Lesions of the Biceps Pulley

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Background: Lesions of the biceps pulley and instability of the long head of the biceps tendon are common diagnoses in patients with anterior shoulder pain.

Purpose: To analyze the pathoanatomy of the biceps reflection pulley (''pulley'') in consecutive patients undergoing shoulder arthroscopy.

Study Design: Cohort study (prevalence); Level of evidence, 2.

Methods: Prospective data were collected on 229 shoulders in consecutive patients (155 male,74 female) who underwent shoulder arthroscopy (121 rotator cuff pathology, 50 instability, 43 osteoarthritis, 15 miscellaneous). The average age was 48.5 years (range, 18-76 years). Sixty-eight shoulders had underwent a previous surgery.

Results: The long head of the biceps tendon was absent in 21 shoulders (9.2%); 1 was excluded for incomplete data. In 207 shoulders, the mean width of the long head of the biceps tendon was 6.0 mm (range, 3-10 mm), and the pulley complex, 7.2 mm (range, 4-15 mm). Sixty-seven patients (32.4%) had a pulley tear: 48 shoulders had anteromedial pulley tears, 32 posterolateral, with 13 combined anteromedial-posterolateral lesions. Patients with pulley tears were significantly older than those without (57 vs 44 years, $P < .001$). For anteromedial pulley tears, the mean width of the long head of the biceps tendon was significantly larger in the torn group (6.4 vs 5.8 mm, $P = .012$). The anteromedial or posterolateral pulley tears were significantly associated with subluxation or dislocation of the long head of the biceps tendon ($P = .001$), with a pulley torn in all 27 cases of biceps dislocation. In 173 shoulders with a centered long head of the biceps tendon, the pulley was torn in 36 (23 anteromedial, 18 posterolateral [with 5 being combined]). Pulley tears and rotator cuff injury showed a significant association ($P < .001$). Superior labral anterior posterior lesions were significantly associated with anteromedial ($P < .008$) and posterolateral pulley tears ($P < .021$).

Conclusion: Pulley lesions are fairly common in patients undergoing arthroscopic surgery and were found in 32.4% of this prospective cohort (67 of 207). Current consensus indicates that pulley lesions are often associated with rotator cuff tears. This series also showed correlations with superior labral anterior posterior tears, biceps instability, and long head of the biceps tendon tears.

Keywords: biceps reflection pulley; long head of the biceps tendon; rotator cuff; superior labral anterior posterior

The long head of the biceps (LHB) tendon travels intra-articularly. Starting from its origin—at the supraglenoid tubercle—and making its way to the entrance of the bicipital groove, it exits the joint at the level of the biceps reflection pulley (hereafter, pulley), a soft tissue sling stabilizing the tendon course. The histoanatomy of the pulley system has been described by Gohlke et al[11] and Werner et al.[20] The pulley is built by fibers of the coracohumeral ligament, the superior glenohumeral ligament, and the supraspinatus and subscapularis tendons.[19] Figure 1 shows the typical arthroscopic view from the posterior standard portal. Lesions of the biceps pulley and instability of the LHB tendon are often found in patients with anterior shoulder pain.

It is generally accepted that dislocation of the LHB tendon is associated with rotator cuff lesions—particularly, the subscapularis tendon.[1,7,13,16,18] Tendinosis, partial tearing, and dislocation of the LHB tendon have all been investigated as sources of anterior shoulder pain due to a high degree of innervation of the proximal third of the tendon.[8,17,21] Repetitive wear and trauma to the restraining structures of the LHB tendon may also result in medial or lateral subluxation or dislocation of the tendon, which in many cases is related to tears of the subscapularis or supraspinatus cuff tendons.[1,9,10,18,19]

Anteromedial (AM) instability of the LHB tendon has been described by various authors.[3,6,9,13,20] Lafosse et al[14]

