

2018

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Recommended Citation

Corpus KT, Garcia GH, Liu JN, Dines DM, O'Brien SJ, Dines JS, Taylor SA. Long Head of Biceps Tendon Management: a Survey of the American Shoulder and Elbow Surgeons. . 2018 Jan 01; 14(1):Article 3655 [p.]. Available from: <https://academicworks.medicine.hofstra.edu/articles/3655>. Free full text article.

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Long Head of Biceps Tendon Management: a Survey of the American Shoulder and Elbow Surgeons

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Received: 3 May 2017/Accepted: 7 August 2017/Published online: 13 October 2017
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Abstract *Background:* Management of symptomatic long head of biceps tendon (LHBT) pathology remains a source of debate. *Questions/Purposes:* The purpose of this study was to identify consensus trends for the treatment of LHBT pathology among specialists. *Methods:* A survey was distributed to members of the American Shoulder and Elbow Society (ASES), consisting of three sections—demographics, case scenarios, and general LHBT pathology management. Cases presented common clinical scenarios, and surgeons reported their management preferences. Consensus responses were defined as > 50% of participants giving a single response. *Results:* One hundred and forty-two of 417 (34%) surgeons completed surveys. Forty-seven percent of questions reached a consensus answer. Biceps tenodesis was the overwhelmingly preferred technique in cases demonstrating LHBT pathology, as compared to tenotomy. No consensus, however, was reached regarding a specific surgical technique for biceps tenodesis. The two most popular techniques were arthroscopic tenodesis to bone and open subpectoral biceps tenodesis. Fellowship-trained arthroscopic surgeons and surgeons with a largely arthroscopic practice were more likely to perform

tenodesis arthroscopically. *Conclusion:* ASES members favored biceps tenodesis over tenotomy for surgical management of LHBT pathology, without consensus regarding a specific surgical technique.

Keywords long head biceps tendon · biceps tenodesis · biceps tenotomy · expert opinion

Introduction

Long head of biceps tendon (LHBT) pathology is a common source of anterior shoulder pain often requiring surgical intervention when non-operative management fails [2, 5, 8, 22]. However, little consensus exists among treating surgeons regarding surgical indications, treatment algorithms, and preferred operative technique [5, 8, 15, 23].

The two most common surgical interventions for LHBT pathology are biceps tenodesis and biceps tenotomy. Further, advancements in surgical technique now allow biceps tenodesis to be performed through both open and arthroscopic approaches in several different anatomic locations [3, 12, 14, 28, 29]. Both procedures have been shown to provide equal long-term functional outcomes, and little data has been published to support clear treatment recommendations for LHBT pathology [6, 17, 23]. Therefore, the surgical treatment of choice is often made at the discretion of the operating surgeon based on their training and common practices, as both procedures have inherent strengths and weaknesses [6, 17].

The purpose of this study was to attempt to identify consensus treatment trends in dealing with LHBT pathology among leading shoulder surgeons to help guide surgical practice recommendations by posing several controversial clinical scenarios to each surgeon and allowing responders to provide insight into their treatment strategies and methodologies for specific pathology patterns. We hypothesized that broad variations in surgical management of LHBT pathology would be present across the cohort.

Level of Evidence: Level V: Therapeutic Study.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s11420-017-9575-3>) contains supplementary material, which is available to authorized users.

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Methods

A survey protocol similar to that used in previous studies was conducted [1, 9, 18, 20]. An online survey (Survey Monkey, Portland, OR, USA) of 417 active members of the American Shoulder and Elbow Society (ASES) was administered on two separate occasions. The survey link was distributed via e-mail. The survey was submitted via e-mail as this method has been shown to be more efficacious than standard postal mail [19]. Respondents were blinded to the co-investigators conducting the survey. The survey (Appendix 1) consisted of 22 questions designed to assess the respondents' preferences regarding surgical intervention of the LHBT via case scenarios. The "Introduction" section determined member demographics including: level of experience, type and location of practice, fellowship experience, and arthroscopic experience. The "Methods" section involved the presentation of six case scenarios with a focus on LHBT pathology. These cases were developed by a panel of expert shoulder surgeons. The panel was composed of the senior authors of this publication (DMD, SJO, JSD, SAT). Of note, the last two cases were designed to evaluate consensus opinions regarding management of LHBT in patients with concomitant superior labral anterior posterior (SLAP) lesions. For each case, respondents were asked to identify the preferred intervention with respect to the LHBT. In the last two cases, respondents were also given the opportunity to address the SLAP lesion if desired. In addition, respondents were also asked to provide their preferred technique for biceps tenodesis in each case scenario. The "Results" section posed several general questions regarding management of biceps tendon pathology.

