ORIGINAL ARTICLES

Entrapment of the long head of the biceps tendon: The hourglass biceps—A cause of pain and locking of the shoulder

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We describe an unrecognized mechanical condition affecting the long head of the biceps (LHB) tendon with entrapment of the tendon within the joint and subsequent pain and locking of the shoulder on elevation of the arm. We identified 21 patients with a hypertrophic intraarticular portion of the LHB tendon during open surgery (14 patients) or arthroscopic surgery (7 patients). All cases but one were associated with a rotator cuff rupture. Patients were treated by biceps tenotomy (2 patients) or tenodesis (19 patients) after removal of the hypertrophic intraarticular portion of the tendon and appropriate treatment of concomitant lesions. Minimum follow-up was 1 year. All patients presented with anterior shoulder pain and loss of active and passive elevation averaging 10° to 20°. A dynamic intraoperative test, involving forward elevation with the elbow extended, demonstrated entrapment of the tendon within the joint in each case. This test creates a characteristic buckling of the tendon and squeezing of it between the humeral head and the glenoid (hourglass test). The mean Constant score improved from 38 to 76 points at the final follow-up ($P < .05$). Complete and symmetric elevation was restored in all cases after resection of the intraarticular portion of the LHB tendon. The hourglass biceps is caused by a hypertrophic intraarticular portion of the tendon that is unable to slide into the bicipital groove during elevation of the arm; it can be compared with the condition of trigger finger in the hand. A loss of 10° to 20° of passive elevation, bicipital groove tenderness, and radiographic findings of a hypertrophied tendon can aid in the diagnosis. A definitive diagnosis is made at surgery with the hourglass test: incarceration and squeezing of the tendon within the joint during forward elevation of the arm with the elbow extended. The hourglass biceps is responsible for a mechanical block, which is similar to a locked knee with a bucket-handle meniscal tear. Simple tenotomy cannot resolve this mechanical block. Excision of the intraarticular portion of the LHB tendon, during bipolar biceps tenotomy or tenodesis, must be performed. The hourglass biceps is an addition to the familiar pathologies of the LHB (tenosynovitis, prerupture, rupture, and instability) and should be considered in cases of shoulder pain associated with a loss of elevation. (J Shoulder Elbow Surg 2004;13:249–57.)

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Many causes of shoulder pain have been described, commonly related to rotator cuff pathology and to the long head of the biceps (LHB) tendon. The role of the LHB tendon in shoulder pain and disability has been debated for more than 100 years, almost since the original description of periarthritis by Duplay[9] in 1872. The association of shoulder pain with pathology of the LHB is currently accepted to be due to inflammation (synovitis), impingement, prerupture, or instability of the tendon at the entry into the bicipital groove (subluxation or dislocation).*

We have observed a new pathologic entity, the hourglass biceps, which is essentially hypertrophy of the intraarticular portion of the tendon that leads to entrapment within the joint on elevation of the arm. The intraarticular portion of the tendon buckles and becomes incarcerated within the joint, inhibiting pas-

*References 1, 3, 4, 7, 10, 12, 15, 20, 22, 26, 27.

