Update Article

Disorders of the long head of the biceps: tenotomy *versus* tenodesis☆

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ABSTRACT

Disorders of the long head of biceps tendon are common in clinical practice. Their causes could be degenerative, inflammatory, instability (subluxation or luxation) or traumatic. They are generally associated to other diseases of the shoulder, mainly rotator cuff injuries. Currently, there is controversy in the literature regarding the indications for surgical treatment and the choice of the best technique for each case, due to the possibility of esthetic deformity, loss of muscle strength, and residual pain.

The objective of this study was to identify the indications for surgical treatment, the best surgical technique, and the advantages and disadvantages of each technique described in the orthopedic literature for the treatment of long head of biceps tendon injuries.

A revision of the orthopedic medical literature on the following databases: Biblioteca Regional de Medicina (BIREME), Medline, PubMed, Cochrane Library and Google Scholar, comprising articles published in the period from 1991 to 2015.

Lesões do cabo longo do bíceps: tenotomia *versus* tenodese

RESUMO

As lesões da cabeça longa do tendão bicipital (CLB) são comuns na prática clínica e podem ter causas degenerativas, inflamatórias, instabilidades (subluxação ou luxação) ou traumáticas. Geralmente, elas estão associadas a outras doenças do ombro, principalmente a lesões do manguito rotador. Atualmente, existem controvérsias quanto às indicações dos tratamentos cirúrgicos e à escolha da melhor técnica para cada caso, devido à possibilidade de deformidade estética, perda da força muscular e dor residual.

O objetivo deste estudo foi identificar as indicações do tratamento cirúrgico, a melhor técnica cirúrgica e as vantagens e desvantagens de cada técnica descritas na literatura médica ortopédica no tratamento das lesões da CLB.

Foi realizada revisão da literatura médica ortopédica disponível na base de dados da Biblioteca Regional de Medicina (BIREME), Medline, PubMed, Cochrane Library e Google Scholar, incluindo artigos publicados no período de 1991 a 2015.

Introduction

The long head of the bicipital tendon (LHB) is intra-articular and extrasynovial; it has a flat surface at its origin and becomes rounded in the bicipital groove. It originates in the superior labrum and the supraglenoid tubercle.[1] Vangsness et al.,[2] in a cadaveric study, classified the origin of the LHB into four types; type 3, with input from the anterior and posterior labrum, was the most common. Luciano et al.,[3] in a histological study, concluded that macroscopic inspection is not sufficient to assess the origin of the tendon and that, when analyzed microscopically, the contribution of the anterior labrum is greater than that suggested by macroscopic inspection.

The intra-articular portion of the LHB has an oblique inclination of approximately 30–40°; it passes through the anterior rotator interval shoulder and leaves the joint through the intertubercular groove, which has a mean of 4 mm depth and 56° of medial tilt.

The LHB's intra-articular stabilizers are the biceps reflection pulley (the most important stabilizer, composed of the upper glenohumeral and coracohumeral ligaments) and the fibers of the subscapular and supraspinal muscles tendons. The stabilizers of the extra-articular portion are the intertubercular groove and the transverse ligament (less important stabilizer, composed of fibers of the subscapularis muscle tendon).[4]

The LHB is innervated by the musculocutaneous nerve (C5–C7 roots), and it is vascularized by the ascending branch of the anterior circumflex artery, labial branches of the suprascapular artery, and branches of the thoracoacromial artery. It has two anatomical zones related to its vascularization: the traction zone, with normal vascularization, and the sliding zone, in which there is a reduction in vascular supply, situated from 1.2 to 3 cm from its origin and that may be associated with degenerative lesions.[5]

The function of the LHB in the shoulder is controversial in the literature; some authors consider it to be a vestigial structure with no function (embryonic remnant),[6–8] while others attribute important functions to it, such as humeral head depressant and anterior stabilization.[9–13] In the injured shoulder (unstable or with rotator cuff injury), it is consensually understood to have a stabilizing function, but causes pain. Levy et al.,[8] in an electromyographic study, demonstrated that when elbow function was isolated, the LHB had no function during movement of the shoulder arc; these authors then concluded that the function of the LHB in the shoulder would be interconnected with the movements of the elbow.