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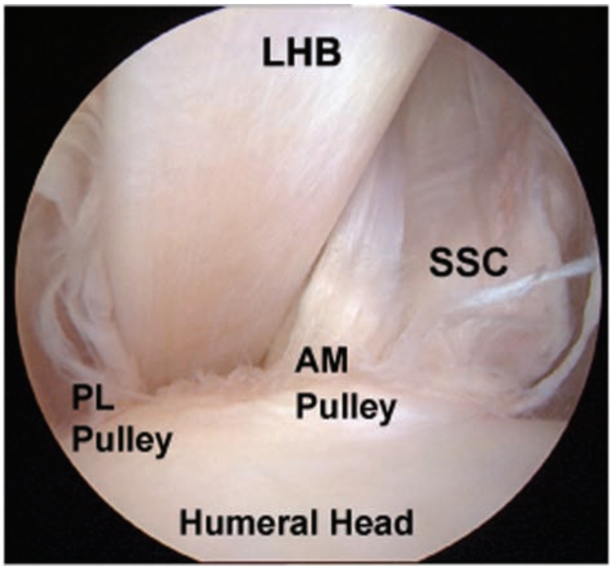

Figure 1. A standard arthroscopic view in a left shoulder from the standard posterior portal using a 30° lens with the arm in 30° of forward flexion and neutral rotation. There is good visualization of the long head of the biceps tendon (LHB), the subscapularis tendon (SSC), and the anteromedial biceps reflection pulley (AM pulley). PL, posterolateral.

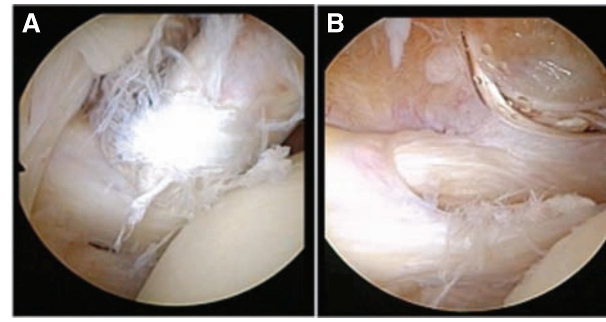

Figure 2. Arthroscopic view of an anteromedially dislocated degenerative long head of the biceps tendon in a right shoulder from the standard posterior portal: A, the dislocated tendon with an intratendinous lesion of the subscapularis tendon; B, the intratendinous tear of the subscapularis after tenotomy of the long head of the biceps tendon.

reported on a series of patients with posterolateral (PL) instability of the tendon. Different classifications of subluxation and dislocation patterns of the LHB tendon, with or without associated lesions of the subscapularis or supraspinatus tendon, have been published.[1,12,14,18] Figure 2A shows a dislocated LHB tendon with an intratendinous lesion of the subscapularis tendon; Figure 2B shows the same arthroscopic view after tenotomy of the LHB. However, there is still little information on the pathomechanisms that may lead to such tears of the pulley[6] and associated injuries besides the association with rotator cuff lesions.

The purpose of this study was to prospectively analyze the pulley in a consecutive series of patients undergoing arthroscopic shoulder surgery to better understand prevalence of pulley lesions, to detail pathoanatomic relationships, to determine if dynamic examination is important in detecting biceps instability and pulley lesions, and to better understand pathomechanisms of injury of the pulley complex.

MATERIALS AND METHODS

Data were prospectively collected on all 229 consecutive patients (155 male, 74 female) with 229 shoulder surgeries who underwent arthroscopic shoulder surgery between September 2007 and October 2008 at 1 institution. The average age of patients in this cohort was 48.5 years (range, 18-76 years). Sixty-eight patients had previous surgery on the index shoulder (49 had 1 operation, 19 had more than 1). In sum, 121 patients underwent surgery for rotator cuff disease, 50 for instability, 43 for osteoarthritis of the glenohumeral joint, and 15 for other various reasons.

