Arthroscopic Versus Open Comparison of Long Head of Biceps Tendon Visualization and Pathology in Patients Requiring Tenodesis

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Purpose: The purpose of this study was to compare arthroscopic versus open examination of the proximal long head of the biceps tendon (LHB) in patients undergoing open, subpectoral tenodesis. **Methods:** Eighty consecutive patients were prospectively enrolled, of whom 62 were included in the study. During arthroscopy, the most distal extent of the LHB visualized was marked with a Bovie device. The tendon was pulled into the joint with an arthroscopic grasper, showing additional LHB and was again marked with the device. LHB fraying, flattening, redness, and degeneration were graded as absent, mild, moderate, or severe. During open subpectoral tenodesis, the grossly visualized LHB was graded in the same manner and the locations of both marks plus the total length of the LHB observed during open visualization were measured and recorded. After subpectoral tenodesis, the excised portion of the LHB was histologically graded as normal, fibrosis/tendinosis, or inflamed. **Results:** On average, during open tenodesis, 95 mm (range, 75 to 130 mm) of LHB was visualized. This was greater than the length visualized during diagnostic arthroscopy of 16 mm (range, 5 to 28 mm), or 17%, and the length visualized while pulling the tendon into the joint with an arthroscopic grasper of 30 mm (range, 15 to 45 mm), or 32%. The difference in LHB length observed during open versus arthroscopic examination with a grasper was statistically significant ($P < .0001$). In addition, when compared with LHB pathology observed in an open manner, arthroscopic visualization showed only 67% of pathology, underestimated noted pathology in 56% of patients, and overestimated noted pathology in 11% of patients. Histologic evaluation showed fibrosis/tendinosis in 100% of cases but inflammation in only 5%. **Conclusions:** When compared with open inspection during subpectoral tenodesis, arthroscopic examination of the LHB visualizes only 32% of the tendon and may underestimate pathology. **Level of Evidence:** Level II, diagnostic study—development of diagnostic criteria based on consecutive patients with universally applied gold standard.

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The proximal aspect of the long head of the biceps tendon (LHB) is commonly implicated as a source of shoulder pain and dysfunction.[1-5] Tenotomy has shown good results with respect to pain relief, but cosmetic deformity and symptoms of cramping may result.[6-9] Thus several arthroscopic and open techniques for tenodesis have been developed to retain the length-tension relation while addressing cosmesis and weakness.[10-15]

In the diagnosis of biceps pathology, physical examination tests may be unreliable and imaging studies may underestimate disease.[16-18] As a result, arthroscopic examination is often used for ultimate clinical decision making in the treatment of LHB lesions.[1,19-21]

The purpose of this study was to compare arthroscopic versus open examination of the proximal LHB in patients undergoing open, subpectoral tenodesis. Our hypothesis was that arthroscopic examination may underestimate LHB length and pathology versus open inspection.

Methods

After we obtained institutional review board approval and patient informed consent, 80 consecutive participants were prospectively enrolled from all patients scheduled to undergo shoulder arthroscopy with possible subpectoral biceps tenodesis by 1 of 2 attending surgeons (D.Guttman, J.B.R.). The procedures performed were considered standard of care and would have occurred regardless of study participation.

The initial exclusion criteria were minors; pregnant women; patients who did not have the ability to provide informed consent; and other vulnerable populations including institutionalized patients, prisoners, and employees. The final decision for inclusion was determined, intraoperatively, in patients in whom at least one of the following subpectoral biceps tenodesis was indicated by the following criteria: severe biceps tendinopathy, full-thickness longitudinal tearing of the biceps tendon, medial subluxation of the tendon, a degenerative superior labral tear, or a SLAP lesion in a non-overhead athlete. Age and gender demographic data were recorded.

All procedures were performed with patients in the beach-chair position. The arm was positioned in a static arm positioning system with the elbow flexed to 90° and the shoulder at the side in 0° of abduction, 0° of flexion, and neutral rotation. At the beginning of the intra-articular portion of shoulder arthroscopy, the camera was introduced through a posterior viewing portal, and a standard anterior portal was established after localization with a spinal needle. A probe was introduced from the anterior portal allowing for arthroscopic evaluation of the LHB and superior labrum.

