or concern for cosmesis. These authors similarly recommended more high-quality, well-designed, prospective, randomized controlled studies to help support the decision-making process.

Recently, Koh et al\textsuperscript{40} compared tenotomy and tenodesis results in the setting of rotator cuff tears in a prospective cohort study (LOE II). At a final follow-up that averaged 27-months, 5% of patients in the tenodesis group and 10% in the tenotomy group complained of arm pain during resisted elbow flexion ($P = .43$), and 9.3% in the tenodesis group had a Popeye deformity compared with 26.8% in the tenotomy group ($P = .036$, statistically significant difference). The American Shoulder and Elbow Surgeons (ASES) scores improved from 52.1 to 84.7 in the tenodesis...
significant improvement (P < .0001). Constant scores for tenodesis (38.9 to 82.9) and tenotomy (35.2 to 78.3) were clinically and statistically significantly improved (P < .0001) in both groups. There was no difference in outcome scores between the 2 groups. The authors concluded from these results that besides biceps deformity, there was no significant difference between these 2 treatment modalities.

Arthroscopic biceps tenotomy
Walch et al.61 described arthroscopic biceps tenotomy for the treatment of biceps tendonopathy in the setting of massive irreparable rotator cuff tears in 307 shoulders (LOE IV). The tendon is arthroscopically transacted at the superior labrum or supraglenoid tubercle and allowed to retract out of the glenohumeral joint into the bicipital groove. If this does not occur, the intra-articular portion is removed until the tendon can then retract out of the joint. At the follow-up evaluation (average, 57 months), the authors reported statistically significant (P < .0001) improvement in Constant score (preoperatively, 48.4; postoperatively, 67.6) and that 87% of patients were satisfied or very satisfied with their treatment results.

Gill et al.28 reviewed the results after arthroscopic biceps tenotomy in a retrospective case series (LOE IV) in 30 shoulders at an average follow-up of 19 months (range, 12-69 months). They demonstrated improvement in symptoms at the final evaluation, with an ASES score of 81.8, average time to return to work of 1.9 weeks, and 90% of patients returned to their previous level of sporting activity with no complaints of pain. The complication rate was 13.3% (4 of 30 shoulders), 2 related to impingement, 1 with persistent pain, and 1 as a result of the cosmetic biceps deformity, with no pain, who was subsequently revised to a tenodesis.

Kelly et al.46 reviewed the results after arthroscopic biceps tenotomy in 40 patients with an average follow-up of 2.7 years (range, 24-42 months) in a retrospective case series (LOE IV). The authors reported the following outcomes scores: L’Insalata, 75.6 (range, 29.1-100), UCLA, 27.6 (range, 10-35), and ASES, 77.6 (range 13.3-100). They also found that 70% of patients had a Popeye deformity at rest or during active elbow flexion, and 37.5% of patients complained of fatigue, discomfort, and soreness after resisted elbow flexion. The authors concluded that this technique might be useful for a select patient population, specifically an older less active patient population with no concern for cosmesis.

Bradbury et al.10 described an arthroscopic biceps tenotomy technique in which the tendon is released with a portion of the superior labrum to prevent the Popeye deformity. Tenotomy performed in this fashion creates a bulbous proximal biceps stump that becomes entrapped in the intra-articular portion of the bicipital groove, thereby limiting tendon excursion and retraction down the arm. Biomechanical testing of this technique showed significantly increased force was required to pull the tendon through the bicipital groove (73.2 N, with-labrum group; 25.0 N, without-labrum group; P = .001).

Open biceps tenodesis
Open biceps tenodesis historically has been the surgical treatment of choice for young active patients, such as athletes and heavy laborers, and those who wish to avoid cosmetic deformity. The goal of tenodesis of the LHB tendon is to maintain the length-tension relationship of the biceps muscle.52 A variety of reattachment sites have been described, including fixation to the lesser tuberosity,12 coracoid,12,31 intertubercular (bicipital) groove33; suture fixation to the transverse humeral ligament, short head of the biceps,6 or pectoralis major tendon1,6,47; or by a bone tunnel in a subpectoralis major location.33,48 Ultimately, the biggest controversy exists about optimal location of tenodesis and if fixation should occur above, within, or below the bicipital groove. To our knowledge, no LOE I or II studies have compared the outcomes after tenodesis above, within, or below (subpectoral) the bicipital groove to guide surgical decision making using an evidenced-based approach.

