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Value of anterosuperior rotator cuff and labral tears at MRI for predicting long head of biceps tearing at arthroscopy

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Abstract

AIM: To determine whether magnetic resonance imaging (MRI) signs of subscapularis (SBT), supraspinatus (SST), or superior labral tearing predict long head of biceps (LHB) tendon tearing at arthroscopy.

MATERIALS AND METHODS: Subjects with MRI studies followed by arthroscopy were collected. Radiologists graded rotator cuff (RC) tendons and the superior labrum using three grade classifications and blinded to arthroscopy. Correlation between imaging variables and surgical outcome was expressed in terms of odds ratios and determined using a stepwise logistic regression model.

RESULTS: Selection criteria identified 89 participants. Statistically significant increase in odds of finding a partial LHB tendon tear at arthroscopy were noted for both MRI readers with any SBT tear (OR=4.1–5.6, $p<0.0001$ to 0.002), full-thickness SST (OR=8–20.4, $p=0.002$ to 0.006), and combined SST-SBT tears (OR=5.1–7.6, $p<0.0001$ to 0.002) and relative to grade 0 MRI scores for those categories. Statistically significant increase in the odds of finding any LHB tendon tear at arthroscopy were noted for both MRI readers with any SBT tear (OR=9.6 to 14.6, $p<0.0001$), full-thickness SST (OR=9.0 to 52.0, $p<0.0001$ to 0.0004) and combined SST-SBT tears (OR=8.2 to 15.1, $p<0.0001$) at MRI and relative to grade 0 MRI scores for these categories. No significant predictive effect was found for the labral categories.

CONCLUSION: LHB tendons should be closely scrutinised if anterosuperior rotator cuff tears, and SBT tears in particular, are found on MRI.

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5 experimental studies / data analysis: CB, MB

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INTRODUCTION

Primary signs of long head of biceps (LHB) tendon disease at magnetic resonance imaging (MRI) include tendon thickening, increased signal on T2-weighted imaging, irregular tendon contour, and tendon discontinuity [1]. Secondary signs of LHB disease include tendon malposition, osteophytic spurring of the bicipital groove, and tearing of adjacent subscapularis and supraspinatus tendons [2–4]. The anterosuperior rotator cuff (RC) supports the LHB reflection pulley, a ligamentous sleeve formed by the superior glenohumeral ligament (SGHL) and coracohumeral ligament (CHL). The LHB anchor inserts on the superior glenoid labrum and tears of the superior labrum may extend into the rotator interval segment of the LHB tendon in the form of a type 4 SLAP (superior labral tear from anterior to posterior) tear [5]. The small size and oblique orientation of the LHB tendon in the rotator interval makes visualisation at MRI challenging, and recent literature suggests the accuracy of the primary MRI signs of LHB tendon tearing is low relative to arthroscopy [6, 7]. Determining the utility of secondary signs in predicting LHB tendon tearing is therefore of interest, and yet drawing conclusions from the few studies on the predictive value of proposed secondary signs at MRI is difficult as the sampled populations had a low prevalence of LHB tendon tearing at arthroscopy [3, 4].

The primary aim of this retrospective case–control study is to determine whether MRI signs of anterosuperior RC and superior labral tearing predict LHB tendon tearing, in particular partial tears, at arthroscopy. Both routine MRI and MRI arthrogram studies are included in the analysis, and using data previously reported in a separate study on the effect of patient age on the accuracy of primary MRI signs of LHB [8].

MATERIALS AND METHODS

Subject collection

The project was approved by the institutional review board and received a waiver for consent. No formal power calculation was performed; rather prior published literature was used as a guideline for determining an appropriate and practical number of participants. Participants with arthroscopy documenting normal (grade 0), tendinopathic (grade 0), partially torn (grade 1), and fully torn (grade 2) LHB tendons were collected by using Boolean keyword searches, including time span (1 January 2014 to 1 January 2015), specific facilities, surgeon name, anatomy (shoulder), document type (operative report), and descriptors of LHB status such as “normal”, “biceps tear or rupture”, “biceps tendinopathy”, and “biceps fraying”.