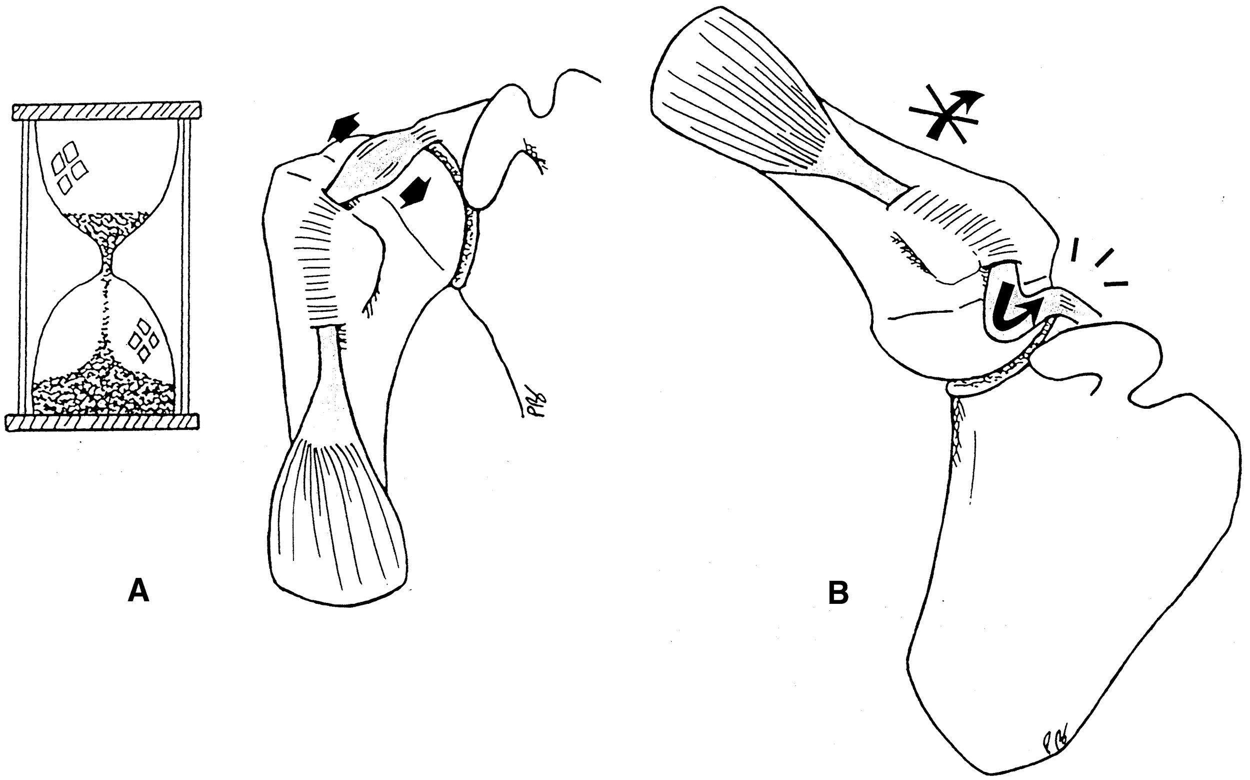

Figure 1 Illustrations demonstrating the mechanical consequences of the hourglass biceps. The tendon, which has become hypertrophic (**A**), is unable to slide into the bicipital groove, leading to its incarceration in the joint on elevation of the shoulder (**B**).

sive and active elevation and causing pain. The hypertrophy of the intraarticular tendon leads to a disproportion between the tendon and the cross-sectional size of the bicipital groove, preventing sliding of the tendon into the groove and leading to its entrapment.

This condition is analogous to a trigger finger in the hand, although the surgical approach to this condition (release of the tunnel) is not appropriate in this situation, as releasing the biceps pulley can lead to tendon instability.[23] We have observed that (1) this intraarticular entrapment of the LHB may be responsible for shoulder pain and functional impairment and (2) only removal of the intraarticular portion of the biceps (during tenodesis or bipolar tenotomy) can solve this mechanical problem.

The purpose of this study is to describe this pathologic condition, discuss its clinical relevance, and present the early results of the surgical treatment.

MATERIALS AND METHODS

A retrospective review was performed at our institution of all patients with a preoperative diagnostic suspicion or diagnostic confirmation at operation of an hourglass biceps. Between June 2000 and April 2002, 21 patients were identified as having a confirmed diagnosis at operation. There were 7 women and 14 men; the mean age was 62 years (range, 47-69 years). The dominant arm was affected in 18 patients. Eleven patients were engaged in manual professions involving regular overhead activity (eg, painter, mason, carpenter).

Inclusion criteria were as follows: shoulder pain associated with hypertrophy of the intraarticular portion of the biceps tendon, free mobility of the extraarticular portion of the tendon demonstrated at operation, and incarceration and buckling of the intraarticular tendon on passive elevation of the arm (a positive hourglass test) at operation (Figure 1).

Exclusion criteria were as follows: proximal disinsertions of the biceps tendon (superior labrum anterior-posterior lesions); hypertrophy of the LHB associated with complete dislocation or rupture of the tendon; evidence of macroscopic pathology of the extraarticular portion of the biceps, such as fibrous adhesions or calcifications in the groove; associated glenohumeral pathology, such as osteoarthritis or inflammatory arthritis; previous shoulder fracture; and existing glenohumeral instability.

Patient demographics are presented in Table I.

