Disorder of the long head of the biceps tendon

Benno Ejnisman, Gustavo Cará Monteiro, Carlos Vicente Andreoli, Alberto de Castro Pochini

Federal University of São Paulo, São Paulo, Brazil

Correspondence to
Dr Benno Ejnisman, Federal University of São Paulo, Rua Embaú 87, CEP 04039-060, São Paulo 05011001, Brazil; bennoale@uol.com.br

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ABSTRACT

This paper focuses on biceps injuries in shoulder surgery. This topic is currently of great interest, and there has been much discussion about diagnosis, treatment and prevention. Biceps tendon pathology exists in many forms and is frequently associated with other shoulder disorders. These facts must be taken into consideration in the evaluation and treatment of patients with long head of the biceps pathology. There is much controversy about the long head of the biceps tendon (LHBT). The clinical significance to shoulder function, diagnosis and treatment are still a source of debate. The purpose of this review is to discuss the anatomy, function, pathology, clinical manifestation, physical examination, imaging and treatment of disorders of the LHBT.

ANATOMY

The LHBT is a structure present in the glenohumeral joint that originates from the glenoid labrum and the supraglenoid tubercle. The tendon is an intra-articular structure but is extrasynovial, being covered by a synovial sheath. Anatomical studies have shown some variation in the origin of this tendon.[1–3] Many anatomical variations are described, including bifurcated origin, absence of the tendon, adherence to the supraspinatus tendon, an extra-articular segment and the presence of vincula.[4–12] These variations are related to the embryological development of the tendon and may acquire pathological significance.[13]

The LHBT runs through the bicipital groove and exits the intra-articular space. Just proximal to the groove, the tendon is stabilised by the pulley system. The superior glenohumeral ligament and the coracohumeral ligament are the structures that compose the pulley system. In the bicipital groove the tendon is stabilised by the transverse humeral ligament, which is formed by fibres from the subscapularis and supraspinatus tendons.[14]

The LHBT is vascularised by branches of the suprascapular artery, the anterior humeral circumflex artery and the deep brachial artery.[15] The tendon innervations are provided by branches of the musculocutaneous nerve.

FUNCTION

There is much controversy about the function of the LHBT. Anatomical, biomechanical and electromyographic studies have been designed to determine the function of the LHBT. Two main functions were attributed to the tendon: humeral head depression and glenohumeral stabilisation.

The humeral head depressor function of the LHBT was shown by biomechanical studies. The contraction of the biceps or the external rotation of the arm provided superior stability to the humeral head preventing superior migration.[16 17] On the other hand, electromyographic testing did not show muscle activity when the elbow was kept immobilised. This may implicate a more static than dynamic stabilisation function of the LHBT.[18 19] In patients with rotator cuff tears increased biceps activity was shown.[20] Another biomechanical study showed that superior humeral head migration occurred during arm elevation without biceps contraction. No migration was detected when the biceps was activated during the arm elevation.[21]

The LHBT is also related to anterior shoulder stability. Detachment of the superior labrum and biceps anchor cause an increased anterior and inferior translation of the humeral head on the glenohumeral joint, with more tension transmitted to the inferior glenohumeral ligament in the cocking position.[22–23] In the unstable shoulder, the contribution to anterior stabilisation is increased, with greater electromyographic activity of the biceps muscle in such individuals during throwing motion.[24–26] Another study showed that loading the LHBT significantly affected glenohumeral rotational range of motion, translation and kinematics in athletes.[27]

PATHOLOGY

Biceps tendinopathy

Biceps tendonitis or tenosynovitis is the degeneration of the tendon itself or the tendon sheath. It can be caused by attrition of the tendon in the groove, which can present some abnormalities such as osteophytes or a shallow and narrow shape.[28 29] Primary tendonitis is an uncommon pathology occurring in approximately 5% of all cases of biceps tendinopathy.[30]

Another cause of tendonitis is the impingement syndrome associated with rotator cuff pathology. In a study of complete rotator cuff tears, Chen *et al*[31] found that 76% of cuff tears had associated LHBT pathology. Gill *et al*[32] showed that in 85% of LHBT partial tears cuff pathology was associated.

A chronic process of tenosynovitis can cause tendon enlargement as a tendinosis process and thickening of the tendon sheath (figure 1). This can cause entrapment of the tendon within the groove, with the intra-articular portion of the tendon getting incarcerated in the joint. This condition is similar to a trigger finger and has been described as the 'hourglass' biceps.[33] The clinical manifestation is pain and locking of the shoulder and is best treated with biceps tenotomy and tenodesis.

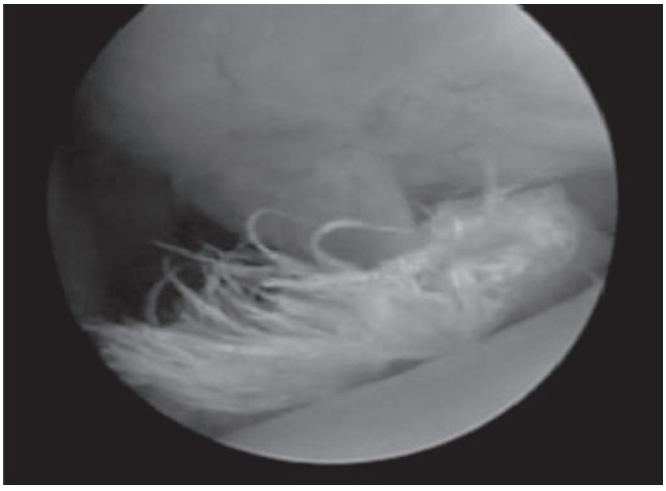

Figure 1 Biceps tendinopathy (>50%)—arthroscopic view.