LHB lesions are common in clinical practice and may be due to degenerative, inflammatory, instability-related (subluxation or dislocation), and traumatic causes. The inflammatory causes are divided as follows: primary causes, which are rarer, representing only 5% of the cases and usually affecting young patients and throwing athletes; secondary causes, which are more common and usually associated with other shoulder disorders, such as rotator cuff tears, impingement syndrome, and superior labrum anterior to posterior (SLAP) lesion, in which the tendon undergoes microscopic and/or macroscopic alterations.[14]

In most cases, the physical examination is non-specific and makes the initial diagnosis difficult. Upon inspection, the *Popeye* sign, limitation of passive elevation (hourglass biceps, described by Boileau et al.[15]) and pain on palpation in intertubercular sulcus may be observed. Stimulative tests for impingement syndrome are generally positive for LHB disorders. Tests that are more specific for SLAP lesion can also be positive, such as the O'Brien test,[16] biceps load test,[17] crank test,[18] and speed test.[18] The Yergasson test[19] is positive in the case of LHB instability in intertubercular groove.

As an auxiliary method to clinically diagnose LHB injuries, the anesthetic test can be made, injecting 8–10 mL of local anesthetic into the subacromial space, which causes pain relief in cases of impingement syndrome and rotator cuff injuries, but not in LHB disorders. It is also possible to inject the intertubercular groove (preferably with the aid of ultrasonography), in which case pain would improve.[14]

Complementary tests commonly used to assess LHB disorders are radiograph of the shoulder by tangential incidence (Fisk[20] method), which evaluates the presence of structural changes in intertubercular groove; ultrasound, which presents high specificity and sensitivity in case of complete lesions or dislocations, albeit not reliable to detect minor lesions or subluxations; and magnetic resonance imaging (MRI), which has low interobserver reproducibility for isolated bicipital disorders, with a sensitivity of 52%, but diagnosis may be sensitized with the use of contrast (arthro-MRI), with an increase in sensitivity to 90%. The diagnostic method considered gold standard for bicipital disorders is arthroscopy, which allows a macroscopic evaluation of the tendon, its stability, and the presence of associated lesions, as well as the assessment of the extra-articular portion of the LHB by its traction into the joint.[21–23]

Habermeyer et al.[24] classified the pathologies of the LHB into four types, according to the integrity of biceps reflection pulley: type 1, isolated lesions of the superior glenohumeral ligament (SGHL); type 2, SGHL lesion and partial supraspinal tendon lesion; type 3, SGHL and subscapularis tendon lesions; and type 4, lesion of all these structures. Walch et al.[25] classified LHB disorders according to the anatomical location of the lesion. Lafosse et al.[26] classified LHB lesions according to arthroscopic findings when evaluating the direction and extent of instability, the macroscopic appearance of the tendon and the presence of associated rotator cuff injuries.

Conservative treatment is usually the initial choice for isolated lesions and for acute LHB ruptures; it consists of rest, analgesics, non-steroidal anti-inflammatory drugs, corticosteroid injection, physiotherapy, and change in daily habits. When treatment fails, or when there is another associated lesion in the shoulder (rotator cuff injury, labial lesion, or instability), surgical treatment is indicated, which may include debridement of the lesion, acromioplasty, simple tenotomy, or tenotomy associated with LHB tenodesis.

Currently, there are controversies regarding the indications of surgical treatments and the decision of the best technique for each case, due to the possibility of esthetic deformity, loss of muscle strength, and residual pain.