Data was stored using Microsoft Excel (Microsoft, Redmond, WA, USA) and analyzed using SAS Software version 9.3 (SAS Institute, Inc., Cary, NC, USA). Demographic survey responses were reported using descriptive statistics. Responses to clinical survey questions were reported using frequencies and percentages. In order to identify when a majority consensus was achieved for a given question, responses were flagged as reaching consensus when $> 50\%$ of participants gave the same response. Because this was an analysis of all respondents, an a priori power calculation was not performed. Associations between training and practice demographics and responses to clinical questions were investigated using chi-squared analyses. All comparative analyses were two-tailed and used $P = 0.05$ as the threshold for statistical significance.

Results

One hundred and forty-two (34%) ASES members responded to the survey. It is important to note that although all ASES members were surveyed, some percentages of ASES members do not perform biceps surgery as their practices are limited to arthroplasty or elbow surgery. Therefore, the 34% response rate may actually represent a majority of those surgeons performing biceps surgery. Of the respondents, 76.8% reported at least 10 years of experience and 81% performed over 150 shoulder cases annually. Surgeons came from academic institutions (37%), private practice (32%), or mixed practices (31%). The majority of respondents were fellowship trained in shoulder/elbow surgery (47%), while fewer

completed a sports medicine fellowship (29%), with only 13% completing both. Seventy-nine percent of respondents have a practice consisting of greater than 50% of arthroscopic cases. The majority (75%) of respondents practiced in the USA and were relatively evenly distributed geographically (West, East, Midwest, South). The remaining 25% of respondents practiced abroad. The most common (58%) anesthetic used by respondents was a mixture of a regional block and general anesthesia. Due to the limitations of the data collected in the survey, the specific methods of regional and general anesthetics were not collected.

Of the 22 survey questions, 7 questions were omitted from consensus calculations as these were designed for demographic categorization rather than professional opinion (questions 1–7). Of the remaining 15 questions, 8 (53%) reached a consensus response. One hundred percent of clinical case scenarios (6 of 6) reached consensus with regard to preferred management. Five of the six cases demonstrated a consensus for selection of biceps tenodesis as the preferred management for the LHBT, while one of the six cases reached a consensus for SLAP repair. Despite this overwhelming response, none of the six cases demonstrated a consensus with regard to preferred surgical technique (Table 1).

In case one, a 50-year-old, moderately active male with a full thickness symptomatic supraspinatus tear with an asymptomatic LHBT on exam and evidence of 50% tearing of the intra-articular portion of the LHBT at time of arthroscopy was recommended for LHBT tenodesis by 81% of the respondents. Preferred surgical technique for tenodesis was highly variable among the seven proposed techniques. The most common technique selected was an arthroscopic repair to the proximal bone (30%).

In case two, a 50-year-old, moderately active male with a full thickness symptomatic supraspinatus tear with symptomatic LHBT on exam and a benign-appearing intra-articular portion of the LHBT at time of arthroscopy was recommended for LHBT tenodesis by 60% of the respondents. Again, preferred surgical technique was diverse, with the most popular technique being an open subpectoral biceps tenodesis (35%).

In case three, a 40-year-old, moderately active male with chronic and refractory biceps tendonitis with a symptomatic LHBT on exam and 50% tearing of the intra-articular portion of the LHBT at time of arthroscopy was recommended for LHBT tenodesis by 94% of the respondents. The most common technique selected in this scenario was again the open subpectoral approach (40%).

In case four, a 40-year-old, moderately active male with chronic and refractory biceps tendonitis with symptomatic LHBT on exam and a benign-appearing intra-articular portion of the LHBT at time of arthroscopy was recommended for LHBT tenodesis by 71% of the respondents. Open subpectoral tenodesis was again the preferred technique (44%) but did not reach consensus.