Biceps instability

The pulley system is responsible for the stability of the tendon as it transits from the intra-articular space into the bicipital groove. It is formed by four structures: the coracohumeral ligament, the superior glenohumeral ligament and fibres from the subscapularis and supraspinatus tendons.[34]

A lesion of the pulley structure can be secondary to a traumatic event or to a degenerative process, associated with rotator cuff pathology.[35 36] After the pulley is torn, the LHBT becomes unstable followed by alteration of the surrounding tissues or the tendon itself.

Bennett[37] found that in 43% of superior labrum anterior–posterior (SLAP) repairs there was pulley system damage. Due to this strong association, the author suggested that this structure should always be inspected when a SLAP repair is performed.

Impingement of the coracoid can also produce subscapularis tendon and LHBT pathology.[38] In throwing athletes, the contact of the pulley with the posterosuperior labrum in the late cocking phase can damage the pulley.[39]

Biceps instability is frequently associated with rotator cuff tears but may be present with no concomitant lesions.[40] The dislocation over the subscapularis tendon has been described in the past.[41] More recently, dislocation under the subscapularis was demonstrated, whereby the biceps tendon assumes a medial intra-articular position or penetrates the substance of the subscapularis.[42–44] A LHBT dislocation with an intact subscapularis tendon implies damage of the rotator interval tissue, including the coracohumeral and superior glenohumeral ligaments.[45]

Biceps instability can produce mild migration of the LHBT from the groove. This is considered a subluxation of the tendon. There is often some degree of subscapularis involvement and the deeper surface of the LHBT is usually frayed. Walch *et al*[46] mentioned that subluxation has a different clinical manifestation when compared with total dislocation of the LHBT. In subluxation patients pain was the most common symptom, whereas in dislocated patients pseudoparalysis of the shoulder was more frequent because of the associated rotator cuff pathology.

LHBT instability is best assessed during arthroscopy. Lafosse *et al*[47] found 45% of LHBT instability in 200 patients submitted to arthroscopic rotator cuff repair. In that series, 85% of the unstable tendons showed some degree of fraying.

Traumatic lesions

Superior labrum anterior–posterior

The studies on the superior labrum gained strength in the 1980s with the use of arthroscopy for the shoulder. Biomechanical and electromyographic studies also contributed to a better understanding of the pathology in this specific area.

Andrews *et al*[48] in 1985 described superior labral pathology in 73 throwers. Snyder *et al*[49] coined the term 'SLAP' in 1990 and proposed a classification. Rodosky *et al*[22] and Pagnani *et al*[23] elucidated the importance of the biceps anchor in shoulder stability.

The SLAP aetiology is traumatic, occurring after repetitive microtrauma or after a major trauma. Andrews *et al*[48] and other authors considered the excessive tension on the biceps anchor during the eccentric contraction of the biceps muscle in the final phase of the throwing motion.[50 51] Snyder *et al*[49] found that a fall on an outstretched hand was the major trauma mechanism. This mechanism was confirmed in cadaveric studies.[52] Morgan *et al*[53] and other authors suggested that the SLAP lesion is the result of a biomechanical disorder of the shoulder, with posterior capsule contracture and scapular dyskinesia.[54] Shepard *et al*[55] suggested that there is a combination of biomechanical factors and traumatic events as the aetiology of SLAP lesions.

Regarding Snyder's classification, type II SLAP lesions result in instability of the biceps anchor with the loss of throwing performance. The suggested treatment is repair of the superior labrum with suture anchors. Because of possible postoperative pain and stiffness after SLAP repair, some authors have suggested biceps tenodesis instead of labral repair and reported better results with this technique.[56] Other authors preferred conservative treatment of isolated SLAP II lesions in patients older than 40 years who were not overhead athletes.[57] In type IV lesions, the LHBT is partly torn. When the tear involves more than 25% of the tendon, tenodesis is indicated.[58]

SLAP lesions can be associated with partial articular supraspinatus tears and paraglenoid cysts. These lesions should be addressed if surgical treatment is performed.

Tendon ruptures

LHBT ruptures are commonly secondary to a degenerative process associated with tendon instability and impingement syndromes. This rupture usually occurs within the groove and a Popeye aspect of the biceps muscle is positive (figure 2). In some cases, the presence of vincula, adhesion or hypertrophy of the tendon can prevent distal migration and deformity.[12] The proximal tendon stump that lies intra-articular is a frequent cause of pain as it is compressed between the humeral head and the glenoid.[59 60] This part of the remaining tendon should be resected if a surgical procedure is indicated.

In some patients the rupture occurs in the musculotendinous junction or within the muscle belly.[61 62] In patients with anabolic steroid abuse this rupture can be located at the tendon–labrum junction.[63]

CLINICAL MANIFESTATION AND PHYSICAL EXAMINATION

Patients with biceps pathology often describe anterior shoulder pain located in the bicipital groove. The symptoms may be difficult to distinguish from associated shoulder pathology, especially rotator cuff disease. A complete examination should

Figure 2 Popeye sign.

be performed with special attention to the rotator cuff tendons and SLAP lesion.

Palpation along the bicipital groove is usually tender. Special tests such as Yergason's and Speed's tests (figures 3–5) can be performed, but the specificity of these provocative tests is somewhat limited.[64 65] These tests are not good tools to evaluate SLAP lesions.[66] Lafosse *et al*[47] found that preoperatively performed O'Brien (figure 6) and Speed's tests did not correlate with intraoperatively observed pathology and rotator cuff symptoms overlap biceps manifestations, making the evaluation difficult.

Biceps instability tests can be performed with palpation of the tendon in the groove and rotation of the arm in different degrees of abduction. A palpable clunk may indicate LHBT instability.

IMAGING

The radiographic evaluation consists of regular views for the glenohumeral joint, acromioclavicular joint and impingement syndrome. Plain films are normal in primary tendinopathy. Special views for the visualisation of the bicipital groove can be used.[67 68] These views may demonstrate the presence of spurs in the groove, which can be a cause of secondary tendinopathy.

