ACTA ORTHOPAEDICA et TRAUMATOLOGICA TURCICA
www.aott.org.tr

Research Article

Combined subscapularis and supraspinatus tears markedly increase the risk of long head of the biceps tendon pathology

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ARTICLE INFO

Article history:
Submitted June 17, 2025
Received in revised form June 18, 2025
Last revision received form December 26, 2025
Accepted December 26, 2025
Publication Date April 16, 2026

Keywords:
Lafosse grade
LHBT pathology
long head of the biceps tendon
rotator cuff tears
subscapularis
supraspinatus

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ABSTRACT

Objective: This study aimed to examine the frequency of long head of the biceps tendon (LHBT) pathologies in anterosuperior rotator cuff tears (RCT) involving the LHBT pulley system and investigate the relationship between RCT types and LHBT pathology subtypes.

Methods: A retrospective review was conducted of 555 shoulder arthroscopies performed for rotator cuff tears between 2017 and 2023. Patients were classified into 3 groups: isolated subscapularis (SSC) tears (n=74), isolated supraspinatus (SSP) tears (n=177), and combined SSC+SSP tears (n=304). The severity of the subscapularis tear was graded using the Lafosse classification. The LHBT pathologies were categorized as tendinitis, subluxation, dislocation, partial rupture, and full-thickness rupture.

Results: The LHBT pathology was present in 86.1% of cases. The most common pathologies were tendinitis (44.7%), complete rupture (13.5%), partial rupture (12.1%), subluxation (8.5%), and dislocation (7.4%). The SSC+SSP group had the highest LHBT pathology rate (99.0%) compared to isolated SSC (70.3%) and SSP (70.6%) groups ($P < .001$). The SSC+SSP group had a 36.04 times higher risk of LHBT pathology than the SSP group ($P < .001$). Dislocation and complete rupture were most frequent in the SSC+SSP group ($P < .001$). The LHBT pathology prevalence increased with Lafosse grade ($P < .001$), and higher grades were strongly associated with dislocation and rupture.

Conclusion: Anterosuperior rotator cuff tears are strongly associated with LHBT pathologies, and the severity of LHBT pathologies increases in parallel with the Lafosse grade. Combined SSC+SSP tears significantly increase the risk of LHBT pathology, particularly dislocation and complete rupture, highlighting the need for thorough LHBT evaluation in anterosuperior RCT cases.

Level of Evidence: Level III, Prognostic Study.

Introduction

The long head of the biceps tendon (LHBT) starts from the superior glenoid labrum and supraglenoid tubercle of the scapula and exits the glenohumeral joint through the bicipital groove. At the entrance of the bicipital groove, the tendon fibers of the supraspinatus and subscapularis, and the fibers of the coracohumeral and superior glenohumeral ligaments unite to form the anterior and posterior pulley system of LHBT. The stability of the LHBT is provided by this pulley system formed at the entrance of the bicipital groove.[1,2]

The LHBT lesions are a frequent source of shoulder pain.[1,3,4] While they can be the sole source of pain, they are frequently seen in association with other shoulder pathologies.[1,5,6] Pathological changes of the LHBT include tendinitis, tendinopathies, subluxation or dislocation of the tendon, SLAP lesions, and partial or complete tears of the tendon. The LHBT lesions are usually associated with rotator cuff pathologies.[2,7,8] The relationship between LHBT pathology and rotator cuff tears (RCTs) has been investigated in many studies. Chen et al reported that LHBT lesions were seen in 76% of patients who underwent arthroscopic repair for RCTs.[9] Furthermore, Lafosse et al reported that 45% of patients with RCTs had LHBT instability and 55% had erosions and partial tears.[10] RCTs, particularly subscapularis tendon tears, have been associated with biceps tendinopathy, as well as medial subluxations or dislocations of the biceps tendon.[11,12] Since the subscapularis helps form the medial border of the biceps pulley, anterior subluxation or dislocation of the LHBT is considered one of the primary pathologies associated with subscapularis tears.[11]

Massive RCTs involving the infraspinatus tendon can impair shoulder stabilization, which in turn can affect the biomechanics of the LHBT, which also aids in supporting the humeral head. As of the writing of this article, there are a limited number of studies in the literature examining LHBT lesions accompanying RCTs. On the other hand, there are studies demonstrating the relationship between massive RCTs and LHBT pathologies.[9,13] However, the number of studies examining the relationship between LHBT pathologies and RCTs in the anterosuperior region (where LHBT is located) is limited.[14] To the current knowledge, there are a limited number of studies evaluating the frequency and severity of LHBT lesions according to the Lafosse classification in subscapularis tears.