Becker et al.6 evaluated the results of 51 patients in a retrospective case series (LOE IV) after open biceps tenodesis at an average follow-up of 7 years (range, 1-21 years). Three different surgical techniques were used in these patients: (1) suture of the tendon stump in or adjacent to the bicipital groove, as described by Hitchcock et al.33 (2) a keyhole technique,12 or (3) side-to-side suturing to the short head of the biceps.12 All patients underwent tenotomy with resection of the intra-articular portion of the LHB tendon in conjunction with tenodesis. At final follow-up, only 22 of the 51 shoulders (43%) were still pain-free, whereas 26 (50%) continued to have moderate to severe pain. The authors concluded that biceps tenodesis should not be recommended as a primary procedure but should be performed in conjunction with a larger surgical procedure.

Crenshaw and Kilgore19 retrospectively reviewed (LOE IV) the results of 3 tenodesis techniques in 92 shoulders at 1 year. The techniques included suturing LHB tendon to the lesser tuberosity without tenotomy, transfer of the tendon to the coracoid, or the Hitchcock procedure,12,33 in which the tendon is reattached to the bicipital groove beneath a periosteal flap. Pain relief was good to excellent in 90% of patients, but only 85% had return of their normal shoulder motion at final follow-up.

Froimson and Oh,24 Dines et al.22 and Berlemann and Bayley,7 in small retrospective case series (LOE IV), reviewed the results of keyhole tenodesis and found good to excellent results at final follow-up. These authors attributed clinical failures of this technique to unrecognized additional shoulder pathologies such as subacromial impingement with rotator cuff tearing.
Subpectoral biceps tenodesis

Subpectoral biceps tenodesis removes the tendon completely from the bicipital groove, thus avoiding leaving behind inflamed tendon in this area, which could cause residual painful symptoms from persistent stenosis or tenosynovitis. Mazzocca et al. in a prospective case series (LOE IV), reviewed the results after subpectoral biceps tenodesis with interference screw fixation in 41 patients at an average follow-up of 29 months (range, 12-49 months). Mean scores were Rowe, 86 (range, 67-100); ASES, 81 (range, 32-100); Simple Shoulder Test, 9 (range, 3-12); Constant score, 84 (range, 67-100); and Single Assessment Numeric Evaluation score, 84 (range 50-100). There was only 1 failure, with loss of fixation at the bone tunnel resulting in Popeye deformity on physical examination. No patients reported any residual pain in the area of the bicipital groove at final follow-up. The authors concluded that this procedure reliably and successfully eliminates symptoms associated with biceps tendinitis and maintains the anatomic length-tension relationship of the muscle.

In a similar, retrospective case-control study (LOE III), Millett et al. compared subpectoral suture fixation vs interference screw fixation for LHB tenodesis. The authors reviewed 88 patients (34 interference screw, 54 suture anchor fixation) at an average 13-month follow-up and found no fixation failures. All patients demonstrated clinical and statistically significant improvement in scores preoperatively to postoperatively, respectively, of 9 to 2 on the visual analog scale (VAS) score ($P < .0001$), 28 to 76 on the ASES ($P < .0001$), and 29 to 59 on the Constant ($P < .0001$). In addition, there were no statistically or clinically significant differences between the groups on the VAS ($P = .04$), ASES ($P = .2$), and Constant ($P = .09$) scores. The authors concluded that both fixation methods provide a reliable means for treating symptomatic biceps tendinitis by alleviating pain and no Popeye deformity at short-term follow-up.

Arthroscopic biceps tenodesis

Arthroscopic biceps tenodesis may be performed using interference screws, suture anchors, or soft tissue fixation. Arthroscopic tenodesis of the LHB tendon was described by Boileau et al., in which the tenotomy was performed and a bioabsorbable interference screw was used to anchor the tendon stump to the proximal aspect of the bicipital groove. The authors also reported the results after this procedure in 43 patients at an average of 17 months (range, 12-34 months) in a prospective case series (LOE IV). The average Constant score was significantly improved clinically and statistically from 43 preoperatively (range, 13-60) to 79 postoperatively (range, 59-87; $P < .005$). Strength averaged 90% of the contralateral arm, and biceps shape and contour was maintained in 41 of 43 patients (95%).