A data questionnaire (designed pre hoc for the pulley complex for this study) was used to collect data for the cohort. Surgical data were also collected. Shoulder arthroscopic operations were typically performed with the patient in a beach-chair position with a pneumatic arm holder. One patient with acute traumatic posterior instability underwent surgery in the lateral decubitus position. For all patients, a standard posterior viewing portal was used for inspection of the glenohumeral joint. An arthroscopic probe with a 2-mm tip, introduced through an anterosuperior portal, was used for measuring the anatomic structures of interest. For the assessment of the LHB tendon and inspection of the pulley, the arm was positioned with the glenohumeral joint adducted, in neutral rotation, with approximately 30° of forward flexion. The elbow was positioned with approximately 90° of flexion with neutral rotation of the forearm to achieve reproducible results. Dynamic evaluation was also performed. In this cohort, attention was paid to the pulley, the biceps tendon, the rotator cuff tendons, and the rotator interval.

The biceps tendon was assessed (1) statically in neutral rotation and 30° of forward flexion (standard position) for its position (centered, subluxated, or dislocated) and (2) dynamically by internally and externally rotating the arm to the maximum that still allowed visualization of the structures of interest in 30° of forward flexion and 30° and 60° of abduction. Positive subluxation was defined for a biceps tendon leaving its normal course in the bicipital groove medially or laterally but not dislocating over the lesser or greater tubercle (Figures 3 and 4 show AM and PL subluxation of the LHB, respectively). A complete dislocation was defined as the biceps tendon leaving the bony groove.[18] The type of biceps dislocation was recorded (under, over, or into the subscapularis tendon, under the supraspinatus tendon) with respect for the Habermeyer classification of pulley tears.[12]

The intra-articular portion of the LHB tendon was assessed for tendinosis (chronic process of degeneration), tenosynovitis (acute inflammatory process) (Figure 5),

Figure 3. Arthroscopic view (right shoulder, standard posterior viewing portal) of anteromedial subluxation of the long head of the biceps tendon.

Figure 4. Arthroscopic view (right shoulder, standard posterior viewing portal) of posterolateral subluxation of the long head of the biceps tendon.

fraying, partial tears (in percentage of the tendon diameter), location of the injury (AM or PL), flattening or full tear of the tendon, as well as hourglass deformity of the biceps tendon. The same data were collected for the intertubercular portion of the biceps tendon, which was visualized by pulling it into the joint with a grasper or probe. The biceps tendon anchor at the supraglenoid tubercle was inspected and graded as normal or superior labral anterior posterior (SLAP) tears, types I to IV. The pulley complex was assessed and defined as narrow if the pulley sling entrapped the biceps tendon at the level of entrance to

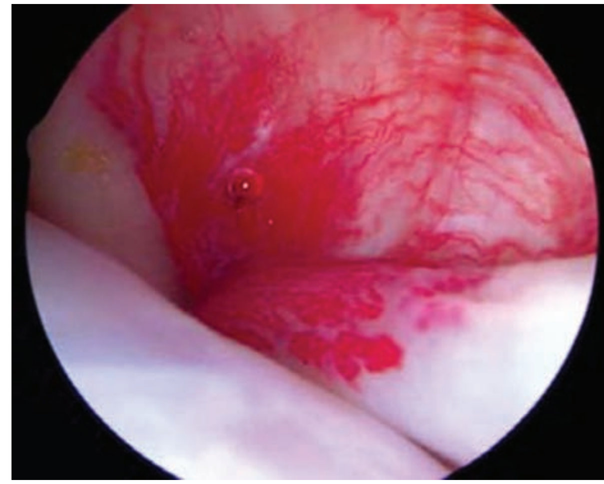

Figure 5. Arthroscopic view of tenosynovitis of the long head of the biceps with typical small blood vessels.

the groove. At this level, the width of the biceps tendon and the pulley sling was measured in millimeters (arthroscopically), using the 2-mm probe as a reference. AM or PL tearing of the pulley sling was recorded.

Data were analyzed using nonparametric univariate analysis performed with the Mann-Whitney *U* test for 2 group comparisons and Kruskal-Wallis analysis of variance for multiple-group comparisons. Chi-square tests were run for coded binomial data comparisons. Spearman ρ was used for assessing associations between continuous variables. Statistical analysis was done with SPSS 11.0 (SPSS Inc, Chicago, Illinois). All reported *P* values are 2-tailed with an α level of .05 indicating statistical significance.