Ultrasonography allows a dynamic evaluation of the biceps tendon and rotator cuff. Armstrong *et al*[69] found 100% specificity and 96% sensitivity for subluxation and dislocation of the LHBT. The technique also detected all ruptures but was not reliable for the detection of intra-articular partial thickness tears. The cost effectiveness and patient tolerance are advantages of this method.

Magnetic resonance imaging is a good tool. It is a non-invasive method that provides detailed images. It permits the evaluation of the LHBT and superior labrum, as well the rotator cuff. It allows the diagnosis of subluxation, dislocation,

Figure 3 Yergason test.

Figure 4 Yergason test.

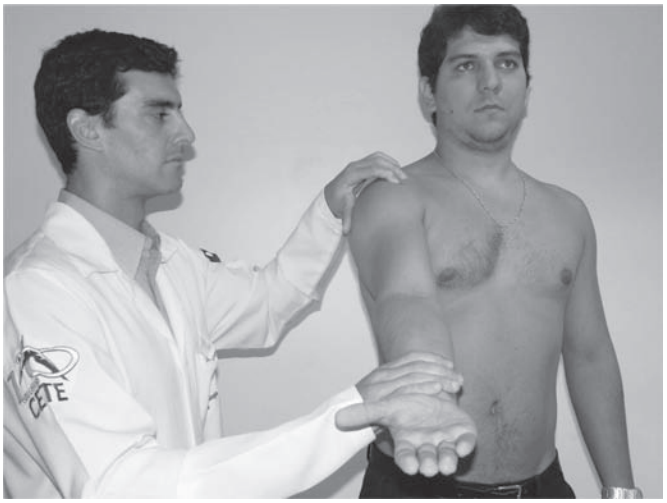

Figure 5 Speed test.

Figure 6 O'Brien test.

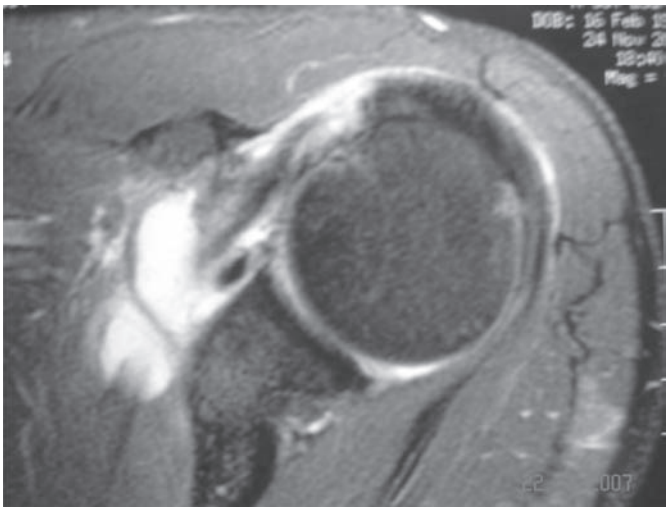

Figure 7 Magnetic resonance image showing subscapular rupture and biceps dislocation.

ruptures and tendinopathy. Intra-articular contrast can be added in selected patients.[70] It is probably the best tool available but it is an expensive examination and not well tolerated by some patients (figure 7).

Arthroscopy is the gold standard technique for diagnosis and also allows the correct treatment. It permits the evaluation of the tendon from the origin to the intertubercular portion.[28] It is also possible to evaluate the pulley system and tendon stability.[71] Surrounding structures can also be inspected with direct view and palpation. Arthroscopic studies reveal direct signs of biceps pathology. The chondromalacia or depression on the humeral head close to the biciptal groove is related to biceps instability.[72 73] This technique is also the best tool to describe the hourglass biceps as mentioned by Boileau *et al*.[33]

CONSERVATIVE TREATMENT

This modality of treatment is indicated for primary tendinopathy or in older or inactive patients with secondary pathology.[30 74]

Conservative treatment is based on rest, medications and physical therapy. Athletes must go through a complete rehabilitation protocol including strengthening of the periscapular muscles.[75]

Patients with chronic pain due to biceps tendinopathy may present with spontaneous rupture of the tendon. This event usually relieves the painful condition. In older individuals the cosmetic deformity that might result is not an important issue. Supination and elbow flexion strength deficit may be approximately 10–21% and may not be noticed by the inactive population. Comparative studies did not show benefit for tenodesis in this population.[5] In an active population biceps tenodesis is indicated.

SURGICAL TREATMENT

The operative treatment for LHBT disorders is focused on the biceps and associated pathology. Important factors such as age, level of activity, sports participation, occupation and type of injury must be considered. Surgical options are synovectomy and tendon debridement, repair of partial tears, tenotomy and tenodesis.

Debridement is an option for patients with superficial fraying of the tendon without associated disorders in the shoulder. The diseased tissue is resected and it should not compromise more than 25–50% of the tendon.[76] This procedure should be chosen for a very selected population because of the risk of recurrence of the symptoms.

Another option for primary tendinopathy is tendon decompression with synovectomy and tenosynovial release.[77] This procedure may not be possible for all areas of the pathological tendon, especially the intertubercular segment, and symptoms may persist.

Acute biceps rupture may occur in the older population with a chronic history of pain in the shoulder (figure 8) or in a younger and active population with overuse syndromes (figure 9). These populations should be differentiated and treated differently. The deformity is usually not an important aspect in older patients and may not occur in chronic processes. In younger individuals, the deformity may play a more important role. Strength loss and cramping may not be noticed by less active individuals. Therefore, conservative treatment is indicated in older patients and surgical treatment is performed in younger and more active patients.[63] Biceps tenodesis is the surgical option of choice and all possible associated lesions must be evaluated (figures 10 and 11).

It is also important to address the intra-articular proximal tendon stump, as it can impinge between the humeral head and glenoid, producing pain and chondral erosion. Richards and Burkhart[78] described an arthroscopic technique for repair of a retracted LHBT rupture. The tendon is retrieved and passed retrograde through its anatomical tract, beneath the pectoralis major and tenodesis is performed in the upper part of the bicipital groove.