Clinical findings

All patients presented with a painful shoulder. In 16 cases the pain was localized anteriorly, 10 with radiation

Table I Epidemiology

Case	Age (y)	Sex	Duration of symptoms (mo)	Active elevation (°)	Passive elevation (°)	Constant score (preoperatively)	Arthrosopic/open procedure	Supraspinatus tear	Infraspinatus tear	Subscapularis tear	Rotator cuff repair	Tenodesis/tenotomy
1	63	M	6	170	160	49	Open	1	1	0	1	Tenodesis
2	69	M	12	130	170	38	Open	1	1	0	1	Tenodesis
3	62	M	6	80	150	28	Open	1	1	0	1	Tenodesis
4	54	F	1	80	170	32	Open	1	1	0	1	Tenodesis
5	62	M	8	160	160	46	Open	0	0	1	1	Tenotomy
6	67	M	13	140	160	43	Open	1	1	1	1	Tenodesis
7	58	F	1	120	170	23	Open	1	1	0	1	Tenodesis
8	58	F	1	160	160	52	Open	1	1	0	1	Tenodesis
9	52	M	1	160	160	38	Arthroscopic	1	1	1	0	Tenodesis
10	54	F	12	170	170	50	Open	1	1	0	1	Tenodesis
11	57	M	24	90	150	36	Open	1	1	0	1	Tenodesis
12	64	M	36	170	170	38	Open	1	0	0	1	Tenodesis
13	68	F	12	70	140	22	Open	1	1	1	1	Tenodesis
14	69	M	12	110	160	33	Arthroscopic	1	1	0	0	Tenodesis
15	57	M	60	90	180	38	Open	1	1	0	1	Tenodesis
16	67	M	1	130	160	34	Arthroscopic	1	0	0	1	Tenodesis
17	69	F	12	170	170	42	Arthroscopic	1	1	0	1	Tenodesis
18	59	M	9	170	150	44	Arthroscopic	1	1	0	0	Tenodesis
19	76	M	24	90	160	32	Arthroscopic	Partial	0	0	0	Tenodesis
20	62	F	36	170	170	46	Arthroscopic	1	1	0	0	Tenodesis
21	47	M	7	180	160	59	Open	1	1	0	1	Tenotomy

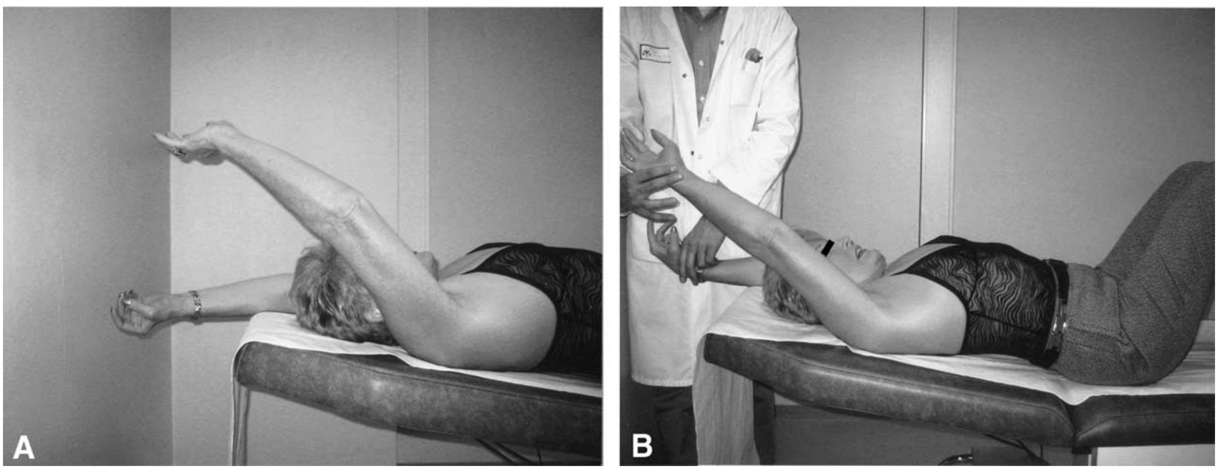

Figure 2 A loss of 10° to 20° of passive elevation, resulting from mechanical locking, is evocative of an hourglass biceps (**A**). Attempt to force passive elevation results in increasing shoulder pain (**B**).

toward the elbow and 8 with radiation toward the neck. In 14, it was described as a constant pain. In all patients the pain was worse during active elevation above the horizontal. The mean duration of symptoms before consultation was 13.2 months. All of the patients had received nonoperative therapy for at least 6 months. This included nonsteroidal antiinflammatory drugs, physiotherapy, rest, and local injections. The patients had received, on average, 2.6 injections (range, 0-15) of a steroid into either the bursa or the glenohumeral joint.