Criteria for inclusion included age greater than 18 years, MRI within 6 months prior to arthroscopy, and absence of prior surgery in the shoulder of interest. Four facilities with standardised imaging protocols and magnet strength (1.5 T) were selected. Participants fulfilling criteria for the study were collected until a reasonable balance was achieved in the LHB tendon arthroscopy categories of interest: normal tendons, tendinopathic tendons, partial-thickness tears, and full-thickness tears. For the MRI results, the records were de-identified and ordered randomly, scored independently and in blinded fashion by two

fellowship-trained musculoskeletal radiologists with 8 and 12 years of experience. Images were reviewed on a Philips iSite PACS workstation (Amsterdam, Netherlands).

MRI technique

Imaging studies consisted of routine MRI or MRI arthrogram studies performed on 1.5-T MRI systems (Siemens Espree and Avanto wide bore units with Syngo MR B19 software package [Siemens Medical Solutions, Malvern, PA, USA] and General Electric 450 wide bore and GE Signa units with DV24.0 software package [General Electric Medical Systems, Milwaukee, WI, USA]). The routine MRI protocol included T2 axial fast spin (FS) turbo spin echo (TSE); proton density (PD) axial TSE, PD coronal TSE; T2 coronal FS TSE; PD sagittal TSE; and T2 sagittal FS TSE sequences. The MRI arthrogram protocol consisted of a fluoroscopically guided injection of 12–18 ml of a mixture containing 10 ml normal saline, 5 ml 1% lidocaine, 5 ml Isovue-200, and 0.08 ml Multihance into the glenohumeral joint via the rotator interval using a 22 G spinal needle. MRI was performed within 45 minutes of the injection and included T1 axial TSE, T2 axial FS TSE, T1 coronal FS TSE, T1 sagittal TSE, T2 sagittal FS TSE, T2 coronal FS TSE, and T1 ABER view FS TSE using a flexible shoulder or torso coil.

Anterosuperior RC

The grading scheme used to characterise RC tears is a modified form of the original Codman classification for RC tears [9]. Normal SST and SBT signal, tendon calibre, and contour defined grade 0. Tendinopathy was defined as a thickened tendon with or without hyperintense signal on fluid sensitive sequences. Any perceived fibre discontinuity with fluid equivalent signal or gadolinium imbibition (in the case of an arthrogram) in any imaging plane constituted a tear. Grade 1 lesions were defined as partial-thickness tears of any width (width being defined in the anterior–posterior plane), and grade 2 lesions were defined as full-thickness tears of any width. An example of a subtle partial LHB tearing in the setting of partial-thickness anterosuperior RC tearing at MRI arthrogram is illustrated in all three planes in Figs. 1–4. A more obvious partial LHB tear is illustrated in Fig. 5.

Glenoid labrum

The labral tear classification system popularised by Snyder and Maffet [5, 10] was used with tear extent described using clock face terminology and categorised as type 1–10 SLAP lesions with or without paralabral cysts. SLAP categories were subsequently simplified into three groups. Group 0 consisted of normal labra defined as normal superior triangular morphology and smooth labral surfaces on all sequences with absence of linear or globular signal on both short and long TE sequences. Group 1 lesions were limited to the superior labrum from 2–10 o'clock (type 2 SLAP). Group 2 lesions were defined as any bucket handle tear, displaced flap tear or labral tear extending beyond the 2–10 o'clock position (type 3–10 SLAP lesions). Labral groups 1 and 2 were later combined into one group so that labral status could be dichotomised for statistical purposes.

Surgical technique and operative report interpretation

The lead author reviewed de-identified arthroscopy reports documenting the status of the labrum, cartilage, pulley structures, RC tendons, and LHB. LHB tendon status was described as normal, tendinopathic (injection), partially torn, or fully torn, and the status of the rotator interval capsule, presence of biceps instability, and RI synovitis were mentioned when relevant. LHB tendons described as normal or tendinopathic were labelled grade 0, partially torn tendons as grade 1, and fully torn tendons as grade 2.

SST tears were commonly described by size, shape, and degree of thickness (descriptions included low-grade partial-thickness, high-grade partial-thickness, and full-thickness tears). SST was described in 100% of cases and arthroscopic descriptive categories easily matched MRI classification.

