

Long Head of Biceps Tendon Pathology in Rotator Cuff Tears: Review of Incidence, Pathology and Current Trends of Management

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ABSTRACT

Pathology of the long head of the biceps tendon (LHBT) is a recognised pain generator and often associated with rotator cuff tears (RCT). In patients with a RCT, the incidence of concomitant LHBT pathology is very high, and has been reported to range from 36% to 76%, and significantly correlates with the size of RCTs. Treatment of LHBT lesions with tenotomy or tenodesis in the context of RCT has been controversial particularly in the early 2020's. Over the last decade the dilemma tenotomy versus tenodesis has been supplanted by arthroscopic versus open tenodesis. We present an update of incidence, pathology and histopathology of LHBT lesions and review the relevant biomechanical and clinical studies. We also discuss the current trends and management of biceps tendon lesions in the context of rotator cuff repair.

Key words: Long head of biceps; Tendon tears; Rotator cuff tears; Biceps tenodesis; Biceps tenotomy; Suprapectoral tenodesis

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INTRODUCTION

Pathology of the long head of the biceps tendon (LHBT) is a recognised pain generator and often associated with rotator cuff tears (RCT)^[1-8]. In patients with a RCT, the incidence of concomitant LHBT pathology is very high, and has been reported to range from 36% to 76%^[4,7-10], and significantly correlates with the size of RCTs. Biceps tendon lesions in the early stage may include, tenosynovitis and dynamic instability and at a later stage, degenerative findings (hypertrophy, hourglass deformity, delamination, partial tears), and static tendon instability. Treatment of LHBT lesions with tenotomy or tenodesis in the context of RCT has been controversial particularly in the early 2020's. Over the last decade the dilemma tenotomy versus tenodesis has been supplanted by arthroscopic versus open tenodesis. Early biomechanical and clinical data have reported conflicting results in regard to the preferred implant of fixation, tenodesis location, and various tenodesis procedures.

We present an update of incidence, pathology and histopathology of LHBT lesions and review the relevant biomechanical and clinical studies. We also discuss the current trends and management of biceps tendon lesions in the context of rotator cuff repair.

SURGICAL ANATOMY, PATHOLOGY AND INCIDENCE OF LHBT LESIONS IN PATIENTS WITH RCT

The LHBT courses in an oblique direction from its origin toward the intertubercular groove^[3]. The LHBT and pulley system lie in close anatomic proximity to the subscapularis and supraspinatus tendons.

This unique anatomy of the proximal biceps places it at high risk of abrasive wear and injury.

INJURIES TO THE ROTATOR CUFF PREDISPOSE THE LHBT TO DEGENERATIVE AND INSTABILITY LESIONS

In a prospective arthroscopic study of 89 patients, Neviasser *et al.* were the first to report a strong association of coexistent biceps tendon lesions and rotator cuff pathology, and an increasing severity of biceps tendon lesions according to the size of rotator cuff tear. Biceps tenodesis was part of the surgical treatment^[1]. Common macroscopic pathologic findings affecting the proximal LHBT in the presence of rotator cuff tears include, in the early stage, tenosynovitis and dynamic instability and at a later stage, degenerative findings (hypertrophy, hourglass deformity, delamination, partial tears), and static tendon instability (subluxation or dislocation)^[5-8,11-12].

LHBT INSTABILITY LESIONS

Pulley injuries result in LHBT instability, occurring mainly in the presence of a rotator cuff tear. The biceps pulley system is the antero-posterior stabiliser of the LHBT tendon. The anterior pulley is part of the rotator interval between the supraspinatus and subscapularis tendons and consists of the coracohumeral ligament, the superior glenohumeral ligament, and the glenohumeral joint capsule fibers.^[13] The posterior pulley is formed by the main part of the coracohumeral ligament blending with the anterior fibers of the supraspinatus tendon^[7,14-15]. In the neutral position of the upper limb, the LHB lies against the anterior pulley and the medial wall of the bicipital groove. External rotation increases the stress on the anterior stabilizing structures; internal rotation reverses the load from the anterior to the posterior pulley^[7,13]. In external rotation and abduction of shoulder, the LHBT is prevented from posterior subluxation by the posterior sling^[7,14].