Reconstruction of the damaged pulley was proposed by some authors for the treatment of biceps instability.[79 80] Bennett[79] described an arthroscopic technique that consists of reconstruction of the normal stabilisation structures in the groove, including the subscapularis and supraspinatus tendons. Debridement of the frayed biceps tendon is performed if necessary. The technique was considered efficient by the author and decreased the symptoms of biceps inflammation and subluxation in the majority of cases in his cohort. Maier *et al*[81] considered stabilisation of the LHBT in young patients with traumatic subscapularis tears.

In patients with intense tendinopathy and gross instability, biceps tenotomy or tenodesis are the treatment options. There is much controversy about this issue. Regardless of the procedure chosen, the associated pathology should always be addressed.

Biceps tenotomy is a simple procedure that requires no immobilisation and a short period of rehabilitation when

Figure 8 Acute Popeye sign in older patient.

Figure 9 Exact moment of a boxer having proximal biceps injury of the right shoulder.

Figure 10 Open biceps tenodesis.

performed in isolation. The disadvantages are the residual deformity, although not always present, weakness in supination and elbow flexion and sometimes pain or cramping when performing heavy activities.

Distal migration of the LHBT after tenotomy may produce the Popeye sign. Boileau *et al*[82] found 62% of patients with this deformity after isolated tenotomy in patients with irreparable rotator cuff tears. Kelly *et al*[83] mentioned 70% of deformity. Patients with a chronic inflammatory process may develop tendon hypertrophy and flattening avoiding distal tendon migration. Adhesion in the groove and the presence of vincula may also preclude the deformity.[84] Loss of supination and elbow flexion strength after biceps tenotomy has been described.[85–87] In the less active population the deficits may not be noticed but in athletes and active individuals this should be taken into consideration. Pain and cramping during heavy activity may also result after biceps tenotomy. Kelly *et al*[83] found 38% of patients complaining of soreness with resisted elbow flexion, although the majority of patients were considered good results. Osbahr *et al*[88] found no difference in muscle spasms in the biceps when comparing patients submitted to tenotomy or tenodesis.

The overall results for isolated biceps tenotomy are considered favourable by some authors. Gill *et al*[86] reported improved function and pain reduction after simple arthroscopic tenotomy. Walch *et al*[87] reported 87% improvement and satisfaction in patients with irreparable rotator cuff tears. Tenotomy should be considered in older patients with low demand activities who are not concerned about a possible residual deformity.[89 90]

Biceps tenodesis has been described to treat anterior shoulder pain in the past. Isolated biceps tenodesis without the subacromial space procedure was performed by some surgeons.[58 75 91]

After Neer's description of the impingement syndrome,[92] the focus changed to the subacromial space. Neer[92] found that 70% of patients who underwent acromioplasty had significant bicipital pathology. Considering the biomechanical importance of the tendon, the author avoided biceps tenodesis. The patients continued to experience anterior shoulder pain at long-term follow-up and tenodesis became an important procedure during acromioplasty or rotator cuff repair.[93] Neviaser *et al*[94] described the four-in-one procedure for impingement syndrome and tenodesis was included. Walch *et al*[95] mentioned the importance of opening the rotator interval to evaluate biceps aspect and stability during rotator cuff repair.

The advantages of tenodesis are the maintenance of muscle strength and cosmetic. The disadvantages are the necessity for hardware in some techniques, a more complex procedure when compared with tenotomy and a longer rehabilitation period.

Biceps tenodesis can be performed as an open or arthroscopic procedure (figures 10 and 11), with soft tissue or bone fixation and above or below the bicipital groove. A soft tissue procedure consists of fixation of the biceps tendon to the subscapularis, supraspinatus or conjoint tendons.[96–103] This is a simple technique with minimal technical challenge but depends entirely on the integrity of the surrounding soft tissue.

The tenodesis can also be performed using hardware.[104–109] Suture anchors, interference screws, screw and washer and bone tunnels are the fixation possibilities. Many biomechanical studies comparing different tenodesis techniques have been designed.[110–116] Most of the studies show that the interference screw provides superior biomechanical properties with respect to cyclic displacement and primary fixation strength, which permits early rehabilitation.

The site of the tenodesis is controversial. Some authors have shown good results with intertubercular tenodesis.[30 117] However, persistent tenderness after this procedure was mentioned by other authors.[118 119] This could be the result of residual tenosynovitis after proximal tenodesis, with the diseased tendon causing pain within the groove. A retrospective

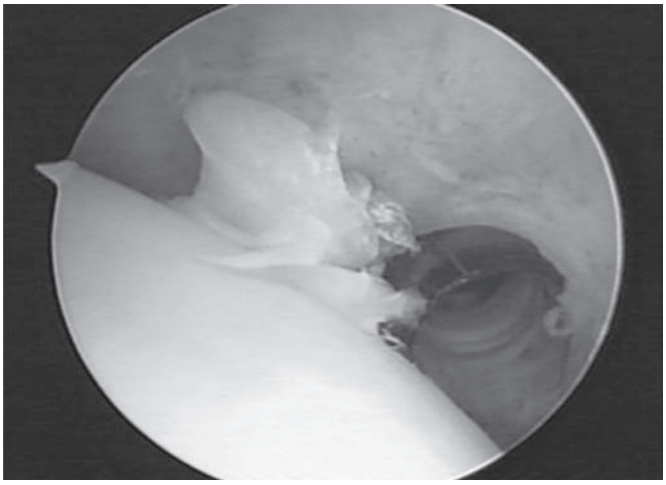

Figure 11 Arthroscopic tenodesis using suture anchors.

study including 188 patients who underwent biceps tenodesis showed that distal tenodesis techniques required fewer revision procedures when compared with proximal tenodesis.[120] Other authors suggest this site of fixation considering the importance of removing most of the LHBT and its associated tenosynovitis.[121–124]

Competing interests None.