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Cite this article as: *Kaya I, Yaş S, Bircan R, Ahmadov A, Sarikaya B, Kanatli U. Combined subscapularis and supraspinatus tears markedly increase the risk of long head of the biceps tendon pathology. Acta Orthop Traumatol Turc., 2026, 60(2), 0483, doi: 10.5152/j.aott.2026.25483.*

In this retrospective study, the surgical records of RCTs that were treated arthroscopically were reviewed. The aim of the study is to determine the frequency of LHBT pathologies in the anterior-superior region RCTs, which contribute to the LHBT pulley system, and to investigate the relationships between RCT types and LHBT pathology subtypes. The hypothesis of this study is that as the grade of tear increases according to the Lafosse classification in patients with subscapularis tears, the frequency of biceps lesions and the severity of biceps pathology will be higher than expected. The second hypothesis of the study is that the frequency and severity of biceps pathologies increase as the number of tendons affected in RCTs involving the anterior-superior region increases.

Material and methods

In this study, operative videos and patient records of 2741 patients who underwent shoulder arthroscopy at the senior author's (U.K.) institution between 2017 and 2023 were retrospectively reviewed. All patient data were collected prospectively. The study protocol was approved by the Gazi University ethics committee (04.01.2024 E-77082166-604.01-841087). The study was conducted in accordance with the principles of the Declaration of Helsinki, and written informed consent was obtained from all subjects.

Patients who underwent surgery due to tears in the supraspinatus or subscapularis tendons were included in the study. Patients with infraspinatus tears, partial supraspinatus tears, massive tears including the posterior region of the rotator cuff, chronic and inflammatory arthritis, glenohumeral instability, a history of significant shoulder trauma (fractures, traumatic cuff tears), LHBT anatomic variations, previous shoulder surgeries, and incomplete medical records were excluded from the study. After performing the exclusion criteria, 555 patients (208 male, 347 female) were included in the study. Patients were classified into 3 groups based on the affected rotator cuff tendon: isolated subscapularis (SSC) tears (n=74), isolated supraspinatus (SSP) tears (n=177), and combined (SSC+SSP) tears (n=304). The patient selection process is shown in the flowchart (Figure 1).

Demographic data, including age and gender, were also collected. In the department, magnetic resonance imaging (MRI) is routinely performed after standard X-rays when shoulder pathology is suspected. Arthroscopic surgery recordings are routinely archived in shoulder arthroscopy procedures. To grade the ruptured subscapularis tendon according to the Lafosse classification system, arthroscopic videos and MRI scans were reviewed together. The evaluations were performed by a radiologist with 8 years of experience in musculoskeletal radiology and a shoulder surgeon with 10 years of experience; both were blinded to previous radiological reports and arthroscopic findings. Cases for which no consensus was reached were re-evaluated in a consensus meeting, and the final decision was determined by mutual agreement.[15]

HIGHLIGHTS

- Combined anterosuperior rotator cuff tears (subscapularis+supraspinatus) significantly increase the risk of long head of the biceps tendon (LHBT) pathologies, with a 41.7-fold higher odds compared to isolated supraspinatus tears.
- The prevalence and severity of LHBT pathologies, particularly dislocation and complete rupture, are strongly correlated with increasing Lafosse classification grades.
- The LHBT tendinitis is the most frequent pathology in anterosuperior rotator cuff tears (RCTs), whereas complete ruptures and dislocations are more common in higher-grade tears and combined tendon injuries.
- This study presents the largest case series to date evaluating the association between anterosuperior RCTs and LHBT pathology subtypes using Lafosse classification.

In Lafosse classification, type 1 indicates a partial tear, while type 2 signifies a complete tear of the superior one-third of the tendon. Type 3 tears involve a complete tear of the superior two-thirds of the tendon. Type 4 is a complete tear of the tendon, with the tendon being humeral head centered and its fatty degeneration classified as less than or equal to Goutalier stage III. Type 5 includes complete tears, usually with anterior glenohumeral subluxation and fatty infiltration greater than or equal to Goutalier stage 3.