In case five, a 25-year-old male, recreational softball player, with a positive O'Brien sign and dynamic labral shear test but negative bicipital tunnel tenderness, Speed's and Yergason's test on exam, and an MRI demonstrating a type 2 SLAP tear with arthroscopy revealing a type 2 SLAP tear and a benign appearing intra-articular portion of the LHBT, was recommended for SLAP repair by 71% of respondents. Again, the respondents who preferred biceps tenodesis were unable to reach a consensus regarding surgical technique, but open subpectoral was the most commonly preferred at 36% of respondents.

Table 1 Selected responses for each case scenario ($N = 142$)

Case	Consensus surgical intervention	Preferred LHBT tenodesis technique(s)
<ul style="list-style-type: none"> • 50M moderately active • Full thickness, symptomatic supraspinatus tear • Asymptomatic LHBT on exam • Intra-articular LHBT with 50% partial tearing at arthroscopy 	LHBT tenodesis (81%)	Proximal to bone arthroscopic (30%) Open subpectoral (26%)
<ul style="list-style-type: none"> • 50M moderately active • Full thickness, symptomatic supraspinatus tear • Symptomatic LHBT on exam • Intra-articular LHBT benign appearing at arthroscopy 	LHBT tenodesis (60%)	Open subpectoral (35%) Proximal to bone arthroscopic (26%)
<ul style="list-style-type: none"> • 40M moderately active • Chronic refractory biceps tendonitis (isolated) • Positive bicipital tunnel tenderness to palpation, O'Brien sign, Speed, Yergason • Intra-articular LHBT with 50% partial tearing identified at arthroscopy 	LHBT tenodesis (94%)	Open subpectoral (40%)
<ul style="list-style-type: none"> • 40M moderately active • Chronic refractory biceps tendonitis (isolated) • Positive bicipital tunnel tenderness to palpation, O'Brien sign, Speed, Yergason • Intra-articular LHBT benign appearing at arthroscopy 	LHBT tenodesis (71%)	Open subpectoral (44%)
<ul style="list-style-type: none"> • 25M recreational softball player • Positive O'Brien sign, dynamic labral shear • Negative bicipital tunnel tenderness to palpation, Speed, Yergason • Type 2 SLAP tear on MRI • Type 2 SLAP tear at arthroscopy with benign appearing intra-articular LHBT 	SLAP repair (71%)	(n/a)
<ul style="list-style-type: none"> • 45M recreational softball player • Positive O'Brien sign, dynamic labral shear, bicipital tunnel tenderness to palpation • Negative Speed, Yergason • Type 2 SLAP tear on MRI • Type 2 SLAP tear at arthroscopy with benign appearing intra-articular LHBT 	LHBT tenodesis (74%)	Open subpectoral (40%)

LHBT long head biceps tendon, SLAP superior labrum anterior posterior, n/a not applicable

In case six, a 45-year-old male, recreational softball player, with a positive O'Brien sign, Dynamic Labral Shear test, and bicipital tenderness to palpation but negative Speed's and Yergason's test on exam and an MRI demonstrating a type 2 SLAP tear with arthroscopy revealing a type 2 SLAP tear and a benign appearing intra-articular portion of the LHBT, was recommended for biceps tenodesis by 74% of respondents. Again, the respondents who preferred biceps tenodesis were unable to reach a consensus regarding surgical technique, with open subpectoral tenodesis chosen by 40% of respondents.

ASES members were divided on preferred technique for biceps tenodesis. The most popular technique was an open subpectoral tenodesis (32%). Other commonly preferred techniques were an arthroscopic proximal tenodesis to bone (23%), an open proximal tenodesis to bone (16%), an arthroscopic proximal tenodesis to soft tissue (12%), and an arthroscopic suprapectoral tenodesis (12%). Only one respondent in the cohort preferred to perform biceps transfer to the conjoint tendon (1%).

The majority of respondents (48%) prefer to use the same biceps tenodesis technique for the majority of cases but stated

that they occasionally modify their standard practice based on the pathology, age, and activity level of the patient. Thirty-eight percent of respondents always choose their tenodesis technique based on the individual patient and case specifics. Fourteen percent of respondents use the same technique for each tenodesis regardless of patient and case specifics.

