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SHOULDER

Diagnostic performance of clinical tests for subscapularis tendon tears

Thomas Kappe[1] · Mirco Sgroi[1] · Heiko Reichel[1] · Manuel Daexle[1]

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Abstract

Purpose Tears of the subscapularis (SSC) tendon constitute a diagnostic challenge. The purpose of the present study was to evaluate the diagnostic capabilities of five clinical SSC tests.

Methods Five established clinical tests were evaluated in 106 consecutive patients prior to shoulder arthroscopy. The tests included the Lift Off Test, Internal Rotation Lag Sign, Belly Press Test, Belly Off Sign, and Bear Hug Test. The integrity of the SSC tendon at surgery was used as the gold standard. Lesions to the SSC were graded according to Fox and Romeo.

Results There were 32 SSC lesions accounting for an incidence of 30.2%. The sensitivity for all tests was 0.66, while the specificity was 0.82. For all tests, positive tests results were found to be dependent on subscapularis integrity ($p < 0.001$, respectively). The sensitivity for any type of SSC lesion for the Lift Off Test, Internal Rotation Lag Sign, Belly Press Test, Belly Off Sign, and Bear Hug Test was 0.35, 0.41, 0.34, 0.31, and 0.52, respectively. Specificity was found to be 0.98, 0.91, 0.96, 0.97, and 0.85, respectively. If only grade 2–4 tears were analysed, sensitivity was 0.32, 0.42, 0.37, 0.37, and 0.72 and specificity 0.94, 0.86, 0.92, 0.94, and 0.84. A positive correlation was found between the number of positive tests and the severity of the SSC lesions.

Conclusion In the present study, the Bear Hug Test was found to have the highest sensitivity of all tests studied, especially for tears of the upper tendon border. It appears advisable to perform more than one clinical subscapularis test to further improve sensitivity. Nevertheless, SSC tears may still escape clinical recognition. Therefore, a high index of suspicion has to be maintained in order not to miss SSC tears.

Level of evidence Diagnostic study, Level I.

Keywords Subscapularis tendon tears · Clinical examination · Bear hug test

✉ Thomas Kappe
Thomas.kappe@rku.de

1 Department for Orthopaedic Surgery, RKU, University of Ulm, Ulm, Germany

Introduction

Tears of the subscapularis (SSC) tendon occur at a high incidence and pose diagnostic and therapeutical challenges [1, 5, 8, 23, 29, 34]. The subscapularis has a key role in shoulder biomechanics [31, 33]. SSC integrity is a prerequisite for a variety of surgical techniques in shoulder reconstruction, and its disruption may lead to pain, disability, and static shoulder instability [7, 9, 20, 21, 29, 31, 35, 36]. Therefore, the reconstruction of SSC tendon tears has been reported to be key step in shoulder reconstruction [10, 25, 33]. Arthroscopic recognition of SSC tendon tears and especially partial tears may be difficult due to the anterior insertion of the tendon and the obstructed field of view by the humeral head when viewing from a posterior portal [8, 23, 28].

While posterosuperior rotator cuff tears are commonly detected on magnetic resonance imaging (MRI), SSC tendon tears have been reported to frequently escape MRI diagnostics [1, 2, 14, 16]. A number of clinical tests have been described in order to detect SSC tendon tears, yet reports from the literature have been differing in terms of their diagnostic capabilities [4–6, 19, 30, 37]. In particular, the Bear Hug Test has been proposed to possess the highest sensitivity for SSC tendon tears, yet its full diagnostic capabilities have not been compared to the four other common SSC tests in an independent study. The aim of the present study therefore was to determine the diagnostic accuracy of five clinical tests for SSC tendon tears.

Materials and methods

In a prospective cohort study, 106 shoulder joints in 106 consecutive patients undergoing shoulder arthroscopy at a single institution were included into the present study. Patients with shoulder instability or a history of shoulder trauma or surgery as well as patients with advanced osteoarthritis (Samilson-Prieto grade 2 or 3) or shoulder stiffness were excluded from the present study. There were 40 women and 63 men with a mean age of 57.3 ± 12.2 years (range 32.5–85.0 years). Seventy right and 38 left shoulder joints were included.