What is already known on this topic

- There is still much controversy about LHBT function and treatment options.
- Biceps tendon pathology exists in many forms and is frequently associated with other shoulder disorders.
- It is important to understand that the LHBT may be the primary or secondary source of pain.
- These facts must be taken into consideration during the evaluation and treatment of patients with LHBT pathology.

What this study adds

- In this article, the anatomy, function, pathology, clinical manifestation, physical examination, imaging and treatment of disorders of the LHBT are discussed.

Provenance and peer review Commissioned; not externally peer reviewed.

Patient consent Obtained.

REFERENCES

1. **Habermeyer P**, Kaiser E, Knappe M, *et al.* Functional anatomy and biomechanics of the long biceps tendon. *Unfallchirurg* 1987;**90**:319–29.
2. **Vangsness CT Jr**, Jorgenson SS, Watson T, *et al.* The origin of the long head of the biceps from the scapula and glenoid labrum. An anatomical study of 100 shoulders. *J Bone Joint Surg Br* 1994;**76**:951–4.
3. **Tuoheti Y**, Itoi E, Minagawa H, *et al.* Attachment types of the long head of the biceps tendon to the glenoid labrum and their relationships with the glenohumeral ligaments. *Arthroscopy* 2005;**21**:1242–9.
4. **Enad JG**. Bifurcate origin of the long head of the biceps tendon. *Arthroscopy* 2004;**20**:1081–3.
5. **Mariani PP**, Bellelli A, Botticella C. Arthroscopic absence of the long head of the biceps tendon. *Arthroscopy* 1997;**13**:499–501.
6. **Glueck DA**, Mair SD, Johnson DL. Shoulder instability with absence of the long head of the biceps tendon. *Arthroscopy* 2003;**19**:787–9.
7. **Smith EL**, Matzkin EG, Kim DH, *et al.* Congenital absence of the long head of the biceps brachii tendon as a VATER association. *Am J Orthop* 2002;**31**:452–4.
8. **Franco JC**, Knapp TP, Mandelbaum BR. Congenital absence of the long head of the biceps tendon. A case report. *J Bone Joint Surg Am* 2005;**87**:1584–6.
9. **Wahl CJ**, MacGillivray JD. Three congenital variations in the long head of the biceps tendon: a review of pathoanatomic considerations and case reports. *J Shoulder Elbow Surg* 2007;**16**:e25–30.
10. **Audenaert EA**, Barbaix EJ, Van Hoonacker P, *et al.* Extraarticular variants of the long head of the biceps brachii: a reminder of embryology. *J Shoulder Elbow Surg* 2008;**17**:114S–17S.
11. **Hyman JL**, Warren RF. Extra-articular origin of biceps brachii. *Arthroscopy* 2001;**17**:E29.
12. **Johnson LL**, Bays BM, van Dyk GE. Vincula of the biceps tendon in the glenohumeral joint: an arthroscopic and anatomic study. *J Shoulder Elbow Surg* 1992;**1**:162–6.
13. **Dierickx C**, Ceccarelli E, Conti M, *et al.* Variations of the intra-articular portion of the long head of the biceps tendon: a classification of embryologically explained variations. *J Shoulder Elbow Surg* 2009;**18**:556–65.
14. **Gleason PD**, Beall DP, Sanders TG, *et al.* The transverse humeral ligament: a separate anatomical structure or a continuation of the osseous attachment of the rotator cuff? *Am J Sports Med* 2006;**34**:72–7.
15. **Burkhead W**. The biceps tendon. In: Rockwood CJ, ed. *The shoulder*. Philadelphia, Pennsylvania, USA: WB Saunders, 2004:1059–150.
16. **Kumar VP**, Satku K, Balasubramaniam P. The role of the long head of the biceps brachii in the stabilization of the head of the humerus. *Clin Orthop* 1989;**244**:172–5.
17. **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**:366–72.
18. **Yamaguchi K**, Riew KD, Galatz LM, *et al.* Biceps activity during shoulder motion: an electromyographic analysis. *Clin Orthop Relat Res* 1997;**336**:122–9.
19. **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**:250–5.
20. **Sakurai G**, Tomita Y, Nakagaki K, *et al*. Role of long head of biceps brachii in rotator cuff tendon failure: an EMG study. *J Shoulder Elbow Surg* 1996;**5**:S135.
21. **Kido T**, Itoi E, Konno N, *et al.* The depressor function of biceps on the head of the humerus in shoulders with tears of the rotator cuff. *J Bone Joint Surg Br* 2000;**82**:416–19.
22. **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**:121–30.
23. **Pagnani MJ**, Deng XH, Warren RF, *et al.* Effect of lesions of the superior portion of the glenoid labrum on glenohumeral translation. *J Bone Joint Surg Am* 1995;**77**:1003–10.
24. **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**:546–50.
25. **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**:220–6.
26. **Kim SH**, Ha KI, Kim HS, *et al.* Electromyographic activity of the biceps brachii muscle in shoulders with anterior instability. *Arthroscopy* 2001;**17**:864–8.
27. **Youm T**, ElAttrache NS, Tibone JE, *et al.* The effect of the long head of the biceps on glenohumeral kinematics. *J Shoulder Elbow Surg* 2009;**18**:122–9.
28. **Favorito PJ**, Harding WG III, Heidt RS Jr. Complete arthroscopic examination of the long head of the biceps tendon. *Arthroscopy* 2001;**17**:430–2.
29. **Pfahler M**, Branner S, Refior HJ. The role of the bicipital groove in tendopathy of the long biceps tendon. *J Shoulder Elbow Surg* 1999;**8**:419–24.
30. **Post M**, Benca P. Primary tendinitis of the long head of the biceps. *Clin Orthop Relat Res* 1989;**246**:117–25.
31. **Chen CH**, Hsu KY, Chen WJ, *et al.* Incidence and severity of biceps long head tendon lesion in patients with complete rotator cuff tears. *J Trauma* 2005;**58**:1189–93.
32. **Gill HS**, El Rassi G, Bahk MS, *et al.* Physical examination for partial tears of the biceps tendon. *Am J Sports Med* 2007;**35**:1334–40.
33. **Boileau P**, Ahrens PM, Hatzidakis AM. Entrapment of the long head of the biceps tendon: the hourglass biceps – a cause of pain and locking of the shoulder. *J Shoulder Elbow Surg* 2004;**13**:249–57.
34. **Habermeyer P**, Magosch P, Pritsch M, *et al.* Anterosuperior impingement of the shoulder as a result of pulley lesions: a prospective arthroscopic study. *J Shoulder Elbow Surg* 2004;**13**:5–12.