The presence of LHBT pathology in patients with anterior-superior RCTs was evaluated. Subgroups of LHBT pathologies were classified as tendinitis, subluxation, dislocation, partial rupture, and complete rupture (Figure 2). LHBT pathologies were classified by reviewing arthroscopic video recordings. During arthroscopic procedures in the department, the senior surgeon documents the observed pathologies and the surgical techniques performed, and these records are entered into the database. Subsequently, the arthroscopy records are reviewed by 2 shoulder surgeons (İ.K. and S.Y.), with 7 and 10 years of surgical experience, respectively, who are blinded to the initial reports, to confirm the identified pathologies. In cases where no consensus was reached, the matter was re-evaluated in a consensus meeting involving the senior surgeon and the 2 shoulder surgeons, and the final decision was made by mutual agreement. For LHBT classification, static and dynamic examination was performed. First, the LHBT was examined for any signs of tendinitis, partial tear, complete tear, or dislocation. If the tendon was not in the bicipital groove without any manipulation, it was classified as dislocated. After inspection, the position of the tendon within the groove was assessed during internal and external rotation of the humerus, and any evidence of instability was classified as subluxation. If no subluxation was detected during rotational maneuvers, a dynamic assessment with an arthroscopic probe was performed to further evaluate potential instability.[10] Partial LHBT tears were defined as any loss of tendon integrity, ranging from fraying (degeneration or fibrillation of tendon fibers) and/or delamination, up to but not including complete rupture.

All procedures were performed by the senior surgeon of the study, who has 20 years of experience in shoulder arthroscopy (U.K.). The patients were in a lateral decubitus position, allowing them to rotate 20°-30° posteriorly to place the glenoid fossa parallel to the floor. The anesthesia option was a single interscalene block or general anesthesia with or without an interscalene block. Following sterilization with an iodine solution, the arm was positioned in 45° abduction and 15° forward flexion under 4 kg of longitudinal traction. The glenohumeral joint and subacromial space were examined with a 30° rigid arthroscope from the standard posterior portal, and labrum, rotator cuff tears, and biceps tendon pathologies were evaluated.

Statistical analysis

All statistical analyses were performed using SPSS (version 27; IBM Corp., MacOS) and R version 4.4.3 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were used to summarize demographic and clinical characteristics. Associations between Lafosse grades and LHBT pathology were assessed using Pearson's chi-square tests for categorical variables. Similarly, comparisons between RCT tear groups (SSC, SSP, SSC+SSP) were

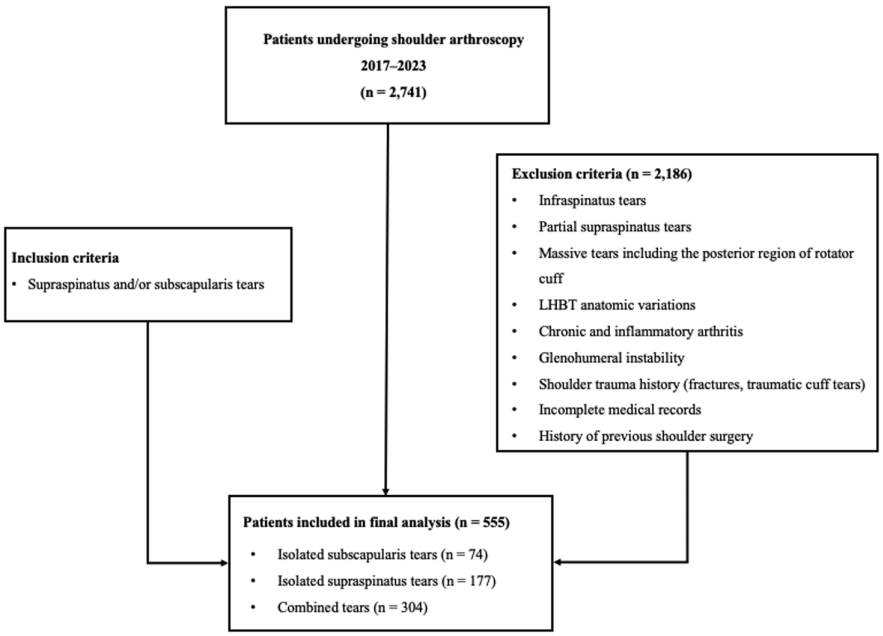

Figure 1. Patient inclusion and exclusion criteria flowchart.

performed using chi-square tests. Statistical significance for all tests was set at $P < .05$.