Once the final determination for study inclusion was made according to the previously mentioned criteria, an anterolateral portal was established just anterior to the leading edge of the supraspinatus tendon. The distal extent of the LHB visualized was then marked with an arthroscopic electrocautery device introduced through the anterolateral portal. This was performed to allow the arthroscopic mark to be placed at the most distal point where the tendon exited the joint and entered the bicipital groove. An arthroscopic grasper was then introduced through the anterior portal. The tendon was grasped and drawn maximally into the joint, and a second electrocautery mark was made at the most distal aspect visualized during grasping. Next, the appearance of the LHB was assessed arthroscopically according to the following outcome criteria: normal, frayed, flattened, red, and/or degenerative. Fraying was intended to indicate a change in the surface of the tendon, whereas degeneration was intended to describe intrinsic qualities of the tendon that were abnormal and included such findings as thickening without flattening, hardening of the tissue to probing, dystrophic calcifications, or a yellowed appearance. Pathology, if present, was graded as mild, moderate, or severe. In addition, the following associated pathology was noted if identified during diagnostic arthroscopy: partial- or full-thickness rotator cuff tear, SLAP lesion, anterior or posterior labral pathology, and/or chondral defects or degenerative cartilage changes.

Finally, the LHB was released at its origin, and an open subpectoral biceps tenodesis was performed as described by Mazzocca et al.[10] While the tendon was delivered into the surgical field, a third electrocautery mark was made at the musculotendinous junction, as defined by the most proximal point at which muscle fibers were present by gross inspection. All marks were then measured and recorded in centimeters from the biceps origin using a sterile ruler. The gross biceps pathology was then graded, as described earlier, using open visual inspection (Fig 1).

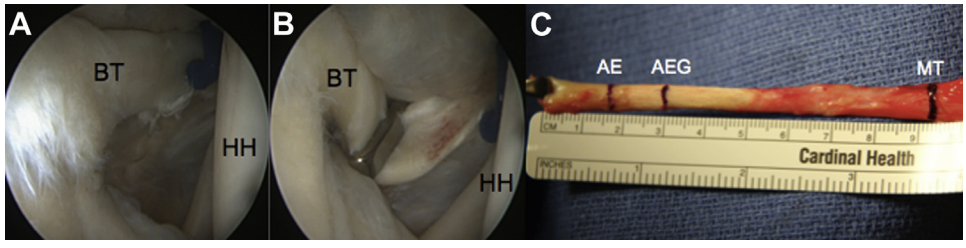

Fig 1. Arthroscopic and gross evaluation of the long head of the biceps tendon (BT). (A) Arthroscopic view of a left shoulder, in the beach-chair position, through the posterior viewing portal, showing the BT visualized without manipulation of the tendon. Through the anterolateral portal, a blue radiofrequency device marks the most distal extent of the tendon visualized. (B) Arthroscopic view in the same shoulder. Through the anterior portal, a silver grasper pulls the BT into the joint. Through the anterolateral portal, a blue radiofrequency device marks the most distal extent of the tendon visualized during pulling. One should note that the red hemorrhagic injection of the tendon is revealed during pulling of the tendon into the joint. (C) Gross specimen observed during open subpectoral tenodesis with proximal BT stump to the left and distal muscle belly to the right. The marks show the amount of tendon visualized during arthroscopic examination (AE) and during arthroscopic examination and pulling with a grasper (AEG), as well as the total length of tendon visualized grossly to the musculotendinous junction (MT). (HH, humeral head.)

After tenodesis, the excised portion of the LHB specimen was histologically evaluated by a board-certified surgical pathologist. Pathologic outcome measures were as follows: normal, fibrosis/tendinosis, or inflammatory changes.

Arthroscopic observations of the LHB pathology were then compared with open observations. Analysis included comparison of arthroscopic versus open surgical grading of LHB pathology, as well as correlation with histologic analysis.

Statistical Analysis

Initial analysis conducted after enrollment of initial patients showed a very large effect size between the arthroscopic and open groups for all outcome measures (Cohen d = 0.8). On the basis of the assumption of a significance level of 5% ($\alpha = .05$), 80% power, and a large effect size, 58 patients were required to achieve statistical power as determined by post hoc power analysis.

A 1-tailed unpaired *t* test was used to compare measurements of the LHB observed arthroscopically with a grasper versus open. The effect size between arthroscopic and open examination of the proximal LHB was calculated with the Cohen d. The χ^2 test was used to compare the relation between arthroscopic and open grading of tendon pathology.