SBT pathology descriptions, in contrast, did not match MRI descriptions easily. SBT tears were only described when full-thickness tears were found in the majority of the operative reports. Rotator interval “capsule” tears were described at arthroscopy but not at MRI. Coracohumeral and superior glenohumeral ligament tearing or thickening were described at MRI but seldom described at arthroscopy. Due to non-standard descriptions of SBT pathology at arthroscopy, the following assumptions were made after consulting with the participating surgeon in the study in order to find correspondence between MRI and arthroscopy diagnostic categories. If the SBT was not mentioned in the operative report, and no evidence of LHB tendon malposition was found or described, then SBT was labelled as normal or grade 0. The arthroscopic finding of a rotator interval capsular tear or laxity with LHB tendon malposition was considered to correspond to a grade 1 partial tear lesion in the MRI scheme. Any description of a full-thickness SBT tear was considered grade 2. Labral tears were typically characterised by age, clock face extent, degree of tear thickness (surface fraying, partial thickness, or full thickness) and presence or absence of paralabral cysts. Any labrum described as normal, type 1 SLAP or superior labral surface fraying requiring only debridement was considered to correspond to group 0 of the MRI grading scheme. Any superior labral tear described as a type 2 SLAP tear or superior labral tear limited to the 2–10 o’clock position was considered equivalent to group 1 of the MRI grading scheme. Any labral tear described as a bucket handle tear, displaced labral flap, full-thickness tear, type 3 or 4 SLAP tear or superior labral tear with anterior or posterior labral tearing beyond 3 and 9 o’clock (multi-quadrant) was considered equivalent to MRI group 2. Labral groups 1 and 2 were later combined into one group so that labral status could be dichotomised for statistical purposes.

Statistical analysis

Accuracy of each MRI reader (sensitivity, specificity, positive predictive value, and negative predictive value) relative to arthroscopy was calculated for each predictor variable (SST, SBT, and labrum). Agreement between MRI readers was measured using an unweighted kappa statistic.

The frequency of SST, SBT, and labral tears found by each MRI reader and arthroscopist within each group of arthroscopically proven not torn, partially torn, and fully torn LHB tendons was tabulated.

Univariate analyses for the outcome of LHB tear of any kind at arthroscopy for each predictor variable (SBT, SST, and the labrum) were performed using the chi-square test. The relative odds of finding a LHB tear of any kind at arthroscopy when comparing between different grades of SST, SBT, and labral tears was calculated for each diagnostician. Secondly, SST, SBT, and labral data were dichotomised into either torn (grade 2 or 3) or non-torn groups (grade 0 or 1), and the relative odds of finding a LHB tear of any kind at arthroscopy when comparing between torn and non-torn groups was calculated.

Univariate analyses for the outcome of partial LHB tear at arthroscopy when comparing between different grades of SST, SBT, or labral categories and between torn (grade 1 and 2) versus non-torn (grade 0) SB tendons were performed. Lastly, data were dichotomised and the relative odds of a partial LHB tear various combinations of torn and torn structures were calculated.

The combined effect of tears involving multiple anatomical structures (SST, SBT, labrum and LHB, SST-SBT, SST-SBT-labrum) was calculated using a step-wise logistic regression model.

RESULTS

From the electronic medical records, 868 consecutive patients were found over 12 months with the keyword searches detailed above. A total of 89 subjects consisting of 26 women (29%) and 63 men (71%; mean age=55 years, range=18–86 years) satisfied the inclusion criteria. Of the 89 studies collected, 15 subjects underwent MRI arthrography studies and 74 subjects were routine MRI studies. Of the 15 MRI arthrograms, 12 subjects were in the group 0 LHB group, two subjects in the grade 1 LHB group and only one subject in the grade 2 LHB group. A majority of subjects (84%) underwent diagnostic arthroscopy by one senior surgeon specialising in shoulder arthroscopy with 26 years of experience. The mean time between MRI and surgery was 43 days (range between 6 and 180 days).

Prevalence of LHB, SST, SBT, and labral pathology in the selected population LHB tear prevalence at arthroscopy was 60% with 36 (40%) normal or tendinopathic tendons, 36 partially torn tendons (40%) and 17 fully torn tendons (20%). SST tear prevalence at arthroscopy was 82% with 16 (18%) normal/tendinopathic, 29 (33%) partially torn and 44 (49%) fully torn tendons. SBT tear prevalence at arthroscopy was 51%. A total of 43 (48%) grade 0, 40 (45%) grade 1 and six (7%) grade 2 tendons were found. Labral tear prevalence at arthroscopy was 81% with 17 group 0, 55 group 1, and 17 group 2 lesions.