This study aimed to identify the indications for surgical treatment, the best surgical technique, and the advantages and disadvantages of each technique, described in the orthopedic medical literature, in the treatment of LHB lesions.

Material and methods

The orthopedic medical literature was reviewed in the database of the Biblioteca Regional de Medicina (BIREME), Medline, PubMed, Cochrane Library, and Google Scholar, including publications from 1991 to 2015, from the following search combinations: bicipital tendon long head, tenotomy, and tenodesis.

Articles focused on injuries of long head of the biceps brachii muscle, written in English and Portuguese, were selected for the present review.

Results

According to Khazam et al.,[4] the main surgical indications for LHB lesions, other than failure of conservative treatment, are partial lesions affecting over 25% of the tendon diameter, longitudinal injuries, instabilities with subluxation or medial dislocation, association with subscapularis muscle tendon injury, hourglass biceps (described by Boileau et al.[27]) and detachment of the glenoid labrum (SLAP lesions). They described that LHB should not be routinely tenotomized in the treatment of rotator cuff lesions.

Hsu et al.,[28] in a systematic review with cases between 1966 and 2010, showed a 41% incidence of *Popeye* deformity in cases of LHB tenotomy, *vs.* 25% in tenodesis. They also observed that LHB tenodesis led to residual pain in 24% of cases, *vs.* 17% in tenotomy. They concluded that there was no consensus in the literature about the best surgical technique, since the studies did not present statistically significant differences.

Frost et al.,[29] in a systematic review including studies published between 1982 and 2008, concluded that the success rates for LHB tenotomy and tenotomy associated with tenodesis were similar. The *Popeye* type deformity was more frequently observed in the group that underwent isolated tenotomy, and was generally not perceived by the patients. These authors concluded that tenotomy presented good results, regardless of patient's age, and that tenodesis should be considered in very thin patients who are concerned with the possible esthetic deformity. They suggested that, due to the disparity of methodologies and the relevance of the available studies, new randomized and comparative studies featuring both techniques should be conducted.

Boileau et al.,[27] min a retrospective study of 68 patients with irreparable rotator cuff injuries, treated with tenotomy or tenodesis of the LHB, concluded that the results of the two techniques were similar. They also observed that the *Popeye* deformity was present in 62% of cases, but it was not always perceived by the patient.

Osbahr et al.,[30] in a retrospective study of 160 patients who underwent LHB tenotomy and/or tenodesis, found no significant differences regarding cosmetic deformity, pain, and muscle spasm.

Galasso et al.,[31] in a randomized clinical trial, observed that patients who underwent LHB tenotomy had a loss of forearm supination strength when compared with those who underwent tenodesis. In the study by Shank et al.,[32] this difference was not statistically significant.

Mariani et al.,[33] in a retrospective study, compared the results of surgical and conservative treatment in patients with acute rupture of the LHB. They concluded that there was no significant difference in pain results. Most patients in both groups evolved with improvement. The non-operated group had a higher incidence of esthetic deformity. No significant difference was observed in the shoulder and elbow range of motion between both groups. They also concluded that patients in the non-operated group returned earlier to work, but presented 8% loss of flexion strength and 21% loss of supination force in the elbow.

Almeida et al.,[34] in a prospective cohort study, evaluated the degree of elbow flexion strength after arthroscopic LHB tenotomy and observed a significant deficit when compared with the contralateral upper limb and with the control group. In another prospective cohort study, Almeida et al.[35] evaluated the presence of esthetic deformity after arthroscopic LHB tenotomy and concluded that the *Popeye* deformity was present in 35.1% of the sample. Male patients, those with BMI below 30, and those who were operated on the dominant limb had more esthetic complaints.