Binary logistic regression analyses were conducted using Firth's penalized maximum likelihood estimation to evaluate the predictive value of both Lafosse grades and RCT tear groups on LHBT pathology outcomes. Firth's method was selected to address potential separation and quasi-separation issues that can arise with rare events and small cell counts, providing more stable and conservative odds ratio estimates with improved confidence interval coverage compared to standard maximum likelihood estimation. All regression analyses were univariate, with a single categorical independent variable used in each model. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs), rounded to 2 decimal places for clarity.

Results

Demographic characteristics

The mean age was 60.75 ± 9.69 years, with 37.5% of patients being male and 62.5% female. 86.1% of cases were associated with LHBT

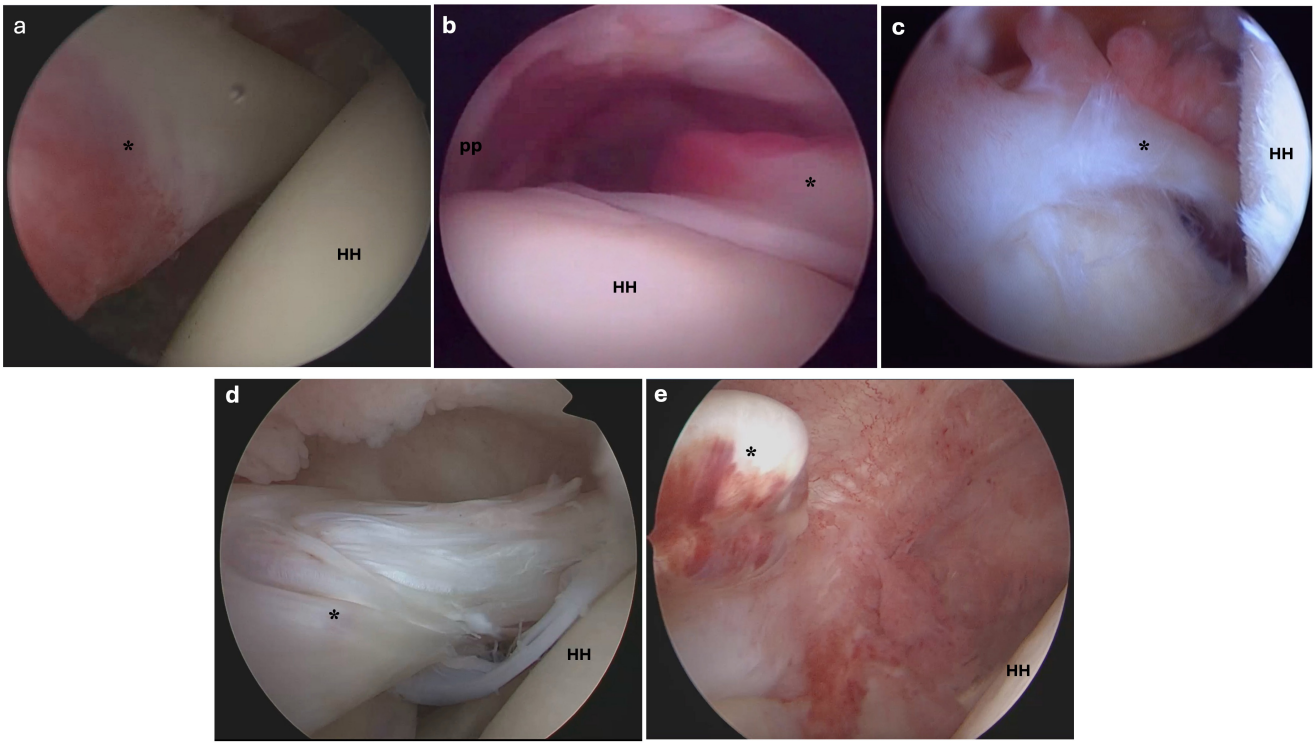

Figure 2. Arthroscopic view LHBT pathologies. a) Tendinitis. b) Subluxation (arthroscopic view of biceps groove). c) Dislocation. d) Partial rupture. e) Complete rupture. (*: LHBT, HH: Humeral head, pp: Posterior pulley).

pathology (478/555 shoulders). Among these, 248 patients (44.7%) experienced tendinitis, 47 (8.5%) had subluxation, 41 (7.4%) had dislocation, 67 (12.1%) suffered partial tears, and 75 (13.5%) had complete ruptures. Treatment of LHBT pathologies included tenodesis in 17 patients (3.5%) and tenotomy in 386 patients (80.7%). In 75 patients (15.7%) with complete rupture, no additional procedure was performed.