Results

Demographic Data

We excluded 18 patients intraoperatively because biceps tenodesis was not indicated, leaving 62 patients for study inclusion. The mean patient age was 53 years (range, 25 to 68 years). Of the patients, 42 were men (68%) and 20 were women (32%). Associated pathology was common at the time of arthroscopy: 40 patients (61%) had associated rotator cuff pathology (9 partial-thickness and 31 full-thickness tears) with subscapularis involvement in 16 of 40 (40%), whereas 28 (45%) had a SLAP lesion, 14 (23%) had anterior or posterior labral pathology, and 5 (8%) had chondral defects or degenerative cartilage changes.

LHB Measurements

The mean total length of the biceps tendon observed during open tenodesis was 95 mm (range, 75 to 130 mm). In comparison, on average, 17 mm (range, 5 to 28 mm), or 17% of total tendon length, was visualized during arthroscopic examination alone. By pulling the tendon into the joint with a grasper, the mean length visualized was 32 mm (range, 15 to 45 mm), or 32% of total tendon length. A statistically significant difference was detected between measured values for arthroscopic evaluation with a grasper and open evaluation ($P < .0001$), with a calculated effect size (d) of 7.27 (Fig 2).

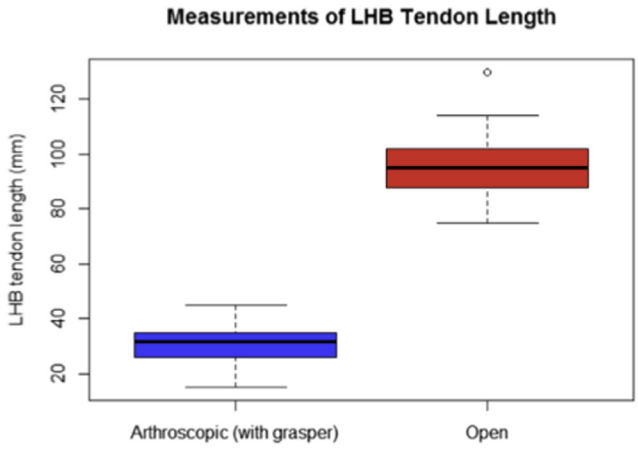

Fig 2. The LHB length (in millimeters, with 95% confidence interval) able to be observed comparing arthroscopic evaluation with a grasper versus open observation shows a statistically significant difference between techniques ($P < .0001$).

Arthroscopic Versus Open Evaluation of Surgical Pathology

Tendon fraying was seen arthroscopically with a grasper in 32 of 62 specimens (52%), redness in 37 of 62 (60%), flattening in 32 of 62 (52%), and degeneration in 34 of 62 (55%). By comparison, open evaluation showed fraying in 51 of 62 (82%), redness in 45 of 62 (73%), flattening in 50 of 62 (81%), and degeneration in 56 of 62 (90%). The difference between arthroscopic and open examinations was statistically significant for fraying ($P = .0006$), flattening ($P = .001$), and degeneration ($P = .00002$) but did not reach statistical significance for redness ($P = .184$) (Fig 3). Arthroscopic examination showed only 67% of all pathology detected on open examination.

The severity of pathology using arthroscopic assessment with a grasper was underestimated in comparison with open observation in 35 of 62 patients (56%). Arthroscopic assessment overestimated the severity of pathology in 7 of 62 patients (11%).

Histologic Evaluation

Histologic evaluation showed that no specimens were normal: 100% of cases were judged to be consistent with a diagnosis of tendinosis and/or fibrosis. In these same cases, only 3 of 62 (5%) were noted to have concomitant inflammation.