Preoperatively, five clinical tests were performed on every patient by one of two examiners in a standardized manner. The patient was standing in an upright manner. First, the Lift Off Test was performed: the patient was asked to put his hand on his lower back, palm facing backwards. The patient was then asked to lift his hand off his back. An inability to do so was rated as a positive test [18]. Next, the Internal Rotation Lag Sign was assessed. From the same starting position, the hand of the patient was pulled away from his back to almost full internal rotation. The patient was then asked to actively maintain this position and warned that his hand would be released. An inability to hold the hand in that position was rated as a positive sign [22]. The Belly Press Test was then performed. The patient was asked to put his hands palm down on his belly, to bring his elbows forward, thereby extending his wrists, and to press into his belly. A loss of wrist extension was rated as a positive test. Next, the Belly Off Sign was evaluated [18]. From the same starting position, the patient's elbow was maximally brought forward holding the patient's hand onto his belly. The patient was then asked to maintain that position and warned that his hand would be released. If the patient was not able to hold his palm on his belly, the sign was rated to be positive [30]. Finally, the Bear Hug Test was performed. The patient's hand was brought over his opposite shoulder, palm facing downwards with the wrist extended. An attempt was made to lift the patient's hand off his shoulder while the patient was asked to resist. If the examiner was able to lift the hand off, the test was rated to be positive [5].

Shoulder arthroscopy was performed in the beach chair position with the use of an arm holder in regional anaesthesia. A standard posterior viewing portal was used for the arthroscope, and a probe was routinely introduced via an anterolateral or anterosuperolateral portal. The integrity of the subscapularis tendon at its footprint was routinely evaluated in a position of slight flexion and internal rotation, allowing adequate visualization with a 30° arthroscope (Figs. 1, 2). Posterior pressure applied to the anterior aspect of the proximal humerus was added if necessary. In the present study, full evaluation of the SSC footprint was possible using the technique described. If this had not been the case, the authors would not hesitate to switch to an anterior viewing portal. The authors of the present study also did not find it necessary to use a 70° arthroscope, even though they acknowledge the ease of exposure with a 70° arthroscope [8, 23]. Integrity of the subscapularis tendon was graded according to Fox and Romeo, where grade 1 is a partial tear, grade 2 a tear of the upper 25%, grade 3 of the upper 50% of the tendon, and grade 4 denominates a complete tear [15]. In case of grade 1 lesions, the tendon was debrided and the anterior capsule was opened in order to expose the coracoid process and assess the coracohumeral interval. A coracoplasty was performed if the latter was below 7 mm. Grade 2 or higher lesions were reconstructed. In most cases, an accompanying biceps tenodesis was performed.

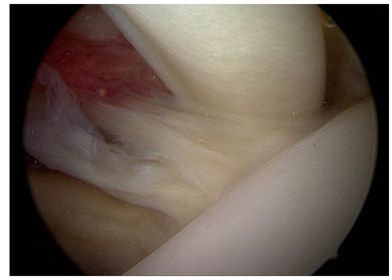

Fig. 1 Arthroscopic picture of a right shoulder joint, posterior viewing portal depicting the long head of biceps tendon and obviously only superficial fraying of the subscapularis tendon. The arm is in neutral position

Fig. 2 Same shoulder as in Fig. 1 with the arm held in flexion and slight internal rotation and posterior pressure applied to the proximal portion of the humerus, revealing extensive fraying and partial tearing of the articular surface of the subscapularis tendon, partially exposing the subscapularis footprint

Independent institutional review board approval was obtained from the Ethics Committee of the University of Ulm, Ulm, Germany (application 236/10).

Statistical analysis

An a priori power analysis for the Chi-Square test with an effect size of 0.3, an alpha error of 0.05, and a power of 0.8 predicted the need for a minimum of 88 participants. The sensitivity, specificity, positive and negative predictive values as well as the accuracy of every single test were calculated using contingency tables. The calculation was first performed rating any Fox–Romeo grade as a tear and then only taking full thickness disruptions (Fox–Romeo grade 2–4) into consideration as these were considered more relevant and more important not to be missed as reconstruction was performed in these cases. Positive and negative likelihood ratios, odds ratios, and Fisher's exact test were calculated for every test. The diagnostic value of all tests combined ("positive" if at least one test was positive, "negative" if all tests were negative) was also calculated. The association between the number of positive tests and the severity of the SSC tear according to the Fox–Romeo classification was assessed using Spearman's rank correlation test. Significance was assumed for $p < 0.05$.

Results

A total of 32 SSC lesions were encountered during arthroscopy accounting for an incidence of 30.2%. According to Fox and Romeo, 13 were grade 1, 13 were grade 2, 2 were grade 3, and 4 were grade 4. An association was observed between a positive test result and the integrity of the SSC tendon for every individual test as well as all tests together ($p < 0.001$, respectively). For all tests combined, the sensitivity was 0.66, specificity 0.82, positive predictive value 0.62, negative predictive value 0.85, and accuracy 0.77. The values for any type of SSC lesion are presented in Table 1. The respective results for Fox–Romeo grade 2–4 tears are presented in Table 2. All tests studied had a specificity of 0.8 or greater for both any type of lesions and grade 2–4 tears. The Bear Hug Test displayed the greatest sensitivity for both any type of lesion (0.52) and grade 2–4 tears (0.72). The greatest accuracy for any kind of SSC lesion was found for the Lift Off Test, while the Belly Off Test reached the greatest accuracy for grade 2–4 tears (Tables 1, 2). A positive correlation was observed for the number of positive tests and the severity of the SSC lesion ($r = 0.532$, $p < 0.001$). In every patient with a Fox–Romeo grade 3 or 4 tear, at least four clinical tests were positive, while not a single clinical test was positive in five cases with Fox–Romeo grade 2 lesions. In cases with grade 2 tears, the Bear Hug