On clinical examination, 15 patients had tenderness over the bicipital groove. Ten had a positive Speed's test, and seventeen had a positive Jobe's test. We observed that both active elevation and passive elevation were restricted, with a loss of the final 10° to 20° of elevation. The loss of passive elevation was best demonstrated with the patient in the supine position and relaxed. Any attempt to force passive elevation resulted in increasing shoulder pain (Figure 2). This mechanical locking of the glenohumeral joint was later related to the hypertrophic intraarticular portion of the biceps tendon, as observed at the time of surgery.

Figure 3 Arthrogram demonstrating intraarticular tendon hypertrophy and showing the difference in diameter between the intraarticular portion and the groove portion of the biceps.

Radiologic findings

In all patients, standard radiographs were obtained, consisting of an anteroposterior projection in neutral, external, and internal rotation, a lateral view of the scapula, and an axillary view. Plain radiography revealed a type III acromion in 9 cases and a mean acromiohumeral distance of 6.4 mm. Sixteen computed tomography arthrograms and four magnetic resonance images were also obtained. Arthrography was the most helpful investigation regarding biceps tendon hypertrophy (Figure 3), although even with this test, only 6 patients were identified as having a hypertrophic tendon. Computed tomography arthrograms confirmed the rotator cuff pathology but was helpful in identifying biceps hypertrophy in only 3 cases. In 6 cases a diagnosis of associated biceps tendon subluxation was made. In the 4 patients for whom a magnetic resonance image was available, the diagnosis of a hypertrophic tendon could not be made. However, those magnetic resonance images had been obtained without intraarticular injection of gadolinium.

The surgical or arthroscopic exploration and treatment were performed by the senior surgeon (P.B.) or under his control. Patients were operated on under general anesthesia in the beach-chair position for both open and arthroscopic surgery. Arm traction was not used. The arthroscope was introduced through a routine posterior portal. After open exploration or diagnostic arthroscopy, the hourglass test was performed (full description below). Only after the hourglass test had been performed was a probe introduced through an anterior portal to pull the entire extraarticular portion of the biceps tendon into the joint for inspection and assessment of its mobility.

Postoperatively, the patients were followed up on a regular basis (at 3, 6, 9, and 12 months after surgery and then every year). They were evaluated by use of the functional score of Constant and Murley[5] at each review.

RESULTS

Operative and arthroscopic findings

A so-called hourglass biceps was identified in 14 cases during open surgery and in 7 during arthroscopic surgery. All cases occurred in the presence of a full-thickness rotator cuff rupture, except for one with a partial deep tear of the supraspinatus. Three cases were associated with a small isolated supraspinatus tear. The cuff lesions are detailed in Table I.

The intraarticular portion of the biceps was hypertrophic in all cases. The mean diameter of the intraarticular biceps tendon, measured with calipers after exteriorization of the tendon, was 12 $\pm$ 3 mm, whereas the diameter of the groove portion of the tendon averaged only 6 $\pm$ 2 mm. In addition to tendon hypertrophy, observation of the intraarticular portion of the tendon revealed gross, macroscopic fraying (delamination) in 15 cases. The tendon was subluxed at the entrance of the groove in 6.

To determine whether the hypertrophic tendon may be a cause of mechanical locking of the shoulder, we developed the **intraoperative hourglass test.** The test was performed during open and arthroscopic surgery and involved passively elevating the arm in the plane of the scapula in neutral rotation with the elbow extended (Figure 4,*A*). In a positive hourglass test, buckling of the hypertrophic intraarticular portion of the tendon was observed (Figure 4, *B* and *C*). The test was considered to be valid only if the portion of the tendon within the groove had been demonstrated to slide freely, by pulling the distal tendon into the joint with a probe or hook. It was also important that the elbow was kept extended. Flexion of the elbow relaxed the biceps muscle–tendon unit and potentially could lead to a false-positive finding as a result of buckling of the tendon in the joint, even in the absence of hypertrophy of its intraarticular portion. As we attempted to bring the arm into full elevation, we could feel resistance and could observe a concomitant squeezing of the tendon between the humeral head and the glenoid. It was clear from observation that biceps incarceration in the joint was the reason for the restricted passive elevation of 10° to 20°.