35. **Le Huec JC**, Schaeverbeke T, Moinard M, *et al.* Traumatic tear of the rotator interval. *J Shoulder Elbow Surg* 1996;**5**:41–6.
36. **Gerber C**, Sebesta A. Impingement of the deep surface of the subscapularis tendon and the reflection pulley on the anterosuperior glenoid rim: a preliminary report. *J Shoulder Elbow Surg* 2000;**9**:483–90.
37. **Bennett WF**. Correlation of the SLAP and pulley. *Arthroscopy* 2007;**23**:e26–7.
38. **Jachna JT**, Buss DD, Freehill MQ, *et al*. Bony and soft tissue coracoid impingement associated with subscapularis and long head of biceps tendon pathology. *J Shoulder Elbow Surg* 2007;**16**:e29–30.
39. **Choi CH**, Kim SK, Jang WC, *et al.* Biceps pulley impingement. *Arthroscopy* 2004;**20** (Suppl 2):80–3.
40. **O'Donoghue DH**. Subluxing biceps tendon in the athletes. *Clin Orthop Relat Res* 1982;**164**:26–9.
41. **Slätis P**, Aalto K. Medial dislocation of the tendon of the long head of the biceps brachii. *Acta Orthop Scand* 1979;**50**:73–7.
42. **Petersson CJ**. Spontaneous medial dislocation of the long head biceps brachii: an anatomic study of prevalence and pathomechanics. *Clin Orthop* 1986;**211**:224–7.
43. **Patte D**, Walch G, Boileau P. Luxation de la longue portion du biceps et rapture de la cauffe des rotateurs. *Rev Chir Orthop* 1990;**76**:95.
44. **Collier SG**, Wynn-Jones CH. Displacement of the biceps with subscapularis avulsion. *J Bone Joint Surg Br* 1990;**72**:145.
45. **Gambill ML**, Mologne TS, Provencher MT. Dislocation of the long head of the biceps tendon with intact subscapularis and supraspinatus tendons. *J Shoulder Elbow Surg* 2006;**15**:e20–2.
46. **Walch G**, Nové-Josserand L, Boileau P, *et al.* Subluxations and dislocations of the tendon of the long head of the biceps. *J Shoulder Elbow Surg* 1998;**7**:100–8.
47. **Lafosse L**, Reiland Y, Baier GP, *et al.* Anterior and posterior instability of the long head of the biceps tendon in rotator cuff tears: a new classification based on arthroscopic observations. *Arthroscopy* 2007;**23**:73–80.
48. **Andrews JR**, Carson WG Jr, McLeod WD. Glenoid labrum tears related to the long head of the biceps. *Am J Sports Med* 1985;**13**:337–41.
49. **Snyder SJ**, Karzel RP, Del Pizzo W, *et al.* SLAP lesions of the shoulder. *Arthroscopy* 1990;**6**:274–9.
50. **Yeh ML**, Lintner D, Luo ZP. Stress distribution in the superior labrum during throwing motion. *Am J Sports Med* 2005;**33**:395–401.
51. **DiGiovane NM**, Jobe FW, Pink M. An electromyographic analysis of the upper extremity in pitching. *J Shoulder Elbow Surg* 1992;**1**:15–25.
52. **Clavert P**, Bonnomet F, Kempf JF, *et al.* Contribution to the study of the pathogenesis of type II superior labrum anterior-posterior lesions: a cadaveric model of a fall on the outstretched hand. *J Shoulder Elbow Surg* 2004;**13**:45–50.
53. **Morgan CD**, Burkhart SS, Palmeri M, *et al.* Type II SLAP lesions: three subtypes and their relationships to superior instability and rotator cuff tears. *Arthroscopy* 1998;**14**:553–65.
54. **Grossman MG**, Tibone JE, McGarry MH, *et al.* A cadaveric model of the throwing shoulder: a possible etiology of superior labrum anterior-to-posterior lesions. *J Bone Joint Surg Am* 2005;**87**:824–31.
55. **Shepard MF**, Dugas JR, Zeng N, *et al.* Differences in the ultimate strength of the biceps anchor and the generation of type II superior labral anterior posterior lesions in a cadaveric model. *Am J Sports Med* 2004;**32**:1197–201.
56. **Bicknell RT**, Parratte S, Chuinard C, *et al*. Arthroscopic treatment of type II SLAP lesions: biceps tenodesis as an alternative to reinsertion. *Arthroscopy* 2007;**23**:e27.
57. **Khetia EA**, Curtis A, Miller S. Factors of failure in SLAP repair. *Arthroscopy* 2007;**23**:e26.
58. **Crenshaw AH**, Kilgore WE. Surgical treatment of bicipital tenosynovitis. *J Bone Joint Surg Am* 1966;**48**:1496–502.
59. **Friedman DJ**, Dunn JC, Higgins LD, *et al.* Proximal biceps tendon: injuries and management. *Sports Med Arthrosc* 2008;**16**:162–9.
60. **Habermeyer P**, Walch G. The biceps tendon and rotator cuff disease. In: Burkhead WZ Jr, ed. *Rotator cuff disorders*. Philadelphia, Pennsylvania, USA: Lippincott/Williams & Wilkins, 1996:142.
61. **Bigliani LU**, Wolfe IN. Biceps tendon rupture in the athlete. *Current Ther Sports Med* 1985:199–203.
62. **Refiar HJ**, Sawa D. Long tendon of the biceps brachii: sites of predilection for degenerative lesions. *J Shoulder Elbow Surg* 1995;**4**:436–40.
63. **Cope MR**, Ali A, Bayliss NC. Biceps rupture in body builders: three case reports of rupture of the long head of the biceps at the tendon-labrum junction. *J Shoulder Elbow Surg* 2004;**13**:580–2.
64. **Yergason R**. Supination sign. *J Bone Joint Surg Am* 1931;**13**:160.
65. **Gilecreest EL**, Albi P. Unusual lesions of muscles and tendons of the shoulder girdle and upper arm. *Surg Gynecol Obstet* 1939;**68**:903–17.
66. **Holtby R**, Razmjou H. Accuracy of the Speed's and Yergason's tests in detecting biceps pathology and SLAP lesions: comparison with arthroscopic findings. *Arthroscopy* 2004;**20**:231–6.
