THE PROXIMAL BICEPS TENDON AND ANTERIOR SHOULDER PAIN

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Abstract

The proximal biceps tendon has long been known as a source of anterior shoulder pain, a common compliant fraught with diagnostic challenge due to its vague nature and myriad potential causes. Despite thorough investigation and detailed anatomic description, diagnosing the proximal biceps tendon as the culprit of anterior shoulder pain remains a challenge. Similarly, its biomechanical function in the shoulder joint continues to remain a matter of debate, as do the best methods of treatment of a painful tendon. A thorough understanding of the presentation, anatomy, diagnosis, and treatment options of a painful proximal biceps are important when addressing a patient complaining of anterior shoulder pain.

Introduction

Over the past decade there has been a dramatic increase in tenodesis procedures and subsequent cost[1]. As such, it is important to understand the anatomy, proper diagnosis, and treatment of this unique structure. The biceps brachii consists of two muscle bellies: the short and long heads. The LHBT originates as an intraarticular structure before coursing within a fibro-osseous groove and finally exiting to form the muscle belly distally. While the biceps brachii is innervated by the musculocutaneous nerve, the soft tissue overlying the LHBT contains a dense network of pain and proprioceptive afferent fibers potentiating the tendon's role as a pain generator of the anterior shoulder[23]. Pathology of the tendon includes instability, inflammation, and rupture. These lesions can be a result of trauma, overhead vocations, throwing activity, or degeneration. Despite a large body of literature on the subject, the precise role and treatment for the LHBT is still controversial. In addition, while the LHBT is an important source of anterior shoulder pain, the differential of anterior shoulder pain must also include rotator cuff pathology, impingement, adhesive capsulitis, and glenohumeral chondral defects.

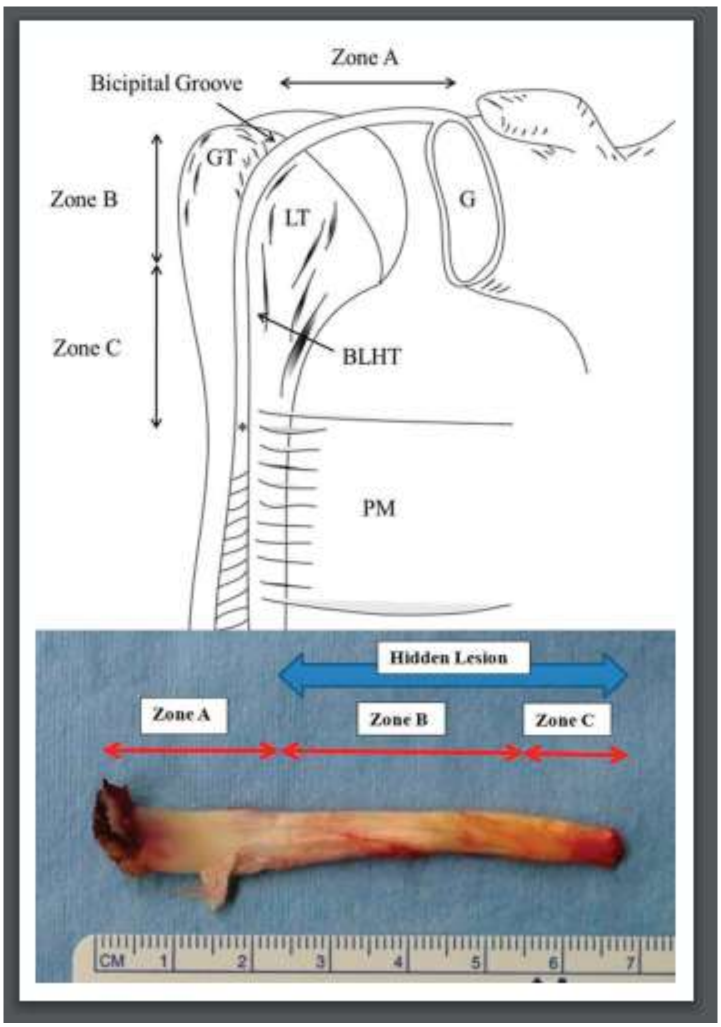

Figure 1: Zones A, B, and C of the proximal biceps tendon. Zone A: the portion from the glenoid tubercle extending distally up to 2.5 cm. Zone B: the intragroove portion extending distally up to 5.6 cm. Zone C: the distal extra-articular portion. Reproduced with permission.