Discussion

Our results show that, when compared with open observation, arthroscopic examination underestimates LHB length. Our hypothesis is supported. Our results may have clinical relevance if preoperative evaluation suggests biceps tendon pathology but, arthroscopically, the LHB appears normal. It may be that some patients have LHB pathology in the distal tendon portion that is

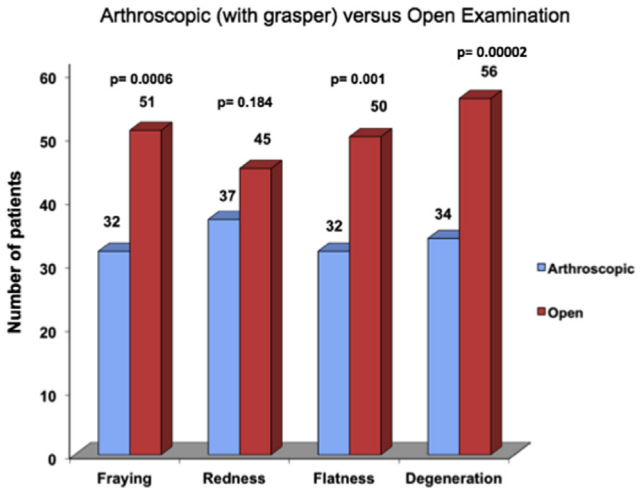

Fig 3. Observations of LHB pathology (x-axis) by number of patients (y-axis). The *P* values show statistically significant differences for fraying, flatness, and degeneration but not for redness comparing arthroscopic evaluation with a grasper versus open observation.

not visualized arthroscopically. In theory, an inability to visualize the distal 68% of the proximal LHB may result in clinical under-treatment of symptomatic pathology. The clinical paradox is that open observation is not possible without first performing a tenotomy.

In our study arthroscopic examination showed only 67% of all pathology detected on open examination, meaning that some degree of fraying, redness, flatness, or degeneration observed during open surgical inspection was noted and was recorded as absent during arthroscopic examination with a grasper. The severity of pathology using arthroscopic assessment with a grasper was underestimated in comparison with open observation in 35 of 62 patients (56%), meaning that the subjective grading of severity (mild, moderate, or severe) in at least 1 category was worse on open examination than arthroscopic evaluation. Interestingly, arthroscopic assessment overestimated the severity of pathology in 7 of 62 patients (11%).

Little published literature is available regarding this subject; however, Gregory et al.[22] performed a review of patients undergoing revision biceps tenodesis. In their series 14 of 21 patients underwent revision for persistent pain, and all patients reported significant pain relief and improved functional outcome scores after revision open subpectoral tenodesis. Further research could correlate clinical evaluation with open observation to address this challenge.

Our results may be compared with a similar study by Murthi et al.[23] In their study 80 shoulders met indications for biceps tenodesis, and open gross inspection showed degenerative changes in all cases whereas such changes were identified arthroscopically in only 49%, despite pulling of the tendon into the joint with an arthroscopic probe. In our study only 67% of pathology observed on open evaluation was identified arthroscopically. We are not able to explain why arthroscopic evaluation showed pathology in two-thirds of cases whereas arthroscopic evaluation by Murthi et al. showed pathology in only one-half of cases. Nevertheless, our conclusion that some pathology may be missed during proximal biceps arthroscopic observation with grasping in comparison with open observation during subpectoral tenodesis is supported by the conclusion of Murthi et al.

We are unaware of other studies comparing open versus arthroscopic observation of LHB length observed in vivo. In a cadaveric analysis Denard et al.[24] evaluated biceps tendon anatomy in terms of implications for restoring the length-tension relation after subpectoral tenodesis. Although their purpose differed from ours, it is notable that they observed a mean total tendon length of 98.5 mm. Our results are similar (95 mm). In addition, Denard et al. found a mean LHB length of 25 mm to the articular margin of the humeral head. This differs somewhat from our value of 17 mm visible arthroscopically (without pulling the tendon into the joint). This difference could be accounted for by differences in technique (arthroscopic *v* open) or differences between live and cadaveric specimens.

Refior and Sowa[25] evaluated the LHB for sites of predilection for degenerative lesions. They described degenerative lesions as most common at the origin from the supraglenoid tubercle and in the distal biceps groove. In contrast, a more recent study by Mazzocca et al.[26] examined molecular and histologic markers of tendon degeneration and found more degenerative changes in the proximal tendon. Our findings cannot be compared with these studies directly because of substantial differences in study purpose and methods, but we note that we measured and recorded distal pathology in cases in which arthroscopic evaluation did not show proximal pathology. In addition, although we measured and reported LHB length visualized while pulling the tendon into the joint, future research is required to determine whether pulling the tendon into the joint shows LHB pathology from within the distal aspect of the biceps groove.