Frequency of SST, SBT, and labral categories in each LHB group

The frequency of specific RC and labral grades for each diagnostician within each arthroscopically defined LHB tendon category is summarised in Table 1, while the

frequency of combined and isolated RC tears within each arthroscopically defined LHB tendon category is summarised in Table 2.

MRI performance for RC and labral pathology

Sensitivity, specificity, and predictive value of MRI for each variable of interest and in regards to each LHB category is summarised in Table 3. Overall simple kappa between MRI readers was 55% (LCL=42%, UCL=69%) for SST, 60% (LCL=46%, UCL=75%) for SBT, and 46% (LCL=32%, UCL=61%) for labral categories.

Univariate analysis

Odds of finding any (grade 1 or 2) LHB tendon tear at arthroscopy when comparing degrees of anatomical structure tearing—Statistically significant increase in odds of finding some degree of LHB tearing at arthroscopy was present when grade 2 versus grade 0 and grade 2 versus grade 1 SSTs were found by all diagnosticians. No statistically significant increase in odds was found for MRI reader 1 when comparing the odds ratio (OR) between grade 1 and 0 SSTs.

A meaningful OR could not be calculated across SBT categories as the LHB tendon was always torn at arthroscopy when a grade 2 SBT was found at MRI or arthroscopy. If SBT data were dichotomised, then a statistically significant increase in odds of finding a LHB tendon tear of any kind at arthroscopy was found for all readers. No significant increase in odds or predictive value was found for any of the labral categories for the outcome of any LHB tear. Data are summarised in Table 4.

Odds of finding a partial (grade 1) LHB tendon tear when comparing degrees of anatomical structure tearing—Statistically significant increase in odds of finding a partial LHB tendon at arthroscopy was found between Grade 2 versus 0 and Grade 2 versus 1 SST categories for all diagnosticians but not for Grade 1 versus 0.

After dichotomising data, a statistically significant increase in odds was found for all diagnosticians when comparing grades 1 and 2 versus grade 0 SBTs as well combined RC tears of any kind versus grade 0 RC tendons. No significant increase in odds was found for the outcome of partial LHB tendon tearing at arthroscopy for any of the labral categories. Data are summarised in table 5.

Multi-step logistic regression model and predictive effect of isolated versus combined RC tears—A stepwise logistic regression model was created to test the association between arthroscopically proven LHB tear of any kind on the presence and absence of tears of the following co-variables: SST, SBT, combined RC tears and the labrum. The covariate with the greatest predictive effect for the outcome (arthroscopically proven LHB tear) was any SBT tear for MRI reader 1 (OR=9.7, LCL=3.5, UCL=26.3; $p<0.0001$), combined SST and SBT tears for MRI reader 2 (OR=15.0, LCL=5.3, UCL=42.8; $p<0.0001$), and any SBT tear for arthroscopy (OR=15.4, LCL=5.2, UCL=45.5; $p<0.0001$). It should be noted that the predictive effect of combined SST and SBT tears versus isolated SBT tears for MRI reader 2 were nearly equivalent. The dominant predictor variable found

in step 1 formed the basis of the logistic regression model in step 2, which tested whether the remaining variables had any additional value for predicting LHB tendon tearing at surgery. No additional significant predictive value was found for the remaining variables for the MRI readers; however, additional predictive power was found at arthroscopy for any SST tears (OR=6.1, LCL=1.4, UCL=27.3, $p=0.018$ when adjusting for SBT tears). No additional effects were found in the arthroscopy model in step 3.

Chi-square scores, odds ratio, p -Values, and confidence limits for each candidate variable for each reader are summarised in table 6.

DISCUSSION

The aim of the present study was to estimate the degree to which SBT, SST, and labral disease predict LHB tears when direct visualisation of the LHB tendon is limited. The radiology and orthopaedic literature both suggest the primary MRI descriptors of tendon discontinuity and irregular contour are poorly sensitive but highly specific for LHB tearing. Razmjou *et al.* reported routine MRI is reliable at detecting the absence of complete LHB tears and presence of LHB instability, but unreliable in detecting partial tears [7]. Similar low sensitivity for partial LHB tears was reported by Dubrow *et al.* [6]. An earlier study by Zanetti *et al.* reported MRI sensitivity for primary LHB tears ranging between 89% and 91% and specificity between 56% and 81%, albeit with a lower prevalence of LHB tears in the sampled population [1].