History

The proximal biceps has been a known pain generator for many centuries and was first described by Hippocrates. In 1694, the first case of a proximal biceps dislocation was reported by William Cowper in his *Myotomia Reformata*[4]. More recently, the LHBT was described by Charles Neer as a depressor of the humeral head[5]. He argued both tenotomy and tenodesis of the tendon was a risk for impingement at the shoulder secondary to superior humeral migration. Since then, there have been extensive publications on the anatomy, pathology, and treatment of the LHBT.

Anatomy

Biceps tendon anatomy

The LHBT is commonly believed to originate from the supraglenoid tubercle at the 12 o'clock position of the shoulder 5 mm medial to the superior labrum as described by Cooper et al[6]. In a cadaveric study of 100 shoulders, Vangsness found that while this origin was present in 50% of the cases, the LHBT actually attached to the superior labrum the remaining 50% of the cases[7]. They described four types of biceps attachments to the glenoid labrum: Type I posterior labral attachment, Type II predominantly posterior labral attachment, Type III equal anterior and posterior labral attachments, and Type IV predominantly anterior labral attachment. Among those shoulders with a labral attachment, they were predominantly posterior Type II and III. Further studies have demonstrated that the LHBT also resembles the posterosuperior labrum on a histologic level[8]. Therefore, proximal biceps origin can be more accurately referred to as a biceps-labral complex[9]. As the tendon travels further distal towards the rotator interval, its histology changes to resemble that of a traction tendon[10].

Rotator interval anatomy

An important stabilizing structure to the shoulder joint and proximal biceps, the rotator interval is made up of fibers from the supraspinatus, subscapularis, coracohumeral ligament (CHL), and superior glenohumeral ligament (SGHL). Jost et al described it as an important suspensory structure of the shoulder joint preventing inferior translation of the humeral head[11]. Medially, the rotator interval is composed of the CHL superficially and the SGHL and joint capsule deep. Laterally, the interval consists of 4 layers: layer 1 superficial fibers of CHL, layer 2 fibers from supraspinatus and subscapularis, layer 3 the deep fibers of CHL, and layer 4 the SGHL and joint capsule. As the LHBT travels distally, the CHL and SGHL form a sling, or biceps pulley, around the tendon that can be injured secondary to trauma or rotator cuff tears[12].

Bicipital groove

The bicipital groove is a depression within the proximal humerus between the greater and lesser tuberosity. The LHBT travels within the groove under the transverse humeral ligament with the combination of the two forming a fibro osseous tunnel. The spanning soft tissue and the bony morphology of the groove imparts stability to the proximal tendon. Yoo et al found that a groove with shallower depth, larger opening angle, and smaller medial angle was a risk factor for LHBT instability[13]. Degeneration of the groove has also been found to correlate with biceps tendon disease[14]. Taylor et al describe the fibro osseous tunnel in three zones relative to the contributory structures[9]. Zone 1 is the bony bicipital groove from the proximal articular margin to the distal margin of the subscapularis tendon (DMSS). Zone 2 extends from the DMSS to the proximal margin of the pectoralis major tendon (PMPM). Referred to as ‘no man’s land’, it cannot be visualized by arthroscopy proximally or via an open subpectoral approach distally. Zone 3 is the subpectoral region of the tunnel distal to the PMPM. Between zone 2 and 3 the tunnel bottlenecks which may act as a mechanical block to lesions within the tunnel proximally. Similarly, Denard et al described three zones of the tendon relative to the bicipital groove divided into three zones: Zone A the intraarticular tendon, Zone B within the groove, and Zone C the tendon distal to the groove[15].