Lastly, use of extra-articular bicipital tunnel anesthetic/steroid injections varied across the cohort, with 11% using them for every patient, 26% never using them, and 63% using them intermittently.

Chi-squared analysis was also completed to evaluate for trends in surgical decision making and technique preferences based on population demographics. The most marked finding through this analysis is that no demographic parameters correlated with treatment decisions in the six cases presented. In addition, very few correlations were demonstrated with preferred surgical technique for biceps tenodesis. Therefore, surgeons were often pursuing different surgical management techniques despite similar training backgrounds and practice characteristics.

Through this analysis, only two trends were demonstrated. First, and not surprisingly, surgeons with a larger percentage of their practice comprised of arthroscopy were more likely to perform LHBT tenodesis via an arthroscopic approach across all cases in question. Secondly, surgeons with fellowship training in arthroscopy and sports medicine were also more likely to perform LHBT tenodesis through an arthroscopic technique. However, the anatomic location of the arthroscopic tenodesis was not consistent. Despite these trends, open subpectoral biceps tenodesis remained the preference of choice for the majority of surgeons.

Discussion

In the absence of standardized treatment guidelines for management of LHBT pathology, most surgeons formulate their treatment regimen based upon a combination of both peer-reviewed evidence and experience [15]. The cohort surveyed in this study consisted of highly experienced shoulder experts. Through this analysis, all six case scenarios reached consensus with regard to overall management of the LHBT (tenotomy versus tenodesis versus SLAP repair). But despite our somewhat homogenous sampling, surgical technique for biceps tenodesis was widely mixed with little correlation to practice and training characteristics, demonstrating the variability in practice across the shoulder community, echoing the findings of Frost et al. [7].

This study has several limitations. First, this study did suffer from a low response rate (34%). However, we had a response rate similar to previous studies [1, 9, 18]. Secondly, the cases presented in this survey were limited in their scope as they were designed to include common LHBT pathology scenarios. As such, their applicability to all cases of LHBT pathology is limited. In order to combat against respondent fatigue and maintain a reasonable response rate, we elected to keep the survey succinct and focus on the most common scenarios. In addition, the cases presented were clearly biased toward surgical intervention as our hope was to elucidate surgical preferences. Therefore, non-operative management practices were omitted to elicit appropriate surgical responses. Lastly, unlike previous studies [20] that have sampled the orthopedic community as a whole, there is inherent bias in the cohort as the sampling was done solely on shoulder experts (ASES members). By surveying this expert respondent pool, the responses of the general orthopedic community were not considered.

One of the interesting findings in this survey was the majority response with regard to biceps tenotomy versus tenodesis in the setting of pathology. Our cohort was largely in favor of biceps tenodesis as compared to tenotomy with regard to the specific cases presented. A breadth of literature comparing the outcomes of biceps tenotomy versus tenodesis is available [4, 10, 16], and the consensus shown through systematic review is that both procedures have very similar outcomes in the long-term [7, 11, 23]. Despite these equivocal long-term results, tenotomy, although a simple and reproducible procedure with predictable pain relief and little post-operative rehabilitation, has been shown to lead to increased biceps fatigue (more commonly in patients < 40 years of age) and Popeye deformity [7, 10, 13]. As such, tenotomy has classically been reserved for older populations and those patients without cosmetic concerns. Given that the patients

presented in our case studies were all 50 years of age or younger, the consensus in favor of tenodesis in this survey may purely reflect the age of the patients. Despite this, there are still a large number of surgeons, up to 30% in some cases, who elected to pursue tenotomy.

The second interesting finding in this survey is the broad spectrum of techniques being used for biceps tenodesis. While the open subpectoral approach was the most common approach used across all cases, still only approximately 30% of respondents used this approach. This highlights the incredibly wide variability in surgical technique, both in anatomic location of biceps fixation and in surgical approach (arthroscopic versus open). Additionally, the majority of respondents (48%) prefer to use the same biceps tenodesis technique for the majority of cases but will occasionally modify their practice based on the pathology, age, and activity level of the patient, and 14% use the same technique regardless of patient and case specifics. Only 38% of respondents choose their tenodesis technique based on the individual patient and case specifics. This variability in surgical technique of biceps tenodesis implies that surgeons group all tenodesis techniques together as equivalent. A recent meta-analysis by Taylor et al. [27] showed a dearth of literature comparing the available techniques. As a result, increasing attention is being paid to the anatomic and biomechanical differences between the available biceps tenodesis techniques to determine if, in fact, these techniques are equivalent.