The poor sensitivity and precision of primary MRI signs for the outcome of LHB disease may be mitigated with awareness of secondary signs of associated anterosuperior RC structures. Multiple prior studies have reported a significant association between SBT and LHB tears [2, 4]. Sakurai *et al.* found a significant correlation between superior, articular-sided SBT tears and LHB disease, and Urita *et al.* reported spurring of the medial lip of the bicipital groove, near the SBT enthesis, likewise predicts LHB tendon disease [2, 11]. Razmjou *et al.* reported that full-thickness RC tears >3 cm in diameter decrease MRI detection of LHB tears, possibly due to synovitis, tendon retraction, and tendon scarring might obscure the LHB tendon [7]. Chen *et al.* reported a significant increase in likelihood of an “advanced” LHB lesion at arthroscopy (such as a partial for full tear) with RC tears >5 cm in size [3].

As anterosuperior RC tears at MRI are to be used as a potential secondary sign of LHB pathology, it was necessary to first determine MRI accuracy for the candidate variables. The data show MRI is highly specific and moderately sensitive in detection of SST tears in the sampled population. Prior literature shows broad agreement that MRI is highly accurate for SST tearing [12]. Less consensus and data are available in regards to MRI accuracy for SBT tears. A major limitation of the current study was the retrospective nature of the study and the non-standardised arthroscopic descriptions of SBT disease requiring interpretation. Based on the interpretative approach outlined in the methods section, SBT tear prevalence in the sampled population was estimated to be 51% (with only six full tears were found at arthroscopy). The validity of the MRI accuracy data for full-thickness SBT tears is questionable given the low number of cases. Despite this limitation, performance in

detection of partial SBT tears, likely those most relevant to LHB disease and most commonly encountered in daily practice, was higher than reported in many prior accuracy studies. Adams *et al.* reported routine MRI had a sensitivity of 36% and specificity of 100% for SBT tears in general compared to sensitivity between 70–85% for partial tears and between 50–100% for full tears in the current study [13]. More recent study by Malavolta *et al.* reported accuracy of 82% more keeping with the present study [14]. Further large, prospective MRI–arthroscopy correlation studies with well-defined classification of SBT disease are warranted to assess the validity of performance data in the present study.

In regards to the primary study aim, the results show a statistically significant increase in the odds of finding partial- and full-thickness LHB tears at arthroscopy when partial- and full-thickness tears of the anterosuperior RC are found at MRI. The odds of finding any LHB tendon tear at arthroscopy increased with increasing degrees of SST tearing (when comparing grade 1 and grade 2 SST tears) for all diagnosticians. In contrast, divergence between diagnosticians was noted when comparing the odds of finding any LHB tendon tear at arthroscopy between grade 1 and 0 SSTs (with a significant difference found only for MRI reader 2). Relative to MRI cases with grade 0 SBT and SSTs, univariate analysis found a significant increase in odds of finding a partial LHB tendon tear at arthroscopy between eight and 20 times with a grade 2 SST lesion at MRI, between 4.1 and 5.6 times with SBT lesions, and between 5.1 and 7.6 times with combined SST and SBT tears. The results suggest SBT tears of any kind and combined anterosuperior RC tears are more tightly correlated with LHB tendon tears at arthroscopy compared to isolated partial SST tears or supraspinatus tendinopathy.

Logistic regression analysis allows comparison of the relative contributions of each anatomical element on the outcome of LHB tendon tears. SBT tears and combined SBT-SST tears had a greater predictive effect relative to supraspinatus and labral tears (which had no significant association with LHB tearing) for two of the three diagnosticians (MRI reader 1 and arthroscopy). There were no examples of isolated LHB tears (i.e., grade 1 or 2 LHB lesions in the setting of grade 0 SBT or SST lesions) in the sampled population. The statistical models generated by each diagnostician converge on the notion that SBT tearing is the single best predictor of LHB tearing.

Patzer *et al.* reported a low prevalence of subjects with concomitant superior labral tears and pulley tears in a population of 182 patients [15]. Correlation with mechanism of injury showed pulley tears occurred after falls with the shoulder in flexion and internal rotation whereas SLAP tears occurred after falls with the shoulder in abduction and external rotation. This provides an explanation for the lack of correlation between superior labral tears and LHB tears in the current study.