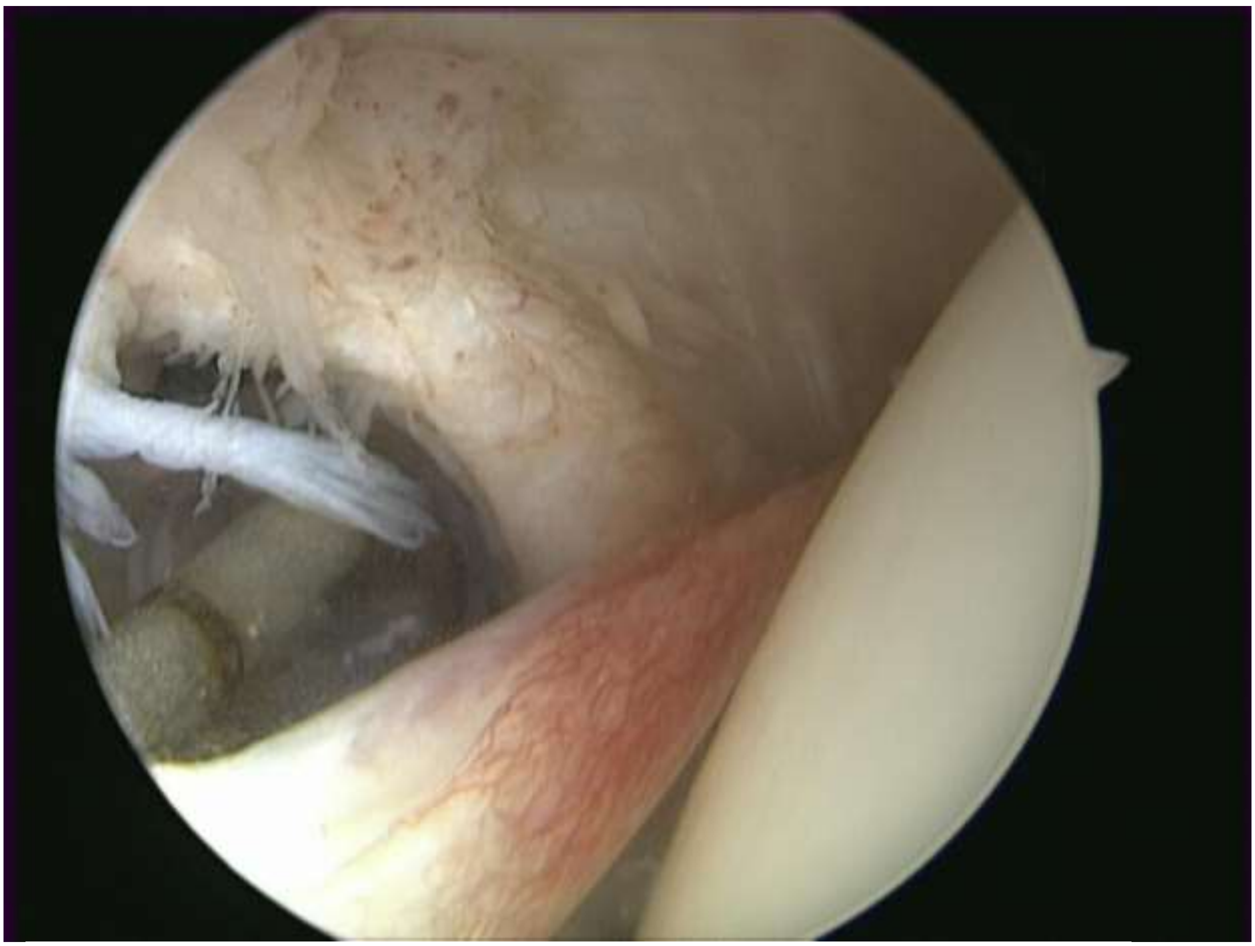

Figure 2: Arthroscopic view, right shoulder, from posterior to anterior of the intra-articular LHBT demonstrating tendinitis along the tendon.