Frequency of long head of the biceps tendon pathologies by rotator cuff tear Group

The LHBT pathology was more prevalent in the SSC+SSP tear group (99.0%) compared to the isolated SSC (70.3%) and SSP (70.6%) groups ($P < .001$). Tendinitis was observed in 44.7% of all cases, with no significant difference among tear groups ($P = .234$) (n.s.). Partial ruptures were more frequent in the SSP tear group (16.9%) compared to SSC (5.4%) and SSC+SSP (10.9%) groups ($P = .024$). Complete ruptures of the LHBT were most frequently observed in the SSC+SSP tear group (19.7%), followed by SSC (13.5%) and SSP (2.8%) ($P < .001$). Dislocation was most common in the SSC+SSP tear group (11.5%, $P < .001$) (Table 1).

Association between Lafosse Grades and long head of the biceps tendon pathologies

During arthroscopic evaluation, a total of 378 patients (SSC and SSC+SSP groups) were found to have a subscapularis tear. For these groups, according to the Lafosse classification, 17 patients (4.5%) had type 1 tear, 128 patients (33.9%) had type 2 tear, 131 (34.7%) patients had type 3 tear, 98 patients (25.9%) had type 4 tear, and 4 patients (1%) had type 5 tear. The LHBT pathology was present in 93.4% of isolated SSC and SSC+SSP groups. The prevalence of LHBT pathology increased significantly with higher Lafosse grades ($P < .001$). Specifically, LHBT pathology was observed in 58.8% of Lafosse grade 1 cases and in 100% of Lafosse grade 5 cases. Tendinitis was the most common pathology, present in 45.8% of all cases, with no significant association across Lafosse grades ($P = .277$). Complete rupture (18.5%, $P < .001$) and dislocation (10.8%, $P < .001$) of LHBT demonstrated a significant association with higher Lafosse grades (Table 2).

Logistics regression analysis

When analyzed using Firth's penalized logistic regression for association between LHBT pathologies and RCT tear groups, the risk of having any biceps pathology in the SSC+SSP group was 36.04 times higher than in the SSP group (95% CI [13.72, 132.85], $P < .001$). The groups also had a statistically significant effect on complete rupture of LHBT, with those in the SSC group having a 5.11 times higher risk of rupture than those in the SSP group (95% CI [1.81, 16.06], $P < .05$), and those in the SSC+SSP group having a 7.76 times higher risk of rupture than those in the SSP group (95% CI [3.46, 21.40], $P < .001$) (Table 3).

The Lafosse classification showed a significant impact on overall LHBT pathology. Patients in grade 3 had a 6.34-fold higher risk compared with grades 1-2 (95% CI [2.24, 24.27], $P < .001$), while those in grades 4-5 had an 11.69-fold higher risk (95% CI [2.93, 106.29], $P < .001$). The classification also identified LHBT instability risks; patients in grades 4-5 had a reduced risk of subluxation compared to those in grades 1-2 (OR = 0.20, 95% CI [0.04, 0.64], $P < .05$). Conversely, the risk of dislocation increased with advancing grade, reaching a 2.86-fold higher risk in grade 3 (95% CI [1.15, 7.91], $P < .05$) and a 5.33-fold higher risk in grades 4-5 (95% CI [2.22, 14.51], $P < .001$) compared with grades 1-2. The risk of complete rupture was also strongly associated with higher grades, with grade 3 showing a 2.58-fold (95% CI [1.30, 5.34], $P < .05$) increase and grades 4-5 showing a 4.13-fold (95% CI [2.08, 8.56], $P < .001$) increase relative to grades 1-2 (Table 4).