INCIDENCE OF LHBT INSTABILITY IN PATIENTS WITH RCT

An LHBT instability can result in shoulder pain and mainly occurs in the presence of a rotator cuff tears.

In previous studies, LHBT instability was observed in up to 20% of cases almost exclusively in the anterior direction^[8,16-18]. Lafosse *et al.* (2007), however, observed LHBT instability in 45% of 200 rotator cuff tears: 16% anteriorly, 19% posteriorly, and 10% antero-posteriorly. Anterior LHB instability was seen in 48% of subscapularis tears and posterior LHBT instability in 31% of supraspinatus tears. LHBT instability was associated with LHBT lesions: an unstable biceps tendon was associated with 85% lesions and a stable biceps tendon was associated with 30% of LHBT lesions. The authors suggested that the high correlation of LHBT instability with LHBT lesions may be explained by the increased anteroposterior motion of the tendon over the tuberosities, like a windshield wiper when rotating the arm. The increasing friction resulting in progressing damage to the tendon^[7]. Braun *et al.* (2011) in a prospective study of 207 cases, reported Pulley tears in 32.4% of rotator cuff tears^[18].

LHBT DEGENERATIVE LESIONS

Lesions of the LHBT are part of the rotator cuff and

acromioclavicular joint degenerative process^[3]. In the presence of a rotator cuff tear, subacromial impingement and abnormal mechanical loading on the LHB can cause progressive deterioration of the biceps tendon. Several clinical studies have shown increasing biceps tendon lesions with increasing rotator cuff tear size^[1-2,7-8].

HISTOLOGICAL STUDIES

Several studies have quantified tendon degeneration of the LHBT and showed tendon degeneration, significantly more in the proximal than the distal part of the tendon^[19-24]. This can be attributed to the different mechanical forces that the two locations are subjected to, with more compression, shearing and frictional forces proximally and less mechanical tensional strain distally^[19,23].

Berenson *et al.* (1996) examined the glycosaminoglycan content of two portions of the biceps tendon (proximal and distal to the transverse humeral ligament) and of the rotator cuff tendons. Glycosaminoglycan content in the intraarticular region of the biceps was two to sixfold higher than in the extraarticular region, distal to the transverse humeral ligament. In addition, there was no difference in glycosaminoglycan content between rotator cuff and intraarticular biceps tendon, suggesting that both structures are subjected to a similar mechanical load^[20].

Joseph *et al.* (2009) reported that the intra-articular portion of the LHB exhibits histological characteristics of tendinopathy and showed a threefold increase of mucoid ground substance proliferation indicative of degeneration and mechanical overload, whereas the extra-articular portion had histological characteristics of a healthy tendon. The majority of degenerative changes of the tendon accompanied concomitant rotator cuff pathology^[21]. Similarly, Mazzocca *et al.* (2013) observed that the intra-articular segment of the LHBT showed more signs of degenerative changes than the extra-articular portion, both in tendinosis and instability. The tendon instability group showed the greatest degree of degenerative changes in the proximal LHBT^[23]. Wu *et al.* (2014), reported that the macroscopic pathology of LHB may not fully reflect the severity of tendinopathy, and the coexisting size of RCTs plays a role in the severity of LHB tendinopathy. The histology of the macroscopically normal LHBT in patients with chronic RCT, showed a 75% incidence of advanced tendinopathy and none with normal histology^[24]. Lakemeier *et al.* (2010.) have reported that the LHBT at the molecular level shows significantly increased levels of vascular endothelial growth factor and matrix metalloproteinases in patients with rotator cuff pathology compared to healthy controls. Both of these markers are known to correlate with tendon degeneration. The authors suggested that these findings indicate that LHB degeneration is related to the course of degenerative rotator cuff and that LHBT degeneration is secondary to the development of rotator cuff tears^[22].