LHB pathology is associated with other shoulder disorders. The rate of biceps pathology associated with rotator cuff tears has been described to be as high as 70%,[23] whereas in our study, 61% of cases had associated rotator cuff pathology (partial- or full-thickness tears), 45% had a SLAP lesion, 23% had anterior or posterior labral pathology, and 8% had chondral defects or degenerative cartilage changes.

In a small number of cases (11%), arthroscopic assessment overestimated the severity of pathology noted during open examination. The reason for this is unclear. It is possible that these cases represented

lesions of the proximal biceps anchor (i.e., SLAP tears) in which the pathology was well appreciated arthroscopically but the remainder of the tendon was relatively normal; in such a case, pathology might be underestimated during open examination.

Regarding histology, Singaraju et al.[27] performed histologic analysis and found no statistical difference in inflammation between tenotomized LHB surgical specimens and controls. Our finding of inflammation in only 5% of patients is supportive of the finding of Singaraju et al. of low rates of LHB pathologic inflammation, and in addition, we report that 100% of tenotomized LHBs showed evidence of tendinosis.

Limitations

Eighty patients were initially enrolled in the study, with institutional review board approval and with an understanding that the study presented minimal risk to patients other than the known risks of the operation and anesthesia. A priori power analysis was not conducted; however, 62 patients met the intraoperative inclusion criteria, and early statistical analysis of the results of included patients showed strong statistical significance regarding the primary research question. With the assumption of a large effect size, post hoc power analysis showed that 58 patients were needed to achieve statistical power. Thus enrollment of additional patients was not required.

A limitation is that the musculotendinous junction of the LHB is not a distinct point but rather is a gradual transition from tendon to muscle that is variable.[28] As such, some subjectivity is required to identify the musculotendinous junction, and this may result in imprecision of our measurement. Nevertheless, our values are similar to other reported values.[24]

Another limitation is that the authors' (B.B.G., J.B.R., D.Guttman) preferred technique for arthroscopic examination of the LHB is pulling the tendon into the joint with an arthroscopic probe, not pulling with an arthroscopic grasper; however, for the purpose of the study, the grasper was used to maximize the amount of tendon visualized and to stabilize the tendon in the joint during marking of the LHB with electrocautery. In addition, our statistical analysis may not be relevant to surgeons who perform diagnostic arthroscopy without pulling the tendon into the joint because we chose to statistically compare arthroscopy with a grasper versus an open technique because this is more clinically relevant to our surgical practice and because we did not perform surgical pathologic grading without pulling. However, we did report arthroscopically observed LHB lengths without pulling, which may be of relevance to surgeons who do not pull the tendon into the joint.

In addition, surgical observation and grading of redness, fraying, flattening, and degeneration are subjective. This classification system was developed based on common clinical arthroscopic findings and in the absence of a previously described and validated classification system in the existing literature. At the time of the study, it was not tested for intraobserver or interobserver reliability, which is a limitation. Other surgeons may judge LHB pathology differently or using different measures.

Conclusions

When compared with open inspection during subpectoral tenodesis, arthroscopic examination of the LHB visualizes only 32% of the tendon and may underestimate pathology.

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References

1. McDonald LS, Dewing CB, Shupe PG, Provencher MT. Disorders of the proximal and distal aspects of the biceps muscle. *J Bone Joint Surg Am* 2013;95:1235-1245.
2. Barber A, Field LD, Ryu R. Biceps tendon and superior labrum injuries: Decision making. *J Bone Joint Surg Am* 2007;89:1844-1855.
3. Barber FA, Byrd JW, Wolf EM, Burkhart SS. How would you treat the partially torn biceps tendon? *Arthroscopy* 2001;17:636-639.
4. Tosounidis T, Hadjileontis C, Triantafyllou C, Sidiropoulou V, Kafanas A, Kontakis G. Evidence of sympathetic innervation and α1-adrenergic receptors of the long head of the biceps brachii tendon. *J Orthop Sci* 2013;18:238-244.
5. Snyder GM, Mair SD, Lattermann C. Tendinopathy of the long head of the biceps. *Med Sports Sci* 2012;57:76-89.
6. Zhang Q, Zhou J, Ge H, Cheng B. Tenotomy or tenodesis for long head biceps lesions in shoulders with reparable rotator cuff tears: A prospective randomised trial. *Knee Surg Sports Traumatol Arthrosc* in press, available online 5 July, 2013. doi:10.1007/s00167-013-2587-8.
7. Frost A, Zafar MS, Maffulli N. Tenotomy versus tenodesis in the management of pathologic lesions of the tendon of the long head of the biceps brachii. *Am J Sports Med* 2009;37:828-833.
8. Galasso O, Gasparini G, De Benedetto M, Familiari F, Castricini R. Tenotomy versus tenodesis in the treatment of the long head of biceps brachii tendon lesions. *BMC Musculoskelet Disord* 2012;13:205.
9. Ahmad CS, DiSipio C, Lester J, Gardner TR, Levine WN, Bigliani LU. Factors affecting dropped biceps deformity after tenotomy of the long head of the biceps tendon. *Arthroscopy* 2007;23:537-541.
10. Mazzocca AD, Cote MP, Arciero CL, Romeo AA, Arciero RA. Clinical outcomes after subpectoral biceps tenodesis with an interference screw. *Am J Sports Med* 2008;36:1922-1929.
11. Provencher MT, LeClere LE, Romeo AA. Subpectoral biceps tenodesis. *Sports Med Arthrosc* 2008;16:170-176.