As the study included both routine MRI and MRI arthrogram studies, readers may be interested in knowing if any difference in accuracy exists between these study types in regards to the outcomes and associations discussed in this manuscript. Only three arthrograms were found in the group with LHB tears (grade 1 and 2) compared to 12 arthrograms in the group without arthroscopically proven tears (grade 0). The study is therefore underpowered in regards to detecting a difference in accuracy between study types.

Study design was focused on achieving a balanced proportion of grade 0, 1, and 2 LHB cases. Requiring a balanced proportion of routine MRI and arthrogram studies would have required more subjects and broadened the focus of this study. In addition, Tadros *et al.* have recently published a study focused on this specific issue and found no significant difference in accuracy between unenhanced MRI and direct MRA for detection of tendinosis and tears of LHB tendons [16]. Several limitations are present in the current study. Selection bias may be associated with convenience sampling (rather than true population sampling) and retrospective studies and applies to the current study. As mentioned earlier, substantial interpretation was required to achieve correspondence between arthroscopic and MRI classification of SBT and labral disease. Secondly, it should be noted the present LHB classification was focused on estimating MRI accuracy for distinguishing between torn and non-torn LHB tendons. Tendinopathic and normal tendons were collapsed into one category for this purpose. Distinguishing between tendinopathy and normal LHB tendons has clinical relevance, and in particular when attempting to diagnose pulley lesions. The MRI performance data reported in this study should therefore be considered only with regards to the task of distinguishing between torn and non-torn LHB tendons. Thirdly, the selection criteria of the current study did not distinguish between participants with the clinical diagnoses of anterosuperior internal impingement versus subacromial external RC impingement. The degree of association of SBT and SST tears with LHB tearing may be less than would be measured had the study been limited to patients solely with anterosuperior internal impingement.

In conclusion, statistical analysis identified SBT and combined SST-SBT tears at MRI as the candidate variables with the greatest degree of association with LHB tendon tearing at arthroscopy. Superior labral tears were not correlated with LHB tears to any significant degree in the sampled population. LHB tendons should be closely scrutinised when anterosuperior RC tears are found at MRI as the odds of a LHB tear are high.

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Highlights

- SBT tears of any kind and combined anterosuperior rotator cuff tears are more tightly correlated with long head of biceps (LHB) tendon tears at arthroscopy compared to isolated partial SST tears or supraspinatus tendinopathy.
- No statistically significant correlation was found between superior labral tears and LHB tears.
- LHB tendons should be closely scrutinized if anterosuperior rotator cuff tears (SBT tears in particular) are noted on MRI as they are highly associated findings.

Figure 1.

A 33-year-old man with instability and suspected RC tear on physical examination. Axial T1-weighted image from an MRI arthrogram. MRI readers both agreed on calling a partial LHB tear given adjacent SBT tear (solid fat arrow), shallow bicipital groove (open fat arrow), medial LHB subluxation (thin white arrow), and subtle contour abnormality (thin white arrow). All MRI grades agreed with arthroscopy grades for this case. Curved white arrow points to a cord-like middle glenohumeral ligament.

Figure 2.

A 33-year-old man with instability and suspected RC tear on physical examination. Coronal T1-weighted image with fat saturation from an MRI arthrogram. MRI and arthroscopy agreed on a full-thickness SST. Curved white arrow points to a full-thickness tear at the anterior SST enthesis with contrast passing through the defect into the subdeltoid bursa.

Figure 3.

A 33-year-old man with instability and suspected RC tear on physical examination. Sagittal T1-weighted image from an MRI arthrogram. MRI and arthroscopy agreed on a full-thickness SBT. Straight white arrows point to a full-thickness SBT tear with a patulous anterior capsule. Note remodelling and flattening of the anterior humeral head (fat white arrow).

Figure 4.

A 33-year-old man with instability and suspected RC tear on physical examination. Sagittal T1-weighted image from an MRI arthrogram. MRI and arthroscopy agreed on a full-thickness SBT. Black arrow points to marked subscapularis muscle atrophy with a highly attenuated myotendinous fibres indicating a chronic SBT tear.

Figure 5.