All patients were treated by biceps tenodesis or

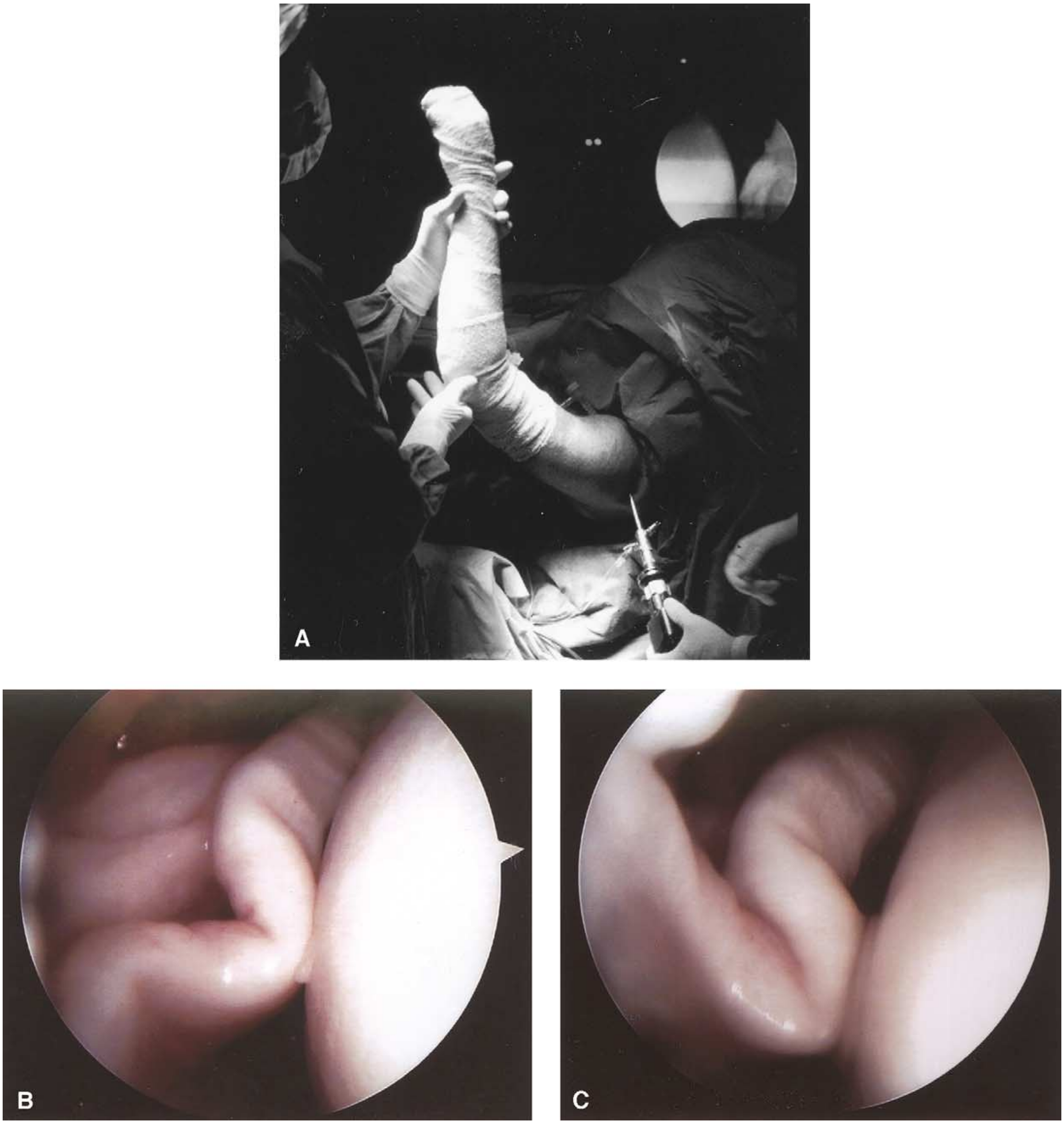

Figure 4 The hourglass test, performed during surgery, involves passively elevating the arm in neutral rotation with the elbow extended (**A**). Arthroscopic intraoperative photographs (**B** and **C**), during the hourglass test, demonstrate incarceration (locking) of the biceps tendon within the joint and the characteristic buckling of the tendon (Z tendon).