Drakos et al. in a retrospective case series (LOE IV), reported the results of arthroscopic transfer of the LHB tendon to the conjoint tendon “subdeltoid” in 40 shoulders at an average follow-up of 28 months (range, 24-53 months). The average L’Insalata score was 78.9 (range, 35.7-100), UCLA score was 27.8 (range, 12-35), and ASES score was 79.6 (range, 30-100) at the final follow-up. Of the 40 shoulders, only 2 patients (5%) had a Popeye deformity at rest or with active elbow flexion, 5 (12.5%) had fatigue soreness after resisted elbow flexion, 38 (95%) reported relief of tenderness on palpation of the bicipital groove, and 32 (80%) rated their shoulders as good, very good, or excellent.

Several authors have reported arthroscopic techniques for performing this procedure (LOE V), with no real outcomes data to support or refute its use.

Once the decision has been made to perform tenodesis of the LHB tendon, the next controversial question that arises is: what is the optimal location of tenodesis? Lutton et al. in a retrospective case-control study (LOE III), compared results after tenodesis into the upper or lower half of the bicipital groove to determine if location was related to residual postoperative pain. A more distal location resulted in a decreased incidence of persistent postoperative pain in the bicipital groove. This study was limited due to its retrospective nature and limited sample size, but to our knowledge, this is the only study in the literature that attempts to answer this important question.

Treatment algorithm

The diagnosis and management of disorders involving the LHB tendon can be challenging. We present an algorithm for the management of these patients (Fig. 7). It is clear from the current literature that the approach to patients who present with biceps pathology begins with an accurate diagnosis, which can be the most challenging aspect in the management of biceps pathology. Physical examination findings with use of a biceps-specific test, such as the upper cut test and Speed’s test, may provide useful clues about the status of the LHB tendon. Imaging of the shoulder with MRI, CT arthrogram, or ultrasound provides detailed visualization of the anatomy of the shoulder and should be considered a critical part of the workup. In our practice, we typically use MRI as our diagnostic study of choice.

Treatment should initially begin with a trial of conservative measures such as nonsteroidal anti-inflammatory medications and physical therapy. Physical therapy should be tailored to other concomitant shoulder pathology with a focus on regaining range of motion and eliminating scapular dyskinesia. Corticosteroid injections placed in the glenohumeral joint, subacromial space, or biceps tendon sheath may be considered initially or after a 6-week trial of physical therapy.

Surgical intervention is appropriate a minimum of 12 weeks of conservative management has failed. Surgical treatment is generally dictated by the major underlying shoulder pathology that coexists with LHB tendon
abnormalities, including rotator cuff tear, osteoarthritis, adhesive capsulitis, and SLAP tears. Age and activity level may also help determine which biceps procedure would be appropriate (tenotomy vs tenodesis; open vs arthroscopic).

In our hands, how the biceps is managed surgically is dictated by patient activity level and functional demands and the other shoulder pathology being treated. We believe an open subpectoral biceps tenodesis is appropriate for an active patient with high functional demands. In older patients (>60 years) with low functional demands, we recommend a biceps tenotomy with a cuff of labrum using the technique described by Bradbury et al.\textsuperscript{10} Finally, in the setting of other shoulder pathology, such as a full-thickness rotator cuff tear, in our opinion, it is appropriate to incorporate the tenodesis into the anterior suture anchors for the cuff repair.

**Conclusion**

Patients presenting with symptomatic LHB tendon lesions must be thoroughly evaluated for other concomitant shoulder pathology, which may make a definitive diagnosis challenging. There are few high-level evidence studies in the current literature to support decision-making strategies. Thorough clinical evaluation...
should include the Speed’s and upper cut tests. Treatment should begin with nonoperative treatment, including activity modification, physical therapy, anti-inflammatories, and injections. Surgery should be considered as a first-choice treatment option in a select subset of patients who have biceps pathology associated with full-thickness subscapularis tears or painful subluxation or dislocation of the tendon as a result of an acute injury. Arthroscopy is the gold standard to identify LHB tendon pathology.

There appears to be no difference in surgical treatment outcomes after LHB tenotomy or tenodesis. Clinical decision making should be tailored to individual patients and their expectations and physical needs after surgical intervention. Well-designed prospective cohort or randomized controlled trials need to be performed to provide evidence to support treatment protocols.

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