Biomechanics

The function of the LHBT with respect to shoulder stability is still controversial as are the effects of tenodesis or tenotomy on shoulder mechanics. The proximal biceps has been described as a humeral head depressor, and Neer believed that tenodesis or tenotomy of the LHBT could lead to impingement[16]. Later, superior migration of the humerus on the glenoid was observed after severing the LHBT when the short and long heads were tensioned[17]. Itoi et al went on to describe the LHBT as a key contributor to anterior glenohumeral stability when tensioned[18,19]. In a biomechanical study looking at glenohumeral translation, simulated biceps contraction resulted in a decrease in humeral head translation[20]. However, more recently, using electromyographic analyses, Levy and Yamaguchi demonstrated that the biceps brachii is electrically inactive during normal shoulder range of motion. Further, Giphart studied the stabilizing effects of the LHBT in vivo on five patients that underwent an open subpectoral biceps tenodesis and found there was no significant effect on glenohumeral biomechanics[21]. The precise contributions of the proximal biceps, both active and passive, to glenohumeral mechanics have yet to be fully elucidated.

Presentation and Physical Exam

Pathology of the LHBT often presents as anterior shoulder pain. It can be located over the groove and may often radiate down the biceps muscle. Following an acute traumatic event, the patient may be diffusely painful about the shoulder, however, in chronic pathology the patient may complain of shoulder pain exacerbated by overhead activities, throwing, or weight bearing through the glenohumeral joint.

As with any physical exam, systematic inspection, palpation, range of motion testing, strength testing for the rotator cuff muscles and deltoid as well as a distal neurovascular exam is vital. Following acute trauma, there may be ecchymosis at the shoulder or down the fascial planes of the arm. If the LHBT has been torn, there may be a visible deformity to the lateral shoulder representing the contracted tendon stump or the classic ‘popeye’ deformity corresponding to the contracted muscle belly distally. Weakness of the biceps brachii is not reliably associated with ruptures due to the intact short head. Tenderness to palpation at the bicipital groove should be tested with the shoulder in slight internal rotation and, while applying pressure over the groove, slightly internally and externally rotating the shoulder to elicit pain. While tenderness may be present, pain at the groove is limited by a poor sensitivity of 53% and specificity of 54%[22]. Similarly, the Speed and Yergason test have classically been described to test for LHBT pathology. However, the Speed test, pain with resisted elbow flexion, was found to have a sensitivity of 43% and specificity of 79%, and the Yergason test, pain with resisted forearm supination, had a sensitivity of 75% and 50%[23]. Pain at the groove, the Speed test, and the Yergason test should be evaluated within the complete clinical workup. Because biceps tendon instability or dislocation can occur in the presence of a subscapularis tear, special evaluation of subscapularis strength, internal and external range of motion, the lift off test, belly press test, and an internal rotation lag sign should be included in the evaluation of the LHBT. For these exam maneuvers, it is important to compare the injured extremity to the contralateral.

Figure 3: Arthroscopic view, left shoulder, from posterior to anterior of the LHBT demonstrating intra-articular tenotomy.

Imaging

To rule out osseous lesions or abnormalities, orthogonal shoulder radiographs should be obtained including anterior-posterior, axillary, and Grashey views. If there is suspicion for LHBT pathology, further advanced imaging is necessary. While ultrasound is a cost-effective means at detecting tendon ruptures and subluxations, it is limited by user-dependent skill as well as poor sensitivity in the detection of partial tears and tendonitis[24]. Subtle LHBT pathology as well as other soft tissue contributions to pain are better evaluated with MRI arthrography of the shoulder.[25].

Treatment overview and author recommendations

Non-operative management

First line treatment for LHBT pathology is rest, ice, activity modification, and non-steroidal anti-inflammatory drugs (NSAIDS). If the patient is an athlete, decreasing the amount of throwing may aid in recovery. This can be combined or followed by multiphase physical therapy to rehabilitate the periscapular muscles and active shoulder stabilizers[26]. If NSAIDS are contraindicated or fail to relieve symptoms, corticosteroid injections into the sheath under ultrasound guidance have been shown to be a safe and well tolerated local anti-inflammatory[27,28]. For local, intraarticular anesthesia, ropivacaine is preferred to bupivacaine due to its decreased chondrotoxicity[26]. Regenerative injection therapies including prolotherapy, platelet-rich plasma, and stem cells attempt to heal and repair damaged tendon, however, their effects and efficacy still being investigated.