RESULTS

Of the 229 patients, 21 were excluded from further description of the LHB because it had been previously ruptured or surgically released (9.2%). One patient was removed from the analysis because of incomplete biceps anatomy data, leaving 207 shoulders with biceps tendon data for analysis.

Pulley Tears

Tears of the pulley complex were present in 67 of the 207 shoulders (32%). The AM pulley was involved in 48 patients and the PL pulley sling in 32. Thirteen patients had combined AM and PL tears of the pulley sling. There was no statistical association between the presence of pulley complex tears and sex ($P = .115$). Patients with pulley tears were significantly older than those without (57 years: 95% confidence interval [CI], 53-60; 44 years: CI 95%, 41-47; $P < .001$) Tears were then further analyzed as AM and PL tears. There was a significant difference in age among those with AM or PL pulley tears compared with those without tears (56 years, AM tears: 95% CI, 52-60; 45 years, no AM tears: CI 95%, 43-48; $P > .001$), and patients with PL pulley tears were significantly older

TABLE 1
Biceps Reflection Pulley Injuries Related to the Position of the Long Head of the Biceps Tendon in 30° and 60° of Abduction With Internal and External Rotation of the Arm

Abduction	n	Anteromedial Pulley, n	Posterolateral Pulley, n	Combined
30°	197			
Biceps centered	172	18	11	5
Subluxated anteromedial	11	4	2	5
Subluxated posterolateral	7	5	2	0
Dislocated anteromedial	5	2	1	2
Dislocated posterolateral	2	2	0	0
60°	196			
Biceps centered	163	16	11	5
Subluxated anteromedial	13	5	1	5
Subluxated posterolateral	8	6	2	0
Dislocated anteromedial	5	2	1	2
Dislocated posterolateral	2	2	0	0

than those without tears (57 years, PL tears: 95% CI, 52-63; 46 years, no PL tears: CI 95%, 44-49; $P < .001$).

Pulley Width

In the 207 patients in whom the LHB tendon was present, the mean width of the tendon at the entrance to the bicipital groove was 6.0 mm (range, 3-10 mm). The mean width of the pulley complex was 7.2 mm (range, 4-15 mm). Men had a significantly larger pulley width and pulley complex width than women ($P < .05$), with or without the presence of a pulley tear.

In the group of AM pulley tears (n = 48; 32 isolated AM, 13 combined AM-PL), the width of the LHB at the level of entrance to the bicipital groove was significantly greater in the torn group than in the shoulders with intact pulley (6.4 mm [range, 3-10 mm] vs 5.8 mm [range, 3-10 mm]; $P = .012$). For the PL pulley tears (n = 32; 13 combined AM-PL), there was no difference in LHB width for torn versus intact pulley (5.7 mm [range, 3-8 mm] vs 6.0 mm [range, 3-10 mm]; $P = .45$).

Tendon Findings

There was a significant association between pathologic abnormalities of the LHB—including tendinosis (chronic process of degeneration), tenosynovitis (acute inflammatory process), fraying, hourglass biceps, and partial tears—and tears of the pulley complex ($P < .05$). The intra-articular portion of the LHB tendon was labeled normal in 95 of 207 shoulders examined (45.9%). With the numbers available, hourglass deformity and full tears of the LHB alone were not significantly associated with pulley tears. In sum, 117 of the 207 patients (56.2%) had SLAP lesions (type I, 58 patients; type II, 55 patients; type III, 2 patients; type IV, 2 patients). The SLAP tears and pulley tears showed a significant association ($P = .003$).

In the group of shoulders with the LHB present, 55 of 207 (26.6%) had an hourglass deformity. Of these 55 shoulders, 15 (27.3%) had pulley tears, 8 AM tears, 3 PL tears, and 4 combined AM-PL tears. Accordingly, hourglass deformity of the LHB was not significantly associated with lesions of the pulley complex in this study group ($P = .40$).

Tendon Position

In 173 of the 202 patients with an intact LHB (data missing for 5 on this parameter), the LHB was centered with the arm in neutral rotation. In this group of 173 with centered LHB, 23 AM tears of the pulley were found, as well as 18 PL and 5 combined AM-PL.