12. Ahmad CS, ElAttrache NS. Arthroscopic biceps tenodesis. *Orthop Clin North Am* 2003;34:499-506.
13. Moros C, Levine WN, Ahmad CS. Suture anchor and percutaneous intra-articular transtendon biceps tenodesis. *Sports Med Arthrosc* 2008;16:177-179.
14. Snir N, Hamula M, Wolfson T, Laible C, Sherman O. Long head of the biceps tenodesis with cortical button technique. *Arthrosc Tech* 2013;2:e95-e97.
15. Lemos D, Esquivel A, Duncan D, Marsh S, Lemos S. Outlet biceps tenodesis: A new technique for treatment of biceps long head tendon injury. *Arthrosc Tech* 2013;2:e83-e88.
16. Sandrey MA. Special physical examination tests for superior labrum anterior and posterior shoulder tears: An examination of clinical usefulness. *J Athl Train* 2013;48: 856-858.
17. Hegedus E, Goode A, Campbell S. Physical examination tests of the shoulder: A systematic review with meta-analysis of individual tests. *Br J Sports Med* 2008;42:80-92.
18. Calvert E, Chambers GK, Regan W, Hawkins RH, Leith JM. Special physical examination tests for superior labrum anterior posterior shoulder tears are clinically limited and invalid: A diagnostic systematic review. *J Clin Epidemiol* 2009;62:558-563.
19. Khazzam M, George MS, Churchill RS, Kuhn JE. Disorders of the long head of biceps tendon. *J Shoulder Elbow Surg* 2012;21:136-145.
20. Nho SJ, Strauss EJ, Lenart BA, et al. Long head of the biceps tendinopathy: Diagnosis and management. *J Am Acad Orthop Surg* 2010;18:645-656.
21. Bhatia DN, van Rooyen KS, de Beer JF. Direct arthroscopy of the bicipital groove: A new approach to evaluation and treatment of bicipital groove and biceps tendon pathology. *Arthroscopy* 2008;24:368.e1-368.e6.
22. Gregory JM, Harwood DP, Gochanour E, Sherman SL, Romeo AA. Clinical outcomes of revision biceps tenodesis. *Int J Shoulder Surg* 2012;6:45-50.
23. Murthi AM, Vosburgh CL, Neviaser TJ. The incidence of pathologic changes of the long head of the biceps tendon. *J Shoulder Elbow Surg* 2000;9:382-385.
24. 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: 1352-1358.
25. Refior HJ, Sowa D. Long tendon of the biceps brachii: Sites of predilection for degenerative lesions. *J Shoulder Elbow Surg* 1995;4:436-440.
26. Mazzocca AD, McCarthy MB, Ledgard FA, et al. Histomorphologic changes of the long head of the biceps tendon in common shoulder pathologies. *Arthroscopy* 2013;29:972-981.
27. Singaraju VM, Kang RW, Yanke AB, et al. Biceps tendinitis in chronic rotator cuff tears: A histologic perspective. *J Shoulder Elbow Surg* 2008;17:898-904.
28. Lafrance R, Madsen W, Yaseen Z, Giordano B, Maloney M, Voloshin I. Relevant anatomic landmarks and measurements for biceps tenodesis. *Am J Sports Med* 2013;41:1395-1399.