In a non-randomized retrospective study, Ikemoto et al.[36] compared the functional outcomes of tenotomy, associated or unassociated with LHB tenodesis, in the arthroscopic repair of rotator cuff injury of 77 patients. The tenodesis was performed through the LHB tendon suture in intertubercular groove, superiorly to the pectoralis major muscle tendon insertion, using two 5-mm metal anchors. The study used the following evaluation criteria: pain, cosmetic deformity (*Popeye* sign), range of motion, University of California at Los Angeles (UCLA) score, and the Elbow Strength Index (ESI). They concluded that there was no statistical significance in the comparison

between the groups regarding pain in the bicipital groove, *Popeye* sign, and the ESI. Statistical significance was observed only for the UCLA score, which presented improvement in both groups, but more significantly in patients submitted to tenotomy associated with LHB tenodesis.

Walch et al.[37] performed isolated LHB tenotomy in 307 shoulders with irreparable rotator cuff lesions with clinical and radiographic follow-up for a mean period of 57 months. They concluded that, in cases of irreparable lesions, as well as in patients who do not intend to perform an adequate rehabilitation, LHB tenotomy presents favorable results, with improvement of pain and function. *Popeye* deformity was observed in approximately 50% of patients. Those authors also observed that patients under 55 years of age are more likely to complain of esthetic deformity. In the same study, they also assessed the acromiohumeral distance on shoulder radiographs, and observed that there was no significant decrease of this space. This suggests that LHB tenotomy did not accelerate the natural course of the disorder for rotator cuff arthropathy.

Checchia et al.[38] evaluated the results of arthroscopic tenotomy of the LHB in 12 patients with symptomatic and irreparable rotator cuff injuries and observed pain improvement in 100% of cases. One case presented *Popeye* deformity, and the mean UCLA score was 28.2 points. They concluded that LHB tenotomy may be indicated for pain relief in cases of irreparable rotator cuff lesions, especially in elderly patients.

Khazzam et al.[4] and Hsu et al.,[28] in review articles that compared LHB tenotomy and tenodesis, suggested that patients over 40 years, sedentary, obese, who would not seek labor compensation, and who did not mind the esthetic deformity, would better indicated for LHB tenotomy; conversely, patients under 40 years of age, with activities of greater demand, eutrophic, who would be bothered by the esthetic deformity or who would seek labor compensation, would be better candidates for LHB tenodesis.

Godinho et al.,[39] in a retrospective study of 63 patients, developed a surgical technique known as bicipital "jelly roll" tenodesis, in which LHB tenodesis was indicated after tenotomy when there was injury in up to 50% of the tendon, whether or not associated with rotator cuff injury, or when subluxation or dislocation occurred. In that sample, 92.06% of the patients were satisfied, without loss of supination force of the forearm and elbow flexion. The *Popeye* deformity was observed in 11.1% of the patients. They observed a difference in the assessment of the esthetic deformity by the examiner and by the patient, and that its onset had no correlation with the age group and the sport practiced.

Narvani et al.,[40] in a prospective study, assessed the results of arthroscopic LHB anchor shape tenotomy, in which two incisions were made in the tendon, one more distal and oblique, and the other at the tendon origin, in which the tenotomy was performed. They did not observe the presence of the *Popeye* deformity in the 12 evaluated patients and suggested that, with the flap made in the oblique incision, the tendon would be trapped in the intertubercular groove, preventing the esthetic deformity.

Checchia et al.[41] described a tenodesis technique in which the LHB tendon was attached with the suture of rotator cuff and assessed the results of 15 patients. They observed 93.4% satisfactory results in the UCLA score, with improvement of the range of motion; 6.6% of patients presented the *Popeye* deformity. All patients were satisfied with the surgery.

Checchia et al.[42] evaluated the results of arthroscopic LHB tenodesis with use of bioabsorbable interference screws in 16 patients. The tenotomy was made at the origin of the glenoid labrum; the tenodesis, in the intertubercular groove. The UCLA score was used to evaluate the results, with a mean of 34.5 points. None of the patients presented a *Popeye* deformity and all patients were satisfied with the surgical outcome. They concluded that the advantages of tenotomy associated with tenodesis include the prevention of muscular atrophy and maintenance of tendon length, muscle tension, and flexion and supination forces, as well as a lower risk of esthetic deformity.