Eighteen shoulders had AM subluxation of the LHB, and 3 had PL subluxation in static neutral position of the glenohumeral joint. Only 1 of the 18 patients with an AM subluxated LHB had an intact pulley; all others had AM pulley tears. One had a combined AM-PL lesion. The individual with AM subluxation without an AM pulley tear had a wide but intact pulley. All 3 with PL subluxation had PL tearing of the pulley. There were no AM or combined AM-PL tears in the 3 patients with PL subluxation. Seven complete AM dislocations were found in neutral arm position, all associated with AM pulley tears; 2 thereof had combined AM-PL pulley tears. Furthermore, we found 1 PL dislocation associated with complete tearing of the PL pulley. The presence of either an AM or PL pulley tear or a combined AM-PL pulley tear was significantly associated with an LHB that was subluxated or dislocated ($P < .001$).

The pulley was torn in all cases of dislocation of the LHB tendon. Twenty-seven complete dislocations of the LHB tendon were found in 203 patients (13.3%), in either static or dynamic evaluation (4 omitted with missing examination position data). Dislocation of the LHB was deep (posterior) to the subscapularis tendon in 10 cases, superficial (anterior) in 11, and into the subscapularis tendon in 3; all were associated with AM tearing of the pulley. There were 3 dislocations of the LHB under the supraspinatus tendon, all of which were associated with PL pulley tears.

Table 1 shows the number of pulley injuries related to the position of the LHB in 30° and 60° of abduction with internal and external rotation of the arm.

Rotator Cuff Findings

There were 105 shoulders with rotator cuff tears in the study group, including 49 partial and 56 full-thickness tears.

A significant association was found between pulley tears and rotator cuff pathologic lesions ($P < .001$). Of 67 shoulders with pulley tears, 45 had a lesion of the supraspinatus tendon ($P < .001$). There was also a significant association found between tears of the infraspinatus tendon and lesions of the pulley complex; 15 of 67 (22%) pulley tears had infraspinatus tendon tears ($P = .004$).

There were 30 shoulders with partial (n = 22) to complete tears (n = 8) of the subscapularis tendon, of which 23 had pulley tears ($P \leq .001$).

DISCUSSION

In this prospective series of patients, we found that lesions of the pulley are common in a population undergoing arthroscopic shoulder surgery and that they were present in approximately one-third of cases. Inspection and probing of the pulley system in standard neutral position for shoulder arthroscopy unveiled 16.2% pulley tears (n = 28) in 173 patients who appeared to have a centered LHB in static evaluation. Interestingly, dynamic evaluation in 60° of abduction with internal and external rotation did not provide any additional information. The dynamic examination of the pulley in the 30° and 60° abduction positions with internal and external rotation did not detect additional lesions to those already diagnosed in neutral arm position. This indicates that putting the arm at either 30° or 60° of abduction with internal and external rotation had less diagnostic value than what was expected pre hoc.

Eighteen patients (11%) had AM subluxation of the LHB, which was associated with a tear of the pulley in 17 cases (16 AM and 7 PL; 9 unifocal, 6 combined AM-PL, and 1 intact pulley). Whereas PL subluxation was less common, with only 3 cases, each patient who had it also had a PL tear.

Walch et al[18] did not find isolated subluxations or dislocations of the LHB tendons in their study. In our study, however, we collected data on patients who had arthroscopic shoulder surgery for indications other than injury to the pulley; therefore, some patients with pulley tears had lesions besides the pulley tear. Interestingly, our findings support various authors who reported correlations between rotator cuff lesions and instability of the LHB tendon and/or pulley tears. Lafosse et al[14] published results on a series of 200 patients who underwent arthroscopic surgery for rotator cuff lesions and reported a 45% rate of biceps tendon instability in this group. In our series, 105 patients underwent surgery for rotator cuff disease, 49 for glenohumeral instability, 35 for osteoarthritis of the glenohumeral joint, and 15 for various other reasons. Overall, we found a 32% prevalence (67 of 207) of torn pulleys in the cohort with intact LHB and a 79% prevalence (53 of 67) of pulley tears for those with torn rotator cuffs.