67. **Cone RO**, Danzig L, Resnick D, *et al.* The bicipital groove: radiographic, anatomic, and pathologic study. *AJR Am J Roentgenol* 1983;**141**:781–8.
68. **Fisk C**. Adaptation of the technique for radiography of the bicipital groove. *Radiol Technol* 1965;**37**:47–50.
69. **Armstrong A**, Teefey SA, Wu T, *et al.* The efficacy of ultrasound in the diagnosis of long head of the biceps tendon pathology. *J Shoulder Elbow Surg* 2006;**15**:7–11.
70. **Zanetti M**, Weishaupt D, Gerber C, *et al.* Tendinopathy and rupture of the tendon of the long head of the biceps brachii muscle: evaluation with MR arthrography. *AJR Am J Roentgenol* 1998;**170**:1557–61.
71. **Motley GS**, Osbahr DC, Holovacs TF, *et al.* An arthroscopic technique for confirming intra-articular subluxation of the long head of the biceps tendon: the ramp test. *Arthroscopy* 2002;**18**:E46.
72. **Castagna A**, Mouhsine E, Conti M, *et al.* Chondral print on humeral head: an indirect sign of long head biceps tendon instability. *Knee Surg Sports Traumatol Arthrosc* 2007;**15**:645–8.
73. **Sistermann R**. The biceps tendon footprint. *Acta Orthop* 2005;**76**:237–40.
74. **Depalma AF**, Callery GE. Bicipital tenosynovitis. *Clin Orthop* 1954;**3**:69–85.
75. **Eakin CL**, Faber KJ, Hawkins RJ, *et al.* Biceps tendon disorders in athletes. *J Am Acad Orthop Surg* 1999;**7**:300–10.
76. **Hsu SH**, Miller SL, Curtis AS. Long head of biceps tendon pathology: management alternatives. *Clin Sports Med* 2008;**27**:747–62.
77. **Ruotolo C**, Nottage WM, Flatow EL, *et al.* Controversial topics in shoulder arthroscopy. *Arthroscopy* 2002;**18**:65–75.
78. **Richards DP**, Burkhart SS. Arthroscopic-assisted biceps tenodesis for ruptures of the long head of biceps brachii: the cobra procedure. *Arthroscopy* 2004;**20**(Suppl 2):201–7.
79. **Bennett WF**. Arthroscopic bicipital sheath repair: two-year follow-up with pulley lesions. *Arthroscopy* 2004;**20**:964–73.
80. **Burkhead WZ Jr**, Arcand MA, Zeman C, *et al.* The biceps tendon. In Rockwood C, Matsen F, eds. *The shoulder*. Philadelphia, Pennsylvania, USA: WB Saunders, 1998:1009–63.
81. **Maier D**, Jaeger M, Suedkamp NP, *et al.* Stabilization of the long head of the biceps tendon in the context of early repair of traumatic subscapularis tendon tears. *J Bone Joint Surg Am* 2007;**89**:1763–9.
82. **Boileau P**, Baqué F, Valerio L, *et al.* Isolated arthroscopic biceps tenotomy or tenodesis improves symptoms in patients with massive irreparable rotator cuff tears. *J Bone Joint Surg Am* 2007;**89**:747–57.
83. **Kelly AM**, Drakos MC, 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**:208–13.
84. **Gothelf TK**, Bell D, Goldberg JA, *et al.* Anatomic and biomechanical study of the biceps vinculum, a structure within the biceps sheath. *Arthroscopy* 2009;**25**:515–21.
85. **Ahmad CS**, DiSipio C, Lester J, *et al.* Factors affecting dropped biceps deformity after tenotomy of the long head of the biceps tendon. *Arthroscopy* 2007;**23**:537–41.
86. **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**:247–9.
87. **Walch G**, Edwards TB, Boulahia A, *et al.* Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: clinical and radiographic results of 307 cases. *J Shoulder Elbow Surg* 2005;**14**:238–46.
88. **Osbahr DC**, Diamond AB, Speer KP. The cosmetic appearance of the biceps muscle after long-head tenotomy versus tenodesis. *Arthroscopy* 2002;**18**:483–7.
89. **Shank JR**, Singleton SB, Kissenbertn M, *et al.* A comparison of supination and elbow flexion strength in patients with either proximal biceps release or biceps tenodesis. *Arthroscopy* 2006;**22**:e21.
90. **Wolf RS**, Zheng N, Weichel D. Long head biceps tenotomy versus tenodesis: a cadaveric biomechanical analysis. *Arthroscopy* 2005;**21**:182–5.
91. **Lippmann RK**. Frozen shoulder, periarthritis, bicipital tenosynovitis. *Arch Surg* 1943;**47**:283–96.
92. **Neer CS II**. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J Bone Joint Surg Am* 1972;**54**:41–50.
93. **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**:376–81.
94. **Neviaser TJ**, Neviaser RJ, Neviaser JS, *et al.* The four-in-one arthroplasty for the painful arc syndrome. *Clin Orthop Relat Res* 1982;**163**:107–12.
95. **Walch G**, Nove Josserand L, Levigne C, *et al*. Tears of the supraspinatus tendon associated with "hidden" lesions of the rotator interval. *J Shoulder Elbow Surg* 1994;**3**:353–60.
96. **Castagna A**, Conti M, Mouhsine E, *et al.* Arthroscopic biceps tendon tenodesis: the anchorage technical note. *Knee Surg Sports Traumatol Arthrosc* 2006;**14**:581–5.
97. **Elkousy HA**, Fluhme DJ, O'Connor DP, *et al.* Arthroscopic biceps tenodesis using the percutaneous, intra-articular trans-tendon technique: preliminary results. *Orthopedics* 2005;**28**:1316–19.
98. **Verma NN**, Drakos M, O'Brien SJ. Arthroscopic transfer of the long head biceps to the conjoint tendon. *Arthroscopy* 2005;**21**:764.
99. **Drakos MC**, Verma NN, Gulotta LV, *et al.* Arthroscopic transfer of the long head of the biceps tendon: functional outcome and clinical results. *Arthroscopy* 2008;**24**:217–23.