tenotomy after removal of the hypertrophic intraarticular portion of the tendon and appropriate treatment of the concomitant lesions. The choice between tenotomy and tenodesis depended on the circumstances of each case, although the surgeon's preference was to perform a tenodesis.

Tenotomy was performed in 2 patients, and the intraarticular, hypertrophic portion of the biceps tendon was excised. This first required division of the tendon at the entrance of the bicipital groove and then release of the tendon at its glenoid origin, which we have called "bipolar tenotomy." The intraarticular portion of the tendon was then removed with a grasper.

In 19 cases a tenodesis was performed by a technique previously described, by placement of the tendon into a bony socket drilled at the top of the groove and by use of an absorbable interference screw for fixation.[2] After tenotomy at the supraglenoid tubercle, the tendon was measured, pulled out of the anterior portal, doubled, and sutured to itself over a distance of 20 to 25 mm with an absorbable suture. The volume of the hypertrophic biceps tendon was surgically reduced before suturing so that the calibrated diameter of the doubled tendon was usually 8 or 9 mm. A bony socket of the same diameter as the calibrated tendon was drilled at the level of the bicipital groove to a depth of 25 mm, 1 cm below the top of the groove. The doubled tendon was inserted into the humeral socket. Fixation within the tunnel was performed with a soft-tissue resorbable interference screw measuring 9 × 20 mm (Tenoscrew; Phusis, St. Ismier, France) (Figures 5 and 6).

Sixteen patients underwent concomitant rotator cuff repair (Table I). There were 14 open and 2 arthroscopic procedures. One patient with a partial deep tear underwent debridement. In 14 patients who underwent rotator cuff repair, a subacromial decompression was also performed. Two patients with irreparable cuff tears were treated with subacromial decompression.

Full elevation of the shoulder was immediately reestablished (during surgery) after complete removal of the intraarticular portion of the tendon. This confirmed that the restriction of shoulder mobility was related to the incarcerated biceps tendon.

The early results of treatment were evaluated for 14 patients with a minimum follow-up of 12 months. Active elevation improved from 120° preoperatively to 167° postoperatively. Active external rotation improved from 38° to 52°. The Constant score improved from 38 points preoperatively to 76 points at final follow-up ($P < .05$). Pain improved from 4 points preoperatively to 13 points at the last review. All patients regained complete and symmetric passive elevation during surgery (negative hourglass test) and at the last review (Figure 7).

DISCUSSION

Although enlargement of the LHB tendon has been described previously, mainly in association with massive rotator cuff tears, to our knowledge, no author has reported that entrapment of the biceps tendon inside the joint could be a cause of pain and dysfunction of the shoulder. We present a previously unrecognized mechanical condition affecting the LHB tendon, in which entrapment of the tendon within the joint causes shoulder pain and limited elevation. In these patients, hypertrophy of the intraarticular portion of the LHB tendon prevents sliding of the tendon into the bicipital groove with elevation of the shoulder. This leads to incarceration and squeezing of the tendon within the joint with elevation of the arm, leading to a loss of 10° to 20° of passive elevation.

Figure 5 Intraoperative photograph, taken during open surgery, demonstrates a typical hourglass biceps: note the difference in diameter between the intraarticular portion and the groove portion.

Simple tenotomy cannot resolve this mechanical block. Tenotomy or tenodesis, with excision of the intraarticular portion of the tendon, must be performed. The fact that complete elevation of the shoulder is immediately reestablished after removal of the intraarticular portion of the biceps confirms that the restricted shoulder mobility is related to the incarcerated tendon.

The cause of hypertrophy of the biceps tendon is still debated.[8,13,15–18,24] Leffert and Rowe[13] ob-

Figure 6 Biceps tenodesis with a bioabsorbable interference screw can be performed with open or arthroscopic surgery; it allows one to remove the pathologic intraarticular portion of the tendon and to keep muscle tension.