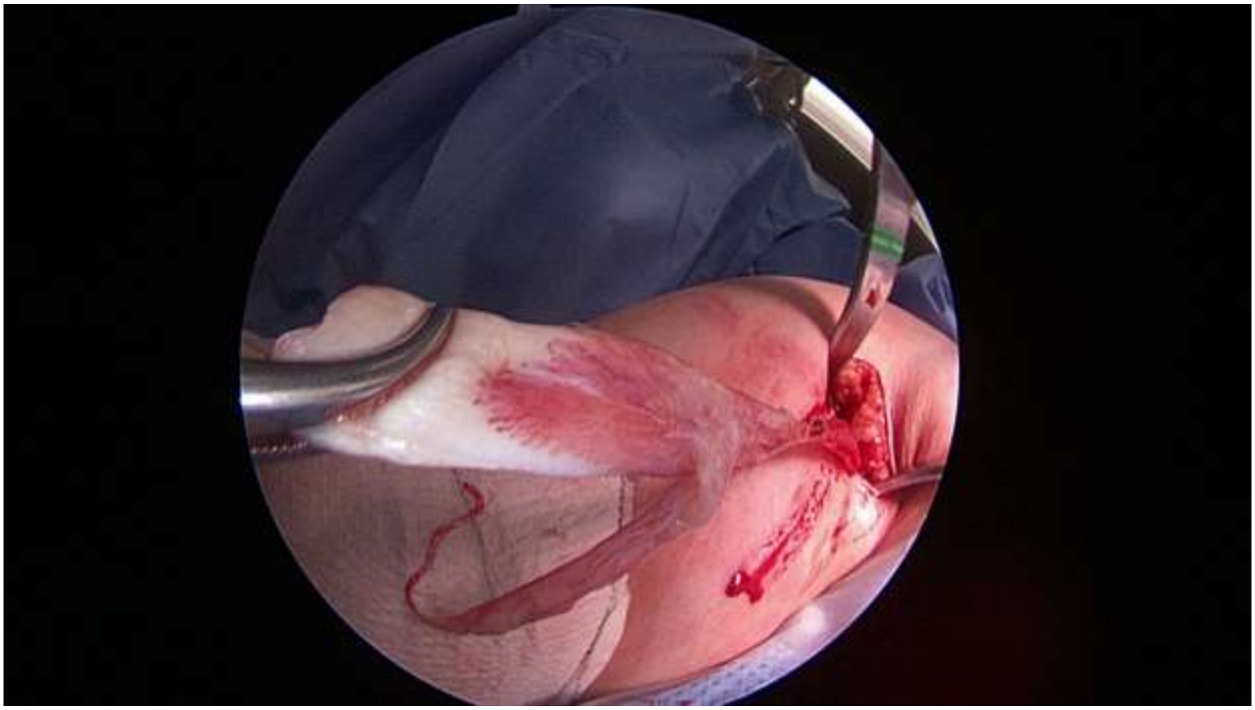

Figure 4: Extra-articular view of the right shoulder demonstrating the tenotomized LHBT with hyperemic tenosynovium or a 'lipstick lesion.'

Operative management

When nonoperative management has failed to provide symptomatic relief, operative intervention is indicated. Prior to surgery, surgical planning should incorporate the patient's age, profession, and activity level. All surgeries should start with a thorough diagnostic arthroscopy of the shoulder evaluating the intraarticular portion of the tendon as well as assessing for other shoulder pathology. A peel back test allows for the most intraoperative visualization of the tendon. If a lesion of the proximal biceps has been identified, treatment varies from debridement, tenotomy, and tenodesis. The decision between tenotomy versus tenodesis as well as the location for tenodesis remains controversial.