Table 1. Association between rotator cuff tear groups and LHBT pathologies

LHBT Pathologies	SSC (n=74) (%)	SSP (n=177) (%)	SSC+SSP (n=304) (%)	Total (n=555) (%)	*P*
Tendinitis	28 (37.8)	75 (42.4)	145 (47.7)	248 (44.7)	.234
Subluxation	4 (5.4)	15 (8.5)	28 (9.2)	47 (8.5)	.574
Dislocation	6 (8.1)	0 (0.0)	35 (11.5)	41 (7.4)	*<.001*
Partial rupture	4 (5.4)	30 (16.9)	33 (10.9)	67 (12.1)	*.024*
Complete rupture	10 (13.5)	5 (2.8)	60 (19.7)	75 (13.5)	*<.001*
Total LHBT pathologies	52 (70.3)	125 (70.6)	301 (99.0)	478 (86.1)	*<.001*

The table shows the frequency (n) and percentage (%) of various conditions across different tear groups (SSC, SSP, and SSC+SSP). Percentages are calculated within each tear group. The *P*-values represent results from the Pearson Chi-Square test for differences among groups. A significance level of $P < .05$ was considered statistically significant.

Discussion

The key finding of this study is that both the incidence and severity of LHBT pathology increase as the number of affected rotator cuff tendons in the anterior-superior region increases. The RCTs involving both tendons had the highest incidence of LHBT pathology. Another significant finding of the study is that the incidence and risk of LHBT pathology increase as Lafosse grade advances. Notably, higher Lafosse grades were strongly associated with an increased risk of LHBT dislocation and complete rupture.

When looking atthe literature, it is a well-known fact that there is a relationship between LHBT pathologies and RCTs. [7-11,13] The reported frequency of LHBT pathologies in RCTs ranges from 36% to 82%. [7,9,13,16] Since the study included only anterosuperior RCTs, this incidence was found to be 86.1%. Chen et al (2005) classified LHBT pathologies into 5 categories: tendonitis, subluxation, dislocation, partial tear, and full-thickness tear. In their review of 122 RCTs, the most frequent condition was tendonitis (41%), while complete rupture was the least common at 5% .[9] In a similar study conducted in 2012, they evaluated LHBT pathologies across 6 groups by adding SLAP lesions to the previously mentioned groups and reported that among the associated LHBT pathologies in 176 RCT patients, the most common was tendinitis (40%) and the least was complete rupture of LHBT and SLAP lesions (9%, 7%, respectively).[13] There are

Table 2. Association between lafosse grades and LHBT pathologies

LHBT Pathologies	Lafosse 1 (n=17) (%)	Lafosse 2 (n=128) (%)	Lafosse 3 (n=131) (%)	Lafosse 4 (n=98) (%)	Lafosse 5 (n=4) (%)	Total (n=378) (%)	*P*
Tendinitis	9 (52.9)	64 (50.0)	58 (44.3)	42 (42.9)	0 (0.0)	173 (45.8)	.277
Subluxation	1 (5.9)	15 (11.7)	14 (10.7)	2 (2.0)	0 (0.0)	32 (8.5)	.081
Dislocation	0 (0.0)	6 (4.7)	15 (11.5)	17 (17.3)	3 (75.0)	41 (10.8)	*<.001*
Partial rupture	0 (0.0)	16 (12.5)	14 (10.7)	7 (7.1)	0 (0.0)	37 (9.8)	.374
Complete rupture	0 (0.0)	13 (10.2)	27 (20.6)	29 (29.6)	1 (25.0)	70 (18.5)	*<.001*
Total LHBT pathologies	10 (58.8)	114 (89.1)	128 (97.7)	97 (99.0)	4 (100.0)	353 (93.4)	*<.001*

The table presents the counts and percentages of clinical conditions (tendinitis, subluxation , dislocation , partial rupture and complete rupture and total LHBT pathologies overall) across Lafosse grades (1 through 5) for SSC and combined tears. Isolated SSP tears were excluded from the analysis. Percentages are calculated within each Lafosse grade group. *P*-values are derived from the Pearson Chi-Square test. Statistical significance is indicated at $P < .05$.

Table 3. Firth penalized logistic regression analysis: rotator cuff tear groups predicting LHBT pathologies