Table 1 Results for the diagnostic properties for tests studied for any type of subscapularis tendon lesion (LR+/LR−: positive/negative likelihood ratio; OR odds ratio; 95% CI 95 per cent confidence interval)

Any SSC lesion	Lift Off Test	IRO Lag Sign	Belly Press Test	Belly Off Sign	Bear Hug Test
Sensitivity	0.35	0.41	0.34	0.31	0.52
Specificity	0.98	0.91	0.96	0.97	0.85
PPV	0.9	0.65	0.79	0.83	0.59
NPV	0.76	0.78	0.77	0.77	0.81
Accuracy	0.78	0.75	0.77	0.77	0.75
LR+	17.5	4.6	8.5	10.3	3.5
LR−	0.7	0.6	0.7	0.7	0.6
OR (95% CI)	8.7 (56.7; 1.3)	2.4 (4.4; 1.3)	3.7 (10.1; 1.3)	4.6 (16.5; 1.3)	2.0 (3.2; 1.2)
p value	<0.001	<0.001	<0.001	<0.001	<0.001

Table 2 Results for the diagnostic properties for tests studied for Fox–Romeo grade 2–4 tendon tears

Fox Romeo 2/3/4	Lift Off Test	IRO Lag Sign	Belly Press Test	Belly Off Sign	Bear Hug Test
Sensitivity	0.32	0.42	0.37	0.37	0.72
Specificity	0.94	0.86	0.92	0.94	0.84
PPV	0.55	0.40	0.50	0.58	0.48
NPV	0.86	0.87	0.87	0.87	0.94
Accuracy	0.83	0.78	0.82	0.84	0.82
LR+	5.3	3.0	4.6	6.2	4.5
LR−	0.7	0.7	0.7	0.7	0.3
OR (95% CI)	1.9 (1.0; 3.7)	1.5 (1.1; 2.2)	1.8 (1.1; 3.0)	2.1 (1.1; 4.2)	1.8 (1.3; 2.6)
p value	0.002	0.002	0.002	0.001	<0.001

Test had a sensitivity of 0.54, while all other tests studied displayed a sensitivity below 0.20.

Discussion

The most important finding of the present study was that despite being highly specific, the sensitivity of clinical tests for SSC tendon tears is limited, with the Bear Hug Test displaying the best sensitivity, especially for lesions to the upper SSC border. Nevertheless, SSC tendon tears may completely escape clinical recognition.

The SSC plays a key role in shoulder biomechanics as it is the only muscle of the rotator cuff that acts as an internal rotator and opposes the external rotation forces of the infraspinatus and teres minor muscles [9, 35]. While an insufficiency of the supraspinatus muscle may be compensated by many patients, insufficiency of the internal and external rotators may not be as well tolerated [33]. This recognition has led to the description of the force couple principle, where the SSC counteracts the two external rotators to provide a stable fulcrum as well as static anterior joint stability [9]. This principle and the disappointing clinical results in the presence of SSC insufficiency have led to the conviction that SSC integrity is a prerequisite to various shoulder reconstruction procedures [20, 29, 31, 36]. Also, numerous reconstruction techniques have been described for SSC insufficiency [13, 17].

In spite of its biomechanical importance, SSC tendon tears may be difficult to diagnose. Nowadays, most patients with rotator cuff-associated problems will receive an MRI. While MRI has a reportedly high accuracy for posterosuperior rotator cuff tears, SSC lesions may be missed rather frequently. In the study by Tung et al., only 31% of arthroscopically confirmed SSC tendon tears were detected on MRI [34]. Adams et al. [2] found comparable numbers (36%). While Pfirrmann et al. [27] found higher sensitivity for MRA compared to MRI, Foad and Wijdicks [17] found a higher sensitivity for native MRI with values comparable to Tung and Adams. Utilizing a systematic approach to the interpretation of the native MRI, Adams et al. [1] reported sensitivity to rise to 0.71, however.

There are contradicting reports for the value of the clinical examination (Table 3). In general, the best results for any clinical test can be found in the report of the first descriptions of the test (e.g. the Lift Off Test or the Bear Hug Test, Table 3) [19]. The results of the present study are compared to results from the literature in Table 3. Yoon et al. [37] published the largest