Simple debridement of the tendon and surrounding inflammatory tissue is indicated in the event of isolated tendinitis or a small partial tear affecting <25% of the tendon[29]. A biceps tenotomy, which involves severing the proximal tendon at its origin near the superior labrum and allowing the distal end to retract, is an option with a more extensive tendon tear, longitudinal tear, or instability. Compared to tenodesis, tenotomy offers the advantage of an arthroscopic procedure, shorter operative times, and faster and less restricted recovery. However, in addition to the cosmetic deformity, fatigue weakness in supination and pain have been reported[30,31]. The authors recommend tenotomy over tenodesis in patients who wish to avoid cosmetic deformity, are physiologically older, or sedentary.

Over the course of three years, the rate of tenodesis has increased 1.7 times in the United States[1]. Tenodesis consists of attaching the distal tendon via bone tunnels, suture-anchors, interference screws, or soft tissue. Tenodesis has a lower rate of popeye deformity and pain compared to tenotomy but a higher surgical morbidity, longer operative time, and lifting restrictions during rehabilitation. Techniques vary but generally fall into two categories: an arthroscopic versus an open approach. This is equivalent to proximal versus distal tenodesis. In 2012, it was reported that proximal tenodesis can lead to persistent tenosynovitis within the biceps sheath and increased revision rates[32]. In 2014, Werner and colleagues found no significant difference in clinical outcomes between arthroscopic suprapectoral tenodesis versus an open subpectoral tenodesis[33]. In a biomechanical study by Kolz et al, the suprapectoral region was found to have higher tensile strength than the subpectoral region and intraarticular region[34]. However, Moon et al found histologic evidence of 'hidden lesions' potentially missed by a proximal tenodesis[35]. They reported evidence of LHBT tears extending into Zone B in 100% of the cases and Zone C in 78% and 83% of lesions distal to the sight of a suprapectoral tenodesis. While the literature remains contentious, the authors believe that an open subpectoral tenodesis allows for resection of distal 'hidden lesions' and offers superior cosmesis and pain relief compared to tenotomy especially for young, active patients.

Figure 5: Arthroscopic view, right shoulder, from posterior to anterior of the LHBT demonstrating fraying of the tendon.

Top five causes of anterior shoulder pain

Lastly, while the proximal biceps is a known pain generator in the shoulder and a cause of anterior shoulder pain in particular, it is far from the only cause of pain in this location. Indeed, shoulder pathologies are notoriously difficult to localize based on the location and pattern of pain, and patient descriptions are often diffuse or vague. Additionally, nearly every cause of shoulder pain on this list is worse at night, providing the examiner with another non-specific feature of what is already a difficult clinical picture and challenging diagnosis.

Probably the most common cause of shoulder pain localizing to the anterior shoulder, and the most common reason for an office visit with a chief complaint of shoulder pain, is rotator cuff pathology. Rotator cuff tendinosis and tears are common and their incidence increases with age. Pain classically radiates down the anterolateral arm, the so called "sergeant's patch," but is often diffuse, and not always associated with clear functional deficits. A truly positive Drop Arm sign is even less commonly encountered, but weakness accompanying the pain during resisted elevation and shoulder external and internal rotation, such as the subscapularis tests mentioned above, are typical of rotator cuff pathology.

Shoulder impingement is intimately related to, and often the cause of, rotator cuff disease, making differentiation of this condition difficult. Impingement is usually confirmed when pain is worse with elevation above the 90 degree plane. Discerning impingement from rotator cuff or biceps tendon pain is usually unnecessary, however, because the latter so often precedes the former, and treatments typically address both associated conditions.

Intra-articular sources of pain, such as chondral defects, glenohumeral arthritis, or inflammatory processes such as synovitis or capsulitis, typically manifest with pain referred to as deep in the shoulder, and are often described as being felt in both the anterior and posterior shoulder. General motion can be painful and restricted, but specific movements producing mechanical symptoms can present a confounding picture and mimic the specific motions or maneuvers that typically isolate the rotator cuff or biceps tendon. In addition, the intra-articular portion of the biceps can be involved in these processes, leading to secondary biceps tendinosis that further complicates the clinical picture.