Dependent Variable	Comparison	OR	95% CI	*P*
Tendinitis	SSC vs. SSP	0.83	[0.48, 1.44]	.513
	SSC+SSP vs. SSP	1.24	[0.85, 1.80]	.260
Subluxation	SSC vs. SSP	0.67	[0.20, 1.85]	.455
	SSC+SSP vs. SSP	1.08	[0.57, 2.11]	.814
Dislocation	SSC vs. SSP	33.69	[3.90, 4415.27]	*<.001*
	SSC+SSP vs. SSP	46.76	[6.57, 5930.43]	*<.001*
Partial rupture	SSC vs. SSP	0.31	[0.10, 0.79]	*.012*
	SSC+SSP vs. SSP	0.60	[0.35, 1.02]	.058
Complete rupture	SSC vs SSP	5.11	[1.81, 16.06]	*.002*
	SSC+SSP vs. SSP	7.76	[3.46, 21.40]	*<.001*
Total LHBT pathologies	SSC vs SSP	0.98	[0.55, 1.78]	.936
	SSC+SSP vs. SSP	36.04	[13.72, 132.85]	*<.001*

Reference category: SSP (isolated supraspinatus tears). Firth's penalized logistic regression was used to address separation and convergence issues. Statistical significance was set at $P < .05$.
OR, = odds ratio; CI, = confidence interval; SSC, = subscapularis; SSP, = supraspinatus.

a limited number of studies in the literature that evaluate the relationship between RCTs and LHBT pathologies by dividing them into subgroups, as in the study mentioned above, and the sample sizes in these studies are smaller than in the study. To the current knowledge, the study is the largest case series addressing this issue.

In this study, tendinitis was the most frequent LHBT pathology (44.7%), whereas subluxation (8.5%) and dislocation (7.4%) were the least common. SLAP lesions were not included in the LHBT classification because the focus was on the impact of biceps pulley–related rotator cuff tears on LHBT. Since SLAP lesions are anatomically distant from the pulley construct and can also result from glenohumeral ligament or labral injuries, they were excluded from the analysis.

There are studies in the literature that have examined the relationship between the size of RCTs and the incidence of LHBT pathologies, with reports of positive correlation.[9,13,16,17] The increase in frequency and severity of LHBT pathology with larger tears may occur as a result of LHBT's functional compensation as a humeral head depressor in the absence of rotator cuff.[18] Desai et al evaluated the relationship between RCTs and LHBT pathologies by classifying cuff tears as small (<1 cm), medium (1-3 cm), large (3-5 cm), or massive (>5 cm). They reported that the incidence of LHBT pathology increased significantly with the increase in the size of RCTs.[16] In another study including 445 rotator cuff repairs, it was reported that 70% of the cases with LHBT dislocation were associated with massive RCTs.[19]

Table 4. Firth penalized logistic regression analysis: Lafosse grade predicting LHBT pathologies

Dependent Variable	Comparison	OR	95% CI	*P*
Tendinitis	Lafosse 3 vs. 1-2	0.79	[0.49, 1.26]	.315
	Lafosse 4-5 vs. 1-2	0.69	[0.42, 1.15]	.157
Subluxation	Lafosse 3 vs. 1-2	0.97	[0.45, 2.05]	.933
	Lafosse 4-5 vs. 1-2	0.20	[0.04, 0.64]	*.005*
Dislocation	Lafosse 3 vs. 1-2	2.86	[1.15, 7.91]	*.023*
	Lafosse 4-5 vs. 1-2	5.33	[2.22, 14.51]	*<.001*
Partial rupture	Lafosse 3 vs. 1-2	0.97	[0.45, 2.05]	.933
	Lafosse 4-5 vs. 1-2	0.62	[0.24, 1.47]	.283
Complete rupture	Lafosse 3 vs. 1-2	2.58	[1.30, 5.34]	*.006*
	Lafosse 4-5 vs. 1-2	4.13	[2.08, 8.56]	*<.001*
Total LHBT pathologies	Lafosse 3 vs. 1-2	6.34	[2.24, 24.27]	*<.001*
	Lafosse 4-5 vs. 1-2	11.69	[2.93, 106.29]	*<.001*

Reference category: Lafosse grade 1-2. Analysis includes only patients with subscapularis tears (isolated SSC and SSC+SSP groups; n=378). Firth's penalized logistic regression was used to address separation and convergence issues. Statistical significance was set at $P < .05$.
OR, odds ratio; CI, confidence interval; LHBT, long head of the biceps tendon.

Furthermore, Chen et al reported the incidence of LHBT pathology as 63.8% in RCTs that are smaller than 3 cm, and 92% for tears bigger than 3 cm (large and massive).[9] Consistent with the literature, the present study also found that as the number of affected rotator cuff tendons increased, both the incidence of LHBT pathology increased (99%) and the frequency of more severe pathologies within the subgroups of LHBT pathologies also rose. Additionally, in RCTs involving 2 tendons, the risk of LHBT pathology was found to be approximately 36 times higher.