A 58-year-old woman with pain and suspected RC tear on physical examination. (a) T2-weighted MRI arthrogram axial and (c) sagittal images show LHB tendon thickening and shaggy contour consistent with a partial tear (straight arrow). (b) LHB tendon subluxation is noted (straight arrows). (c) The T2-weighted sagittal and (b) axial images show linear fluid signal in the SBT (curved arrow) interpreted as a partial tear. (d) The coronal image shows a concomitant partial thickness, bursal-sided SST tear (straight arrow). All findings were confirmed at arthroscopy.

Table 1.

Anterosuperior rotator cuff and labral findings for each diagnostician for the outcome arthroscopically defined LHB group.

LHB arthroscopy grade	Reader	SBT 0	SBT 1	SBT 2	SST 0	SST 1	SST 2	Lab 0	Lab 1
0	Rad 1	29	7	0	13	16	7	14	22
	Rad 2	26	10	0	13	21	2	12	24
	Arthro	30	6	0	12	17	7	11	25
1	Rad 1	11	19	6	3	9	24	16	20
	Rad 2	6	27	3	1	20	15	12	24
	Arthro	7	24	5	2	8	26	6	30
2	Rad 1	5	10	2	4	3	10	8	9
	Rad 2	2	15	0	2	6	9	6	11
	Arthro	6	10	1	2	4	11	0	17

LHB, long head of biceps tendon; SBT, Subscapularis tendon; SST, Supraspinatus tendon; AS RC, Anterosuperior rotator cuff; AS RC Comb, Both SST and SBT torn; Lab, Labrum.

Table 2.

Combined and isolated RC tears for each diagnostician for the outcome arthroscopically defined LHB category.

LHB arthroscopy grade	Reader	AS RC 0	SBT Isolated	SST Isolated	AS RC Comb	Total
0	Rad 1	12	1	17	6	36
	Rad 2	11	2	15	8	
	Arthro	11	1	9	5	
1	Rad 1	2	1	9	24	36
	Rad 2	1	0	5	30	
	Arthro	0	2	7	27	
2	Rad 1	1	3	4	9	17
	Rad 2	0	2	2	13	
	Arthro	0	2	6	9	

LHB, long head of biceps tendon; SBT, subscapularis tendon; SST, supraspinatus tendon; AS RC, anterosuperior rotator cuff; AS RC Comb, both SST and SBT torn.

Table 3

MRI Accuracy for each predictor variable using arthroscopy as a reference standard.

LHB arthroscopy Grade	Reader	SBT				SST				Labrum			
		Sens	Sp	PPV	NPV	Sens	Sp	PPV	NPV	Sens	Sp	PPV	NPV
0	Rad 1	81%	78%	78%	82%	88%	92%	70%	97%	82%	67%	37%	94%
	Rad 2	65%	87%	82%	73%	63%	92%	63%	92%	76%	76%	43%	93%
1	Rad 1	70%	84%	78%	77%	79%	92%	82%	90%	36%	88%	83%	46%
	Rad 2	85%	63%	65%	84%	79%	60%	49%	86%	58%	68%	74%	50%
2	Rad 1	100%	98%	75%	100%	91%	98%	98%	92%	88%	83%	56%	97%
	Rad 2	50%	100%	100%	97%	57%	98%	96%	70%	59%	92%	63%	90%

LHB, long head of biceps tendon; SBT, subscapularis tendon; SST, supraspinatus tendon; Arthro, arthroscopy.

Table 4.

Relative odds for the outcome of any LHB tear at arthroscopy between grades of each predictor variable.

Outcome: any LHB tear	SST Grade 2 versus 0			SST Grade 2 versus 1			SST Grade 1 versus 0		
	OR	CL	p-Value	OR	CL	p-Value	OR	CL	p-Value
Rad 1	9	31–3	0.0004	6.5	19–2	0.0009	1.4	5–0	0.583
Rad 2	52	351–8	<0.001	9.7	46–2	0.004	5.3	21–1	0.017
Arthroscopy	16	64–4	<0.0001	7.5	22–2	0.003	2.1	8–0	0.276

Outcome: any LHB tear	SBT Grade 1 or 2 versus 0.			SST and SBT Grade 1 or 2 versus SST and SBT Grade 0		
	OR	CL	p-Value	OR	CL	p-Value
Rad 1	9.6	26–3.5	<0.0001	8.2	23–3	<0.0001
Rad 2	14.6	42–5	<0.0001	15.1	42–5	<0.0001
Arthroscopy	15.4	45–5	<0.0001	13.1	39–5	<0.0001