INCIDENCE OF LHBT LESIONS IN PATIENTS WITH RCT

Rotator cuff tears have a high incidence of concomitant LHBT pathology, and this incidence is likely to increase with increasing size of rotator cuff tears^[4,7-10]. The incidence of concomitant LHB pathology in patients with a RCT, has been reported to range from 36% to 76%^[4,7-10]. Murthi *et al.* (2000), reported 46.5% LHBT lesions in RCT^[4]. Chen *et al.* (2005) in a study of 122 RCT, reported an incidence of 76% LHBT lesions. The size of the RCT influenced the incidence of LHBT lesions with 60% in small tears, 68% in medium tears and 92% in large and massive tears^[8]. Lafosse *et al.* (2007) in a

prospective study of 200 RCT, reported an incidence of 55% LHBT lesions. Lesions were observed in 35% of isolated subscapularis tears, 17% of isolated supraspinatus tears, 46% in two tendon tears, and 78% in three tendon tears. Desai *et al* (2017), reported a lower overall incidence of LHBT pathology in 36% of RCT. However, the authors did not include any LHB tendinitis cases^[7]. More recently, Candela *et al* (2021), in a study of 202 RCT, demonstrated a prevalence of 74% LHBT pathology, which significantly correlated with RCT severity. LHBT lesions were present in 53%, 80% and 92% of small, large and massive RCTs, respectively. LHBT was absent in 10.9%^[10].

LHB IS A RECOGNIZED AS A PAIN GENERATOR IN PATIENTS WITH ROTATOR CUFF TEARS

In clinical studies, LHBT has been recognized as an important pain generator in RCT^[1,4-8,25]. LHBT spontaneous rupture, tenotomy or tenodesis, in association with a rotator cuff repair, result in satisfactory pain relief. In the setting of an irreparable rotator cuff tear, Boileau *et al* demonstrated significant postoperative pain and functional improvements following biceps tenodesis or tenotomy^[5].

HISTOPATHOLOGY STUDIES

The following histopathology studies provide the evidence that the LHBT acts as a pain generator.

Alpantaki *et al* (2005) demonstrated for the first time that the LHBT contains a large network of sensory and sympathetic nerve fibres, mainly near its insertion^[26]. Tosounidis *et al* (2013) investigated the sympathetic innervation of the LHBT with immunohistochemical staining for protein S-100 and neuropeptide Y and observed that the acute and chronic conditions of LHBT share common sympathetic innervation patterns^[27]. Hadjileontis *et al* (2013) proved neuronal differentiation of tendon stromal cells as the source of biceps tendon pain^[28]. Schmalzl *et al* (2019) in a histological and biomolecular analysis of LHB tendinitis, showed that the gene expression of the proinflammatory cytokines (interleukin 1 alpha, and 1 beta, tumour necrosis factor alpha) and of the catabolic matrix metalloproteinases (MMP1-3-9, -13), was upregulated, whereas the expression of the anti-inflammatory gene tissue inhibitor of matrix metalloproteinase 1, was downregulated. In addition, histological changes of neovascularization, and increased neural innervation could be observed^[29]. In a recent study, Izumi *et al* (2021) reported that both intraarticular and intra-groove samples of degenerative lesions LHB, expressed greater Substance P, a neuropeptide secreted by sensory neurons, than healthy tendons, confirming that LHBT would be a pain generator in RCT patients^[30].

REVIEW OF MANAGEMENT OF LHBT LESIONS IN PATIENTS WITH RCT

Watson *et al.* (2017) showed that patients who underwent a concomitant biceps procedure when indicated at the time of rotator cuff repair (RCR), demonstrated greater improvement in outcome measures after 1 year, compared with isolated RCR patients^[31].

LHBT Tenotomy or Tenodesis

There are several studies in the literature comparing the clinical outcomes of tenotomy and tenodesis for LHBT lesions with concomitant rotator cuff repair. Tenotomy and tenodesis are common treatment options, and both have been shown to be effective in

removing the pain. However, a higher incidence of cosmetic deformity was observed in patients treated with tenotomy. In a retrospective study, Godeneche *et al*, demonstrated equivalent Constant scores in patients with normal biceps who underwent Rotator cuff repair and those with pathologic biceps tendons who were treated with rotator cuff repair and simultaneous biceps tenodesis or tenotomy. However, for patients who had pathologic biceps, Constant scores were significantly better in the tenodesis than the tenotomy group^[32].