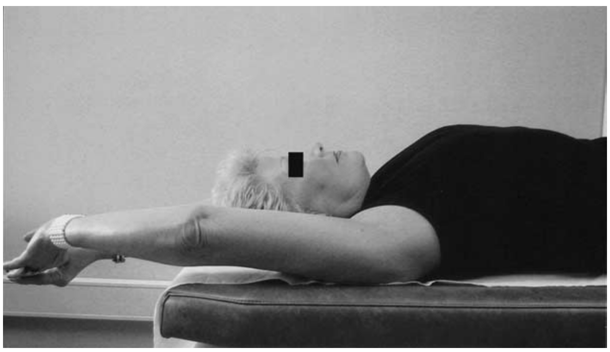

Figure 7 Complete restoration of active and passive elevation after removal of the hypertrophic and entrapped intraarticular portion of the biceps (same patient as in Figure 2).

served that the size of the LHB tendon could be increased in association with degenerative rotator cuff tears. They believed that this hypertrophy represented a mechanism of functional compensation in the absence of a rotator cuff. Neer[17] has also discussed the function of the LHB as a humeral head depressor, as well as its possible hypertrophy in cases of rotator cuff rupture. Goldfarb and Yamaguchi[10] proposed an alternative explanation for hypertrophy of the LHB tendon, relating its occurrence to the tendon's anterior location in the joint and subsequent impingement beneath the coracoacromial arch. According to these authors, hypertrophy occurring in association with chronic rotator cuff tears could represent an inflammatory response resulting from anterosuperior impingement.[10,17] This view is also supported by histologic studies demonstrating inflammatory changes within the pathologic LHB tendon.[16,24] A recent publication has pointed out the lack of functional muscular hypertrophy in cases of massive cuff rupture, which would be expected if the LHB is an active participant in depression of the humeral head.[24] Other recent electrophysiologic and anatomic studies also call into doubt the head-depressing role of the LHB.[11,12,14,15,28]

Hitchcock and Bechtol[12] described inflammation within the bicipital groove leading to adhesions that prevent free movement of the tendon within the groove. They advocated tenodesis with excision of the intraarticular portion of the tendon "to prevent buckling." More recently, decompression and synovectomy have been advocated for tendinitis located within the groove.[16] Cases of significant adhesions within the groove leading to reduced movement of the tendon were specifically excluded from our study, as these conditions could lead to a clinical picture similar to that of the hourglass biceps. In our series the inability of the biceps tendon to slide into the groove was clearly related to the excessive diameter of the intraarticular portion of the tendon. It was always possible to pull the tendon into the glenohumeral joint.

It is also possible that a form of chronic internal impingement due to repetitive friction at the entry of the groove may contribute to the inflammatory process, in a pathologic process similar to a trigger finger. It may have been the primary cause of hypertrophy in our cases with an intact rotator cuff or a small supraspinatus tear. The motion involved has been shown to be movement of the groove over the stationary tendon,[7,12,15] and it may be that bicipital groove stenosis[19,21] and the shape of the bicipital groove play a part in preventing the hypertrophied tendon from entering the groove.[6,12,15] A deep, narrow groove may also be a predisposing factor leading to hypertrophy of the tendon, but this study cannot prove this theory. Our view is that the hypertrophy encountered in the hourglass biceps is the result of multiple factors: (1) functional hypertrophy because of a deficient superior cuff, (2) an inflammatory process resulting from external (anterosuperior) impingement with the coracoacromial arch, and (3) an inflammatory process due to repetitive friction of the tendon in a narrow groove.

The symptoms that are caused by an hourglass biceps are difficult to differentiate from those of accompanying rotator cuff pathology. All of our patients had chronic shoulder pain. Pain was increased by both active and passive elevation of the shoulder above the horizontal. It is reasonable to assume that an inflamed tendon is painful, but it has been our observation that the incarceration of the hypertrophic