Outcome: any LHB tear	Labrum Grade 2 versus 0			Labrum Grade 2 versus 1			Labrum Grade 1 versus 0		
	OR	CL	p-Value	OR	CL	p-Value	OR	CL	p-Value
Rad 1	0.9	3–0.3	0.9	1.7	5–0.5	0.3	0.6	1.6–0.2	0.3
Rad 2	1.5	5–0.4	0.6	1.7	6–0.5	0.4	0.8	2–0.3	0.7
Arthroscopy	1.6	6.4–0.4	0.5	0.3	1.1–0.1	0.07	4.4	14–1.4	0.01

Rad, radiologist; SBT, subscapularis tendon; SST, supraspinatus tendon; OR, odds ratio; CL, 95% upper confidence limit-lower confidence limit.

Table 5.

Relative odds for the outcome of Grade 1 LHB tear at arthroscopy between grades of each predictor variable.

Outcome: Grade 1 LHB tear	SST Grade 2 versus 0			SST Grade 2 versus 1			SST Grade 1 versus 0		
	OR	CL	p-Value	OR	CL	p-Value	OR	CL	p-Value
Rad 1	8	32–2	0.0003	6.5	19–2	0.0009	2.7	12–0.6	.185
Rad 2	20	178–2	0.006	9.7	46–2	0.004	11	91–1	0.025
Arthroscopy	10	50–2	0.0004	7.5	22–2	0.003	2.6	15–0.5	.255

Outcome: Grade 1 LHB tear	SBT Grade 1 or 2 versus 0			SST and SBT Grade 1 or 2 versus SST and SBT Grade 0		
	OR	CL	p-Value	OR	CL	p-Value
Rad 1	4.1	16–2	0.001	5.1	12–2	0.0005
Rad 2	5.6	10–1.6	0.002	7.6	21–2.7	0.0001
Arthroscopy	8.8	24–3.2	0.0001	8.4	22–3	<0.0001

Outcome: any LHB tear	Labrum Grade 2 versus 0			Labrum Grade 2 versus 1			Labrum Grade 1 versus 0		
	OR	CL	p-Value	OR	CL	p-Value	OR	CL	p-Value
Rad 1	1.3	3.4–0.5	0.6	2.2	7–0.7	0.16	0.5	1.7–0.2	0.3
Rad 2	1.2	4–0.3	0.8	1.1	4–0.4	0.8	1	2.5–0.4	0.9
Arthroscopy	1.3	5–0.3	0.7	0.9	3–0.3	0.9	1.3	4–0.4	0.6

Rad, radiologist; SBT, subscapularis tendon; SST, supraspinatus tendon; OR, odds ratio; CL, 95% upper confidence limit-lower confidence limit.

Table 6.

Logistic regression analysis: chi-square scores, odds ratio and predictive value of each anatomical structure for the outcome of arthroscopically proven grade 1 or 2 LHB tendon (any tear).

Rad 1 variable, torn versus not torn	Chi-square score	p-Value	OR	95% UCL-LCL
SBT	21.7	<0.0001	9.6	26.3–3.5
SST	6.5	0.0111	3.7	10.6–1.3
Combined RC	18.1	<0.0001	8.2	23.3–2.9
Labrum	0.36	0.5	0.7	1.8–0.3

Rad 2 variable= torn versus not torn	Chi-square score	p-Value	OR	95% UCL-LCL
SBT	29.6	<0.0001	14.6	41.7–5.1
SST	13.5	0.0002	9.4	36.3–2.4
Combined RC	30.4	<0.0001	15.0	42.8–5.3
Labrum	0.003	0.95	0.9	2.4–0.4

Arthroscopy variable=torn versus not torn	Chi-square score	p-Value	OR	95% UCL-LCL
SBT	29.7	<0.0001	15.4	45.1–5.2
SST	9.7	0.0002	6.1	21–1.8
Combined RC	25.2	<0.0001	13.1	39.7–4.3
Labrum	5.1	0.02	3.5	10.4–1.1

Rad, radiologist; SBT, subscapularis tendon; SST, supraspinatus tendon; OR, odds ratio; CL, 95% upper confidence limit-lower confidence limit.