In the case series, a total of 378 subscapularis tears were identified; 74 were isolated, while 304 were associated with supraspinatus tears. Compared to the total number of patients, subscapularis tears were detected in 68% of patients undergoing surgery for anterosuperior rotator cuff pathology. The diagnostic awareness of subscapularis tendon injuries is of critical importance in terms of shoulder biomechanics and LHBT pathologies and that the subscapularis tendon should be carefully evaluated during diagnostic arthroscopy. The study is one of the largest comprehensive series examining the impact of Lafosse grading on LHBT pathologies. According to the findings, as the Lafosse grade increases, the incidence and risk of LHBT pathologies also increase significantly. Specifically, the incidence of LHBT pathology was 58.8% in Lafosse grade 1, 99% in grade 4, and 100% in grade 5. Logistic regression analysis revealed that the risk of developing LHBT pathology was 11.69 times higher in Lafosse grade 4-5 compared with grade 1-2. In addition, the risk of LHBT dislocation was 2.86 times higher in Lafosse grade 3, and 5.33 times higher in grade 4-5.

Lafosse et al reported a 45% rate of LHBT instability in their series of 200 cases.[10] Chen et al reported that instability (subluxation or dislocation) occurred in 20% of 176 cases with RCTs and also that instability increased to 48% when accompanied by a subscapularis tear.[13] The case series included rotator cuff pathologies in the anterosuperior region, which forms the boundaries of the LHBT, and LHBT instability was found in 15.9% of cases (8.5% subluxation, 7.4% dislocation). When evaluating the relationship between the affected rotator cuff tendons and biceps instability, logistic regression analysis did not identify a significant effect of the groups on dislocation. However, dislocation was most frequently observed in the group where 2 tendons were affected.

Partial or complete ruptures of the LHBT may occur due to chronic RCTs. Alraddadi et al observed that LHBT ruptures were more frequent in RCTs involving 3 tendons compared to tears affecting 2 or just 1 tendon.[20] Candela et al reported in their series of 202 cases that 10.9% of patients had spontaneous ruptures of the LHBT and that there was a significant correlation between the prevalence of LHBT absence and massive RCTs (31% LHBT complete rupture).[17] The findings of the study support the studies of Alraddadi and Candela. In the case series, partial rupture was seen in 12.1% and complete rupture in 13.5% of all patients; and most of the LHBT ruptures were seen in RCTs involving 2 tendons. The study shows that the risk of complete rupture increases significantly in tears involving both the supraspinatus and subscapularis tendons. This result is consistent with previous studies that have shown a relationship between the severity of RCTs and LHBT rupture. Finally, as the Lafosse grade increases, the risk of LHBT complete rupture rises significantly.

This single-center study has several limitations. The retrospective design of the study is a limitation; however, the data were collected prospectively. Another limitation is that the arthroscopic evaluation

of LHBT pathologies, particularly subluxation and dislocation, is challenging, and there is no clear consensus regarding the objectivity of these pathologies. Selection bias, lack of interobserver reliability, and possible underreporting of dynamic LHBT lesions represent additional limitations of the study. The strength of this study lies in its relatively large sample size compared to similar research in the existing literature.

This study demonstrates a strong relationship between anterior-superior RCTs and LHBT pathologies. It shows that the incidence and severity of LHBT pathology increase with increasing Lafosse grade. Especially, Lafosse 3 and above tears are a strong risk factor for dislocation and complete tears of the LHBT. When the supraspinatus and subscapularis tendons that form the anterosuperior region are affected together, LHBT pathology is more common, and the resulting pathology is more severe. Therefore, it is important to carefully evaluate LHBT in patients with anterior-superior RCTs.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Artificial Intelligence Usage Statement: The authors declared that no Artificial Intelligence tool was used in the preparation of the manuscript.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Gazi University (Approval no: E-77082166-604.01-841087, Date: 04.01.2024).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – İ.K., S.Y.; Design – İ.K., R.B.; Supervision – B.S., U.K.; Resources – U.K.; Materials – S.Y., A.A.; Data Collection and/or Processing – İ.K., R.B.; Analysis and/or Interpretation – A.A.; Literature Search – İ.K., S.Y.; Writing – İ.K., S.Y.; Critical Review – R.B., B.S.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

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