Pulley tears had a significant association with rotator cuff lesions ($P = .001$), particularly for lesions of the supraspinatus and subscapularis tendons.

Lafosse et al[14] reported that partial lesions of the subscapularis tendon were significantly more frequent in patients with anterior dislocation of the LHB tendon than in patients with anterior subluxation, which our findings support. Tears of the subscapularis tendon were significantly associated with tears of the pulley ($P = .001$). These findings are supported by the anatomy and histoanatomy of the pulley system.[3,4,11,20] Furthermore, we found an association between tearing of the supraspinatus tendon and tearing of the PL pulley ($P = .001$). The significant association with tears of infraspinatus tendon and pulley tears may be due to concurrence of infraspinatus tendon lesions with supraspinatus tendon tears.

Pulley tears were more common in older patients. In the subgroup analysis, the correlation between lesions of the pulley and age was statistically significant for both PL and AM pulley tears ($P < .001$). The finding of a positive correlation between PL pulley tears and lesions of the supraspinatus tendon may indicate a degenerative process that affects both structures, or perhaps PL instability of the LHB initiates damage to the supraspinatus tendon once the PL biceps pulley ruptures. Bennett[2] stated that symptoms of LHB can be preoperatively confounded by concomitant rotator cuff tears.

Our results show that injury of the LHB tendon was significantly related to tearing of the pulley and SLAP tears ($P < .001$). This was also true for hourglass deformity of the LHB, which has been suggested as a possible pathomechanism for pulley tears.[5] We found that all subtypes of pulley tears (AM, PL, and combined AM-PL) were significantly associated with hourglass deformities in 15 of 55 shoulders (27.3%). Moreover, the width of the LHB was significantly greater when an AM pulley tear was present as compared with that which did not have a tear of the pulley ($P = .012$). Both findings support Boileau's theory[5] that hourglass deformities of the LHB can cause injury to the pulley. There is substantial excursion by the LHB that occurs when the arm is placed in forward flexion.[6] A widened LHB, as seen with the hourglass biceps, or a narrowed stenotic pulley can create a situation where the biceps acts like a wedge that disrupts the pulley. Our data also support the hypothesis that injuries of the LHB are more likely to appear with AM pulley tears. According to Gerber's theory, anterosuperior impingement may be a substantial factor for AM pulley lesions.[9]

This study presents the findings in a prospective cohort of symptomatic patients who underwent arthroscopic shoulder surgery, but it has several limitations. The expressiveness of the dynamic examination may be limited by 10 missing data sets in 30° and 60° of abduction, but we believe that this information would not have had a meaningful effect on the conclusions of the research. Although disease conditions within our cohort were heterogeneous, it is nevertherless a large group that represents most of the typical conditions that affect the shoulder. Furthermore, because of the large size, some of the variations that might occur with time of year or with a smaller sample should be minimized. There is the possibility for selection bias given the location of our sports medicine practice and the fact that it is a referral clinic. This potential bias could limit the generalizability of the findings to the population as a whole. In our opinion, the conditions seen and the types of patients included represent those seen in a typical shoulder specialist's practice. An additional limitation could be the method by which we measured the width of the LHB and the pulley sling: We used the tip of an arthroscopic probe with a known size (2 mm) as a reference. Although validated for other types of arthroscopic measurements, this method has not been validated for quantifying the size of the LHB tendon or the bicipital groove.[15]

In this prospective study, the prevalence of pulley lesions was 32%. Pulley tears were associated with rotator cuff tears and SLAP lesions but not an hourglass shape in the biceps tendon. The dynamic examination did not enhance detection of biceps instability over the static examination. Further study is needed to determine if pathoanatomic changes of the pulley are a function of aging or overuse injury in the shoulder. Ultimately, the pulley lesions' potential as an anterior shoulder pain generator remains unclear. However, proper inspections and treatment of the pulley complex and LHB tendon lesions during shoulder arthroscopy may improve patient outcomes or prevent the need for further surgery.

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