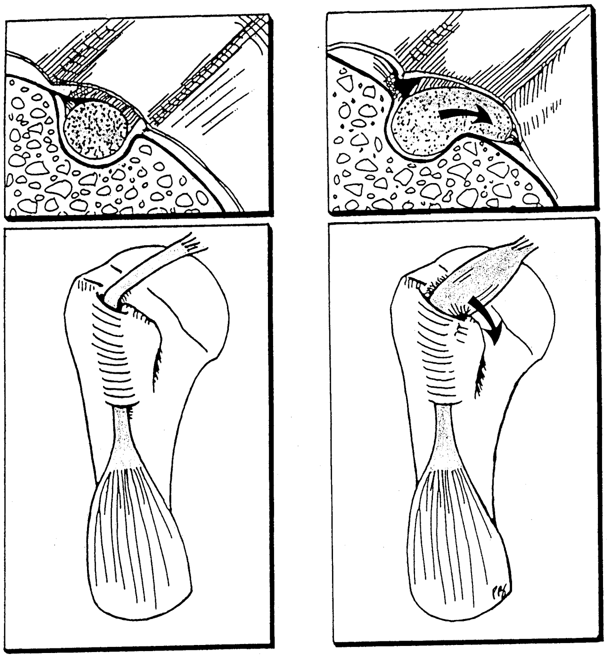

Figure 8 Hypertrophic biceps tendon may be partially responsible for the tear, dilatation or stretching of the pulley system, leading to its instability at the entry of the groove (associated subluxation).

tendon within the joint is equally a cause of pain and a mechanical block of forward elevation. We found that this mechanical block of passive elevation of 10° to 20° is the most consistent finding in the clinical examination. This is similar to the locked knee with a bucket-handle meniscal tear leading to restricted knee extension. Furthermore, this condition should not be mistaken for a mild frozen shoulder. Having a patient with an hourglass biceps see a physiotherapist for passive exercises would be inappropriate, as the locking of the shoulder is mechanical and irreducible. In our opinion the primary treatment for the hourglass biceps is surgical.

Diagnostic imaging of the hourglass biceps can demonstrate a hypertrophied intraarticular tendon. This is best seen on the anteroposterior internal rotation arthrography view (Figure 3). However, arthrography cannot differentiate a simple hypertrophied tendon from a truly incarcerated hourglass tendon. Dynamic ultrasound or magnetic resonance imaging studies may prove to be better techniques for the diagnosis, although we do not have experience with these modalities at present. The presence of subluxation of the LHB does not exclude the diagnosis of an hourglass biceps, as this pathologic association was present in 6 cases in this series. The hypertrophic biceps tendon, in some cases, may be partially responsible for the tear, for dilatation, or for stretching of the pulley system, leading to instability of the tendon at the entry of the groove (Figure 8).

The hourglass test, performed during open or arthroscopic surgery, leads to the definitive diagnosis.

The hourglass biceps can be compared with the condition of trigger finger in the hand, where an enlarged tendon is constrained by a narrowed pulley.[23] However, this condition is fundamentally different with regard to the treatment, as it is not possible to restore the movement of the tendon by enlarging the constraining ring (the superior glenohumeral and transverse humeral ligaments). A release of the biceps pulley in the shoulder might lead to instability of the tendon and persistent symptoms. In our opinion, surgically reducing the size of the tendon would also not likely allow smooth and unrestricted sliding of the tendon within the groove. The most logical treatment is tenotomy with excision of the intraarticular segment of the tendon or tenodesis in the bicipital groove.[25,26]

For tenotomy, it is essential to resect the intraarticular hypertrophied portion of the tendon or there is a risk of persistent and perhaps worsened symptoms as a result of an incarcerated but newly mobile tendon in the glenohumeral joint. Only removal of the intraarticular portion of the biceps can restore complete and normal elevation of the shoulder (Figure 8). In the case of tenodesis, many techniques exist,[1,4,6,8,26] but we prefer to use the technique described earlier.

In summary, entrapment of the LHB occurs in a position of elevation of the arm above the head, when the intraarticular portion of the tendon has become too hypertrophic to pass through the pulley system. Three points should be emphasized:

1. Clinicians should consider the possibility of an hourglass biceps in patients with shoulder pain associated with an asymmetrical loss of 10° to 20° of passive elevation. This clinical entity must not be mistaken for a mild frozen shoulder.
2. Definitive diagnosis of the hourglass biceps can only be made at surgery, either arthroscopically or open, with incarceration and buckling of the tendon on passive elevation of the shoulder with the elbow extended.
3. Simple tenotomy or tenodesis cannot resolve this mechanical block; the intraarticular portion of the tendon must be removed from the joint.

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