One of the most notable differences between the available techniques is their relation to the bicipital tunnel, a fibro-osseous enclosure described by Taylor and O'Brien [24, 25] that has been shown to frequently harbor hidden lesions which can lead to significant symptoms not addressed by some traditional intra-articular techniques [24–27]. In the aforementioned meta-analysis, Taylor et al. [27] found that none of the current literature featured specific evaluations for bicipital tunnel pathology, and patients were treated similarly without directing treatment toward specific pathology. To date, the only study to directly compare outcomes from procedures that address the bicipital tunnel versus those that do not was conducted by Sanders et al. [21], in which 127 patients who underwent revision biceps procedures were retrospectively evaluated. Patients that had undergone a primary procedure in which the bicipital tunnel was not addressed (tenotomy, arthroscopic proximal tenodesis, or open proximal tenodesis) had a significantly higher failure rate (21%) compared to those patients (7%) whose index procedure decompressed the bicipital tunnel (open subpectoral tenodesis or proximal tenodesis with bicipital tunnel release).

To further complicate the matter, bicipital pathology is also difficult to diagnose, as MRI is not highly sensitive and the more distal portions of the bicipital tunnel are unable to be visualized during glenohumeral arthroscopy [27]. This difficulty in diagnosis could potentiate the large variation in surgical technique as incorrect pre-operative diagnosis may lead to choosing the incorrect surgical technique. To that end, a thorough physical examination is vital in identification of these lesions. One strategy, which has been proposed by Taylor and O'Brien [26], is the “3-Pack” shoulder exam, a series of three screening tests to evaluate the biceps-labral complex. The 3-Pack is composed of bicipital tunnel palpation, the active compression test (O'Brien Sign), and the throwing test. Bicipital tunnel palpation and the

active compression test have high sensitivity and negative predictive value (NPV) for bicipital tunnel disease. Essentially, if the patient has no pain with bicipital tunnel palpation and a negative active compression test, bicipital tunnel disease is ruled out. In this case, the biceps can be addressed through tenotomy, decompressing or non-decompressing tenodesis, or labral repair as clinically indicated. Should the patient have pain with bicipital tunnel palpation, the authors advocate for decompression of the bicipital tunnel, via an open or arthroscopic subpectoral tenodesis, subdeltoid biceps transfer, or proximal tenodesis with bicipital tunnel decompression. Through their proposed algorithm [26], they advocate targeting surgical technique through use of physical examination to more accurately address the patient's pathology.

Few statistically significant trends were uncovered when comparing surgical techniques to demographics. As expected, those surgeons with a higher percentage of their practice consisting of arthroscopic cases and those that completed an arthroscopy-centered fellowship were more likely to pursue arthroscopic techniques for biceps tenodesis. Outside of these trends, there were no correlations between demographics and surgical technique, implying that most surgeons simply use the technique with which they are the most comfortable. This finding again highlights the need for further research to compare the available techniques to determine if a patient-specific approach will lead to better outcomes.