While making an accurate diagnosis of anterior shoulder pain can be difficult even for a well trained shoulder specialist, history of a specific pain pattern and utilization of tests specific for the suspected anatomic structures usually helps narrow the differential diagnosis, clarify the indications for advanced imaging, and recommend the appropriate treatment pathway.

Conclusions

The proximal biceps tendon has been a known source of shoulder pain for centuries, yet its role in the shoulder to this day remains a topic of debate. The optimal treatment similarly has yet to be fully elucidated in the literature, with strong opinions on many sides driving different treatment options. Clinical differentiation of biceps pathology from other sources of shoulder pain can be difficult, indeed most commonly proximal biceps tendon pathology does not exist in isolation. Biceps lesions are most accurately diagnosed with MR imaging, and while some respond to non-operative measures, surgical treatment is often necessary, though the optimal treatment of the tendon remains controversial and can be complicated by strong patient preferences.

References

1. Werner BC, Brockmeier SF, Gwathmey FW. Trends in long head biceps tenodesis. *Am J Sports Med*. 2015;43(3):570-578.
2. Soifer TB, Levy HJ, Soifer FM, Kleinbart F, Vigorita V, Bryk E. Neurohistology of the subacromial space. *Arthroscopy*. 1996;12(2):182-186.
3. Bicos J. Biomechanics and Anatomy of the Proximal Biceps Tendon. *Sports Med Arthrosc*. 2008;16(3):111-117.
4. Cowper W. *Myotomia Reformata: Or an Anatomical Treatise on the Muscles of the Human Body*. Gale ECCO; 2010.
5. Neer C. *Anatomy of Shoulder Reconstruction*. (Neer C, ed.). Philadelphia: WB Saunders; 1990.
6. Cooper DE, Arnoczky SP, O'Brien SJ, Warren RF, DiCarlo E, Allen AA. Anatomy, histology, and vascularity of the glenoid labrum. An anatomical study. *J Bone Joint Surg Am*. 1992;74(1):46-52.
7. Vangsness CT, Jorgenson SS, Watson T, Johnson DL. 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(6):951-954.
8. 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(10):1242-1249.
9. Taylor SA, O'Brien SJ. Clinically Relevant Anatomy and Biomechanics of the Proximal Biceps. *Clin Sports Med*. 2016;35(1):1-18.
10. Kolts I, Tillmann B, Lüllmann-Rauch R. The structure and vascularization of the biceps brachii long head tendon. *Ann Anat*. 1994;176(1):75-80.
11. Jost B, Koch PP, Gerber C. Anatomy and functional aspects of the rotator interval. *J shoulder Elb Surg*. 2000;9(4):336-341.
12. Habermeyer P, Magosch P, Pritsch M, Scheibel MT, Lichtenberg S. Anterosuperior impingement of the shoulder as a result of pulley lesions: a prospective arthroscopic study. *J shoulder Elb Surg*. 13(1):5-12.
13. Yoo JC, Iyyampillai G, Park D, Koh K-H. The influence of bicipital groove morphology on the stability of the long head of the biceps tendon.
14. Pfahler M, Branner S, Refior HJ. The role of the bicipital groove in tendopathy of the long biceps tendon. *J shoulder Elb Surg*. 8(5):419-424.
15. Denard PJ, Dai X, Hanypsiak BT, Burkhart SS. Anatomy of the biceps tendon: implications for restoring physiological length-tension relation during biceps tenodesis with interference screw fixation. *Arthroscopy*. 2012;28(10):1352-1358.
16. NeerII CS. Anterior Acromioplasty for the Chronic Impingement Syndrome in the Shoulder. *J Bone Jt Surg*. 2005;87(6):1399.
17. Kumar VP, Satku K, Balasubramaniam P. The role of the long head of biceps brachii in the stabilization of the head of the humerus. *Clin Orthop Relat Res*. 1989;(244):172-175.
18. Itoi E, Newman SR, Kuechle DK, Morrey BF, An KN. Dynamic anterior

stabilisers of the shoulder with the arm in abduction. *J Bone Joint Surg Br*. 1994;76(5):834-836.