Lutton et al.[43] described an arthroscopic LHB tenodesis technique using bioabsorbable screw fixation below the intertubercular groove (suprapectoral region). According to the authors, some studies suggest that LHB tenodesis proximal to the groove leads to a higher incidence of postoperative pain when compared with distal tenodesis, due to the possible maintenance of residual tenosynovitis. They retrospectively compared patients who underwent LHB tenotomy and observed better pain results in the group in which tenodesis was made distal to the intertubercular groove.

David et al.[44] observed that the challenge of LHB tenodesis in achieving a correct length and tension of the tendon. They observed that the decrease in tendon/muscle tension could lead to muscle fatigue, esthetic deformity, and "crackling" during movement; however, in cases of excessive tension, there would be a higher chance of synthesis material pullout and procedure failure. In the surgical technique used, arthroscopic LHB tenodesis was performed in the suprapectoral region, using interference screws and two bone tunnels. They concluded that the arthroscopic technique was superior to open surgery; the interference screw had a lower failure index, the suprapectoral tenodesis was better than the subpectoral, and the use of two bone tunnels allowed better muscle tension.

Jarrett et al.[45] performed anatomical studies on cadavers to evaluate the best place for LHB tenodesis. The study used as anatomical parameter the myotendinous junction of the LHB, which is located 2 cm from the superior edge of the tendon of the pectoralis major muscle, 5.3 cm from the lesser tubercle, 3.4 cm lateral to the musculocutaneous nerve, and 4.6 cm from the anterior humeral circumflex artery (buffer zone). They concluded that tenodesis should be performed near the upper border of the tendon of the pectoralis major muscle and two distal digital pulps from the lesser tubercle.

Papp et al.,[46] in a biomechanical study in cadavers, assessed the maximum tensile strength of two methods of open LHB tenodesis fixation: interference screw and two metal anchors associated with the repair of the transverse ligament. In both techniques, the LHB fixation was performed in the groove. They concluded that the method of fixation with anchors associated with suturing of the transverse ligament was more resistant: the mean force-to-failure in this method was 263 N, *vs.* 160 N for the interference screw. They

suggested that more clinical studies comparing methods were still needed.

Patzer et al.,[47] in a biomechanical study in cadavers, compared four tenodesis techniques with anchors and interference screws in the supra- and subpectoral positions. They concluded that the technique with interference screws presented superior resistance when compared with the technique with anchors, in both the supra- and subpectoral positions.

Abraham et al.,[48] in a systematic review of cases from 2008 to 2015, evaluated the results of the medical literature and compared arthroscopic and open LHB tenodesis. Only studies of isolated LHB lesions or association with SLAP lesion were included. Studies in which patients presented LHB disorders associated with other pathologies, biomechanical studies, and animal studies were excluded. They concluded that both groups had satisfactory results, with no statistically significant difference.

Werner et al.,[49] in a biomechanical study in cadavers, compared the strength and length and tension restoration of the LHB in two tenodesis techniques utilizing interference screws: arthroscopic suprapectoral and open subpectoral. They concluded that in arthroscopic tenodesis there was a tendency to increase the physiological tension of the tendon; this technique was less resistant to cyclical forces when compared with the open technique.

Valenti et al.[50] described an arthroscopic LHB tenodesis technique in which the tendon was fixated with interference screws in the proximal intertubercular groove. The tenodesis was made 5 mm distal to the original location, in order to reduce myotendinous tension and thus achieve a lower incidence of residual pain without causing *Popeye* deformity.

Brady et al.,[51] in a multicenter prospective study, evaluated the results of arthroscopic LHB tenodesis performed in the proximal intertubercular groove with interference screws. They concluded that the technique resulted in a 4.1% rate of revision, 0.4% related to the LHB, low residual pain indexes, and improved functional scores on the operated shoulder.