Appendix

Appendix 1 Survey given to registered ASES members

Demographics questions	Biceps tendon cases	Questions for cases
1. Level of experience? a) < 5 years in practice b) 5–10 years in practice c) 11–15 years in practice d) > 15 years in practice	Case 1: • 50M moderately active • Full thickness, symptomatic supraspinatus tear • Asymptomatic LHBT on exam (negative bicipital tunnel tenderness to palpation, O'Brien sign, Speed, Yergason) • Intra-articular LHBT with 50% partial tearing at arthroscopy	Question for cases 1–4 1. Select your preferred intervention regarding the LHBT. a) No surgical intervention b) LHBT tenodesis c) LHBT tenotomy
2. Percent of practice involving arthroscopy? a) < 25% b) 25–50% c) 51–75% d) > 75%	Case 2: • 50M moderately active • Full thickness, symptomatic supraspinatus tear • Symptomatic LHBT on exam (positive bicipital tunnel tenderness to palpation, O'Brien sign, Speed, Yergason) • Intra-articular LHBT benign appearing at arthroscopy	Question for cases 5–6 1. Select your preferred intervention regarding the LHBT. a) No surgical intervention b) SLAP repair c) LHBT tenodesis d) LHBT tenotomy
3. What type of practice are you involved in? a) Academic b) Private c) Mix of a and b	Case 3: • 40M moderately active • Chronic refractory biceps tendonitis (isolated) • Positive bicipital tunnel tenderness to palpation, O'Brien sign, Speed, Yergason • Intra-articular LHBT with 50% partial tearing identified at arthroscopy	Question for cases 1–6 2. If LHBT tenodesis, which technique would you use? a) Proximal to soft tissue arthroscopic b) Proximal to soft tissue open c) Proximal to bone arthroscopic d) Proximal to bone open e) Open subpectoral f) Biceps transfer to conjoined tendon g) Arthroscopic suprapectoral
4. Fellowship experience? a) None b) Shoulder and elbow c) Sports d) Other	Case 4: • 40M moderately active • Chronic refractory biceps tendonitis (isolated) • Positive bicipital tunnel tenderness to palpation, O'Brien sign, Speed, Yergason • Intra-articular LHBT benign appearing at arthroscopy	General questions What is your preferred technique for biceps tenodesis?
5. Where do you practice? a) West Coast (USA) b) East Coast (USA) c) Midwest (USA) d) South (USA) e) Outside of USA	Case 5: • 25M recreational softball player	

In conclusion, ASES members favored biceps tenodesis over tenotomy for surgical management of LHBT pathology in the proposed scenarios. Surgical technique for biceps tenodesis was widely mixed with little correlation to practice and training characteristics, demonstrating the variability in practice across the shoulder community and highlighting the need for further research to determine if small changes in technique impact patient outcomes.

Compliance with Ethical Standards

Conflict of Interest: Keith T. Corpus, MD; Grant H. Garcia, MD; Joseph N. Liu, MD; Stephen J. O'Brien, MD, MBA; Samuel A. Taylor, MD, have declared that they have no conflict of interest. David M. Dines, MD, reports personal fees from Zimmer Biomet, outside the work. Joshua S. Dines, MD, reports personal fees from Arthrex, Trice Medical, Conmed, and Linvatec; other from American Journal of Orthopedics and Journal of Shoulder and Elbow Surgery; outside the work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: N/A

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

6. What type of anesthesia do you usually use for your shoulder surgeries?
- Regional block with sedation
 - General
 - Both
 - Other
- Positive O'Brien sign, dynamic labral shear
 - Negative bicipital tunnel tenderness to palpation, Speed, Yergason
 - Type 2 SLAP tear on MRI
 - Type 2 SLAP tear at arthroscopy with benign appearing intra-articular LHBT
7. How many shoulder cases do you perform annually (open and arthroscopic)?
- < 50
 - 50–100
 - 101–150
 - > 150
- 45M recreational softball player
 - Positive O'Brien sign, dynamic labral shear, bicipital tunnel tenderness to palpation
 - Negative Speed, Yergason
 - Type 2 SLAP tear on MRI
 - Type 2 SLAP tear at arthroscopy with benign appearing intra-articular LHBT
- Proximal to soft tissue arthroscopic
 - Proximal to soft tissue open
 - Proximal to bone arthroscopic
 - Proximal to bone open
 - Open subpectoral
 - Biceps transfer to conjoined tendon
 - Arthroscopic suprapectoral
- How often do you use your preferred technique?
- Always, regardless of pathology, patient age, and patient activity level
 - Most of the time, however, will occasionally differ based on pathology, patient age, and patient activity level
 - Technique used is always determined by pathology, patient age, and patient activity level
- How often do you use extra-articular injections (anesthetic/steroid) to the bicipital tunnel to confirm diagnosis?
- Always
 - Sometimes
 - Never

LHBT long head biceps tendon, *SLAP* superior labrum anterior posterior

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