19. Itoi E, Kuechle DK, Newman SR, Morrey BF, An KN. Stabilising function of the biceps in stable and unstable shoulders. *J Bone Joint Surg Br*. 1993;75(4):546-550.

20. Pagnani MJ, Deng XH, Warren RF, Torzilli PA, O'Brien SJ. Role of the long head of the biceps brachii in glenohumeral stability: a biomechanical study in cadavera. *J shoulder Elb Surg*. 5(4):255-262.

21. Giphart JE, Elser F, Dewing CB, Torry MR, Millett PJ. The Long Head of the Biceps Tendon Has Minimal Effect on In Vivo Glenohumeral Kinematics. *Am J Sports Med*. 2012;40(1):202-212.

22. Gill HS, El Rassi G, Bahk MS, Castillo RC, McFarland EG. Physical examination for partial tears of the biceps tendon. *Am J Sports Med*. 2007;35(8):1334-1340.

23. Holtby R, Razmjou H. Accuracy of the Speed's and Yergason's tests in detecting biceps pathology and SLAP lesions: comparison with arthroscopic findings. *Arthrosc J Arthrosc Relat Surg*. 2004;20(3):231-236.

24. Yablon CM, Bedi A, Morag Y, Jacobson JA. Ultrasonography of the shoulder with arthroscopic correlation. *Clin Sports Med*. 2013;32(3):391-408.

25. Morag Y, Jacobson JA, Shields G, et al. MR arthrography of rotator interval, long head of the biceps brachii, and biceps pulley of the shoulder. *Radiology*. 2005;235(1):21-30.

26. Schickendantz M, King D. Nonoperative Management (Including Ultrasound-Guided Injections) of Proximal Biceps Disorders. *Clin Sports Med*. 2016;35(1):57-73.

27. Hashiuchi T, Sakurai G, Morimoto M, Komei T, Takakura Y, Tanaka Y. Accuracy of the biceps tendon sheath injection: ultrasound-guided or unguided injection? A randomized controlled trial. *J shoulder Elb Surg*. 2011;20(7):1069-1073.

28. Zhang J, Ebraheim N, Lause GE. Ultrasound-guided injection for the biceps brachii tendinitis: results and experience. *Ultrasound Med Biol*. 2011;37(5):729-733.

29. Busconi BB, DeAngelis N, Guerrero PE. The Proximal Biceps Tendon: Tricks and Pearls. *Sports Med Arthrosc*. 2008;16(3):187-194.

30. Szabó I, Boileau P, Walch G. The proximal biceps as a pain generator and results of tenotomy. *Sports Med Arthrosc*. 2008;16(3):180-186.

31. Ding DY, Garofolo G, Lowe D, Strauss EJ, Jazrawi LM. The biceps tendon: from proximal to distal: AAOS exhibit selection. *J Bone Joint Surg Am*. 2014;96(20):e176.

32. Sanders B, Lavery KP, Pennington S, Warner JJP. Clinical success of biceps tenodesis with and without release of the transverse humeral ligament. *J shoulder Elb Surg*. 2012;21(1):66-71.

33. Werner BC, Evans CL, Holzgrefe RE, et al. Arthroscopic Suprapectoral and Open Subpectoral Biceps Tenodesis. *Am J Sports Med*. 2014;42(11):2583-2590.

34. Kolz CW, Suter T, Henninger HB. Regional mechanical properties of the long head of the biceps tendon. *Clin*

Biomech (Bristol, Avon). 2015;30(9):940-945.

35. Moon SC, Cho NS, Rhee YG. Analysis of "Hidden Lesions" of the Extra-articular Biceps After Subpectoral Biceps Tenodesis. *Am J Sports Med*. 2015;43(1):63-68.