In a prospective cohort study^[33] and two prospective randomised trials^[34-35], the authors found no significant difference in functional scores between the two groups. The incidence rate of Popeye deformity was about 3-times higher in tenotomy (9% to 27%) than in tenodesis (2.7% to 9%)^[33-35].

However, in three recent systematic reviews and meta-analysis, comparing clinical outcomes after concurrent rotator cuff repair and LHBT tenodesis or tenotomy, Leroux *et al* (2015)^[36], Ge *et al* (2015)^[37], and Na *et al* (2019)^[38], reported that biceps tenodesis resulted in a significantly higher Constant score and a lower risk of Popeye sign compared with biceps tenotomy, 3.9% - 8.6% versus 15.5% - 24.3% respectively.

CURRENT TRENDS

Due to the risk of cosmetic deformity, fatigue and muscle cramping, LHBT tenotomy is now indicated for patients aged > 65 years, who do not perform manual labour or other high-demand activities.

Biceps Tenodesis has become the preferred technique to manage LHBT pathology in younger, more active patients. Tenodesis avoids Popeye deformity, prevents muscle atrophy by maintaining the length-tension relationship of the biceps muscle, and maintains elbow flexion and supination strength^[39].

The incidence of biceps tenodesis continues to increase annually, and arthroscopic tenodesis is emerging the most common used technique. Saltzman *et al* (2020) in a study of 8,547 LHBT tenodesis, reported that the rates of open and arthroscopic LHBT tenodesis procedures increased significantly, doubling from 2011 to 2014. Open techniques were more common when LHB tenodesis was performed in isolation, and the arthroscopic technique was the most common tenodesis performed in conjunction with rotator cuff or superior labrum repair. The overall complication rate was 2.9%^[40].

LHBT TENODESIS: OPEN OR ARTHROSCOPIC

Biceps tenodesis can be performed through an arthroscopic (intraarticular above the groove, at the articular margin), arthroscopic proximal supra-pectoral (high in the groove) or an open approach (subpectoral, out of the groove). The tendon may be anchored with an interference screw or suture anchors.

BIOMECHANICAL STUDIES: IMPLANT CHOICE AND SURGICAL APPROACH

Some studies found that interference screws confer greater strength than suture anchors, while other studies reported no difference in ultimate failure load (UFL) between implant types, irrespective of the location of tenodesis^[41,42]. More recently, Aida *et al* (2020) conducted a systematic review and meta-regression using pooled data from 25 published biomechanical studies of biceps tenodesis representing 494 cadaveric specimens. The findings suggested that fixation with interference screws and the use of more sutures are associated with greater biceps tenodesis strength, as well as higher

odds of native tissue failure versus implant pull out. Although suture anchors show inferior UFL compared with those with interference screws, incorporation of additional sutures may increase the strength of suture anchor constructs. Supra and subpectoral repairs provide equivalent biomechanical strength. Multivariate analysis also found no significant association between fixation site and UFL^[43].

CLINICAL STUDIES AND SURGICAL APPROACH: OPEN OR ARTHROSCOPIC TENODESIS

A number of clinical studies have failed to demonstrate a difference in clinical outcomes between arthroscopic and open LHB tenodesis^[40,44-46]. In a systematic review, Abraham *et al* (2016) reported that both techniques showed similar pain relief and clinical outcomes in 98% in both groups. There was a low rate of complications with failure (2.4% vs 1.8%), persistent pain (1% vs 1.1%) and Popeye deformity (1.4% vs 0.7%), in arthroscopic and open tenodesis respectively^[44]. Hurley *et al* (2019), in seven clinical trials with 598 patients and a follow-up of 23.6 months showed that both open and arthroscopic tenodesis result in similarly excellent clinical outcomes. There were no significant differences between the functional outcome scores, patient satisfaction or return to sport in any of the included studies. The authors suggested that the decision to perform the biceps tenodesis either via an open or arthroscopic approach, should be based on surgeon and patient preference, as well as patient age, occupation and functional demands. The approach used for tenodesis may also be dictated by concomitant rotator cuff or labral pathology^[45].