Gilmer et al.,[52] in a prospective study, assessed the efficacy of arthroscopic and macroscopic evaluation of LHB disorders in 62 patients undergoing open subpectoral tenodesis. They suggested that arthroscopic visualization could underestimate LHB lesions. They concluded that it was possible to visualize only 32% of the total length of the tendon.

Vellios et al.[53] conducted a population study in the United States through a database to assess the current trend for LHB tenodesis indication. They concluded that LHB open tenodesis is still indicated frequently, but from 2007 to 2011 the arthroscopic technique was more used. They observed that the mean age of the patients ranged from 30 to 59 years and that the procedure was twice as frequent in men. Rotator cuff injury was the most commonly associated primary disorder.

Friedman et al.,[54] in a retrospective study, compared the results of LHB tenotomy and subpectoral tenodesis, with anchors, in patients under 55 years. The following groups were compared: muscle strength, range of motion, residual pain, and presence of *Popeye* deformity. Significant differences were observed in functional scores, esthetic deformity, and muscle strength. The residual pain index was higher in patients who underwent tenodesis.

Discussion

According to the literature, the main surgical indications for LHB lesions, other than failure of conservative treatment, are partial lesions affecting over 25% of the tendon diameter, longitudinal injuries, instabilities with subluxation or medial dislocation, association with subscapularis muscle tendon injury, hourglass biceps (described by Boileau et al.[27]), and detachment of the glenoid labrum (SLAP lesions). It is also suggested that LHB procedures should not be routinely indicated for the treatment of rotator cuff injuries. The main techniques described for the surgical treatment of LHB disorders were: acromioplasty, debridement, reconstruction of the biceps reflection pulley, tenotomy, and tenodesis.[4,5,9–54]

Studies that advocate the use of LHB tenotomy suggest that its main advantages are the fact that it is technically simpler and lower cost, with a faster rehabilitation and without risks related to the use of synthetic materials. Nonetheless, the chances of *Popeye* deformity, loss of supination force, and muscular fatigue are higher when this technique is used. They could also cause biomechanical changes in the long term and lead to humeral head ascension and biomechanical alterations in the shoulder.[4,27–32,34–38,40]

The studies that advocate the use of LHB tenodesis suggest that this technique provided a lower risk of *Popeye* deformity, with a closer-to-normal biomechanical and anatomical restitution and a better return to sports activities. However, it was associated with a higher cost, greater technical complexity, greater risk of residual pain, and more delayed rehabilitation.

Several LHB tenodesis techniques, arthroscopic or open, have been described, both with good results in the literature. The sites described for LHB fixation in the humerus include the proximal portion of the bicipital groove, suprapectoral, subpectoral, or in the soft tissue, such as in the conjoined tendon and the tendon of the pectoralis major muscle. Some authors have suggested that suprapectoral tenodesis as well as tenodesis performed distal to the intertubercular groove have better results regarding residual pain.[4,27–30,33,36,39–50,52,53]

Regarding the type of material used (interference screw and anchors) for LHB tenodesis, the retrieved studies presented divergences in their results. Some biomechanical studies have suggested that interference screws are more resistant and that the main challenge of tenodesis is to maintain the physiological tendon tension and length. The increase in LHB tension could lead to failure of its fixation and residual pain. The decrease in tension could lead to *Popeye* deformity and decreased strength.[4,27–30,33,36,39–50,52,53]

Because LHB disorders are usually associated with other shoulder conditions, the retrieved studies differ on the best results and the best techniques. Future randomized clinical trials may provide more conclusive results.[4,6–8,14,24–54]

Final considerations

There is consensus among most of the medical literature retrieved regarding the indications for LHB treatment, but not regarding the best techniques to be used.

Conflicts of interest

The authors declare no conflicts of interest.

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