100. **Sekiya LC**, Elkousy HA, Rodosky MW. Arthroscopic biceps tenodesis using the percutaneous intra-articular transtendon technique. *Arthroscopy* 2003;**19**:1137–41.
101. **Moros C**, Levine WN, Ahmad CS. Suture anchor and percutaneous intra-articular transtendon biceps tenodesis. *Sports Med Arthrosc* 2008;**16**:177–9.
102. **Lichtenberg S**, Lehmann M, Habermeyer P, *et al*. A new arthroscopic technique of biceps tenodesis. *J Shoulder Elbow Surg* 1996;**5**:S49.
103. **Weber SC**, Kauffman J. Arthroscopic biceps tenodesis: experience with the castagna technique: long-term follow-up. *Arthroscopy* 2008;**24**:e9–10.
104. **Nord KD**, Smith GB, Mauck BM. Arthroscopic biceps tenodesis using suture anchors through the subclavian portal. *Arthroscopy* 2005;**21**:248–52.
105. **Lo IK**, Burkhart SS. Arthroscopic biceps tenodesis using a bioabsorbable interference screw. *Arthroscopy* 2004;**20**:85–95.
106. **Klepps S**, Hazrati Y, Flatow E. Arthroscopic biceps tenodesis. *Arthroscopy* 2002;**18**:1040–5.
107. **Gartsman GM**, Hammerman SM. Arthroscopic biceps tenodesis: operative technique. *Arthroscopy* 2000;**16**:550–2.
108. **Romeo AA**, Mazzocca AD, Tauro JC. Arthroscopic biceps tenodesis. *Arthroscopy* 2004;**20**:206–13.
109. **Kim SH**, Yoo JC. Arthroscopic biceps tenodesis using interference screw: end-tunnel technique. *Arthroscopy* 2005;**21**:1405e1–5e2.
110. **Kusma M**, Dienst M, Eckert J, *et al.* Tenodesis of the long head of biceps brachii: cyclic testing of five methods of fixation in a porcine model. *J Shoulder Elbow Surg* 2008;**17**:967–73.
111. **Mazzocca AD**, Bicos J, Santangelo S, *et al.* The biomechanical evaluation of four fixation techniques for proximal biceps tenodesis. *Arthroscopy* 2005;**21**:1296–306.
112. **Rodosky MW**, Costis R, Lopez-Vidriero E, *et al*. Failure strength of arthroscopic biceps tenodesis repairs: suture anchor vs. P.I.T.T. technique. *Arthroscopy* 2006;**22**:e21–22.
113. **Richards DP**, Burkhart SS. A biomechanical analysis of two biceps tenodesis fixation techniques. *Arthroscopy* 2005;**21**:861–6.
114. **Ozalay M**, Akpinar S, Karaeminogullari O, *et al.* Mechanical strength of four different biceps tenodesis techniques. *Arthroscopy* 2005;**21**:992–8.
115. **Golish SR**, Caldwell PE III, Miller MD, *et al.* Interference screw versus suture anchor fixation for subpectoral tenodesis of the proximal biceps tendon: a cadaveric study. *Arthroscopy* 2008;**24**:1103–8.
116. **Jayamoorthy T**, Field JR, Costi JJ, *et al.* Biceps tenodesis: a biomechanical study of fixation methods. *J Shoulder Elbow Surg* 2004;**13**:160–4.
117. **Castagna A**, Conti M, Mouhsine E, *et al*. Arthroscopic biceps tendon tenodesis: the anchorage technical note. *Knee Surg Sports Traumatol Arthrosc* 2005;**14**:581–5.
118. **Boileau P**, Neyton L. Arthroscopic tenodesis for lesions of the long head of the biceps. *Oper Orthop Traumatol* 2005;**17**:601–23.
119. **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**:429–35.
120. **Sanders B**, Lavery K, Pennington S, *et al*. Biceps tendon tenodesis: success with proximal versus distal fixation. *Arthroscopy* 2008;**24**:e9.
121. **Wiley WB**, Meyers JF, Weber SC, *et al.* Arthroscopic assisted mini-open biceps tenodesis: surgical technique. *Arthroscopy* 2004;**20**:444–6.
122. **Mazzocca AD**, Rios CG, Romeo AA, *et al.* Subpectoral biceps tenodesis with interference screw fixation. *Arthroscopy* 2005;**21**:896e1–6e7.
123. **Provencher MT**, LeClere LE, Romeo AA. Subpectoral biceps tenodesis. *Sports Med Arthrosc* 2008;**16**:170–6.
124. **Weber SC**. Arthroscopic "mini-open" technique in the treatment of ruptures of the longhead of the biceps. *Arthroscopy* 1993;**9**:365.

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Benno Ejnisman, Gustavo Cará Monteiro, Carlos Vicente Andreoli and Alberto de Castro Pochini

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Notes