Forsythe *et al* (2019) reported the rates and risk factors for revision in 15,257 patients who underwent open or arthroscopic proximal biceps tenodesis between 2008-2017. Of these, 60.8% underwent arthroscopic biceps tenodesis, while 39.2% underwent open biceps tenodesis. There was no significant difference in the revision rate between arthroscopic (1.8%) and open (1.9%) biceps tenodesis. Risk factors for revision surgery included male sex for open biceps tenodesis, while age > 45 years and concomitant rotator cuff repair is not a risk factor for revision procedures, irrespective of the tenodesis technique^[46]. Similarly, Saltzman *et al* (2020) in a study of 8,547 LHBT tenodesis between 2011 and 2014 reported that open techniques were more common when LHB tenodesis was performed in isolation, and the arthroscopic technique was the most common tenodesis technique performed in conjunction with rotator cuff or superior labrum repair. The overall complication rate was 2.9% with no significant difference between open or arthroscopic LHBT tenodesis (stiffness 0.9%, nerve injury 0.2%, humeral fracture 0.3%, infection 0.4%, wound dehiscence 0.2%, haematoma 0.3%)^[40].

DISCUSSION

Due to similar outcomes surgeons have the option of using an arthroscopic or an open approach. However, as rotator cuff repairs are performed arthroscopically, most surgeons prefer to treat both pathologies at the same time without additional open procedure. This could explain that over the last decade, arthroscopic tenodesis is emerging as the most commonly used technique in the context of rotator cuff repair or superior labrum pathology^[40,46]. Arthroscopic tenodesis performed at the articular margin, largely avoids the complications seen with subpectoral and suprapectoral tenodesis. The arthroscopic technique at the articular margin (above the groove) can be performed as an inlay or an onlay “loop ‘n’ tack” procedure. In

a recent biomechanical study, Cagle *et al* (2020), reported that both procedures had similar ultimate load to failure values. The mode of failure involves the suture knot pulling through the tendon rather than implant pull out from bone. Tenodesis at the articular margin achieved comparable fixation strength as subpectoral and suprapectoral tenodesis while conferring several advantages over these techniques^[47]. The inlay procedure requires tendon externalization and an approximation of the appropriate length-tension relationship. The onlay “loop ‘n’ tack” procedure is now the preferred procedure as the tendon is released after the tenodesis, allowing an accurate length-tension relationship. The procedure has been shown to be a reliable clinical technique with a low revision rate^[48].

Early reports of persistent pain with arthroscopic “above the groove” tenodesis techniques were attributed to tenosynovitis and motion of the LHB that remains within the bicipital groove as a pain generator^[49]. Other investigators, however, found no increase in residual anterior shoulder pain with “above the groove” tenodesis. Leroux *et al*, reviewed the reported outcomes after LHBT tenodesis and rotator cuff repair, and across the 5 studies that reported residual bicipital groove pain, observed that the actual rate was very low (0.9%)^[36]. Brady *et al* (2015) in a multi-centre study of arthroscopic biceps tenodesis at the articular margin (above the groove) including 1,083 patients with a mean follow-up period of 2.4 years, reported significant improvements in pain and functional scores, and noted a low rate of residual pain (0.1%) and revision rate (0.3%) for biceps-related problems^[48]. More recently, in a biomechanical study, Kelly *et al* (2021) demonstrated that for intra-articular supra-pectoral fixation (loop ‘n’ tack) tenodesis, movement of the tendon within the groove was minimal^[50].

CONCLUSION

Rotator cuff tears have a high incidence of concomitant LHBT pathology, and this incidence is likely to increase with increasing size of rotator cuff tears. The current literature review suggests that the decision to perform LHBT tenodesis either as an open or arthroscopic approach, should be based on surgeon and patient preference, and the patient’s age, occupation and functional demands. Arthroscopic tenodesis however, is emerging as the most commonly used technique in the context of rotator cuff pathology. This is due to the fact that Rotator cuff repairs are performed arthroscopically and most surgeons prefer to treat both pathologies at the same time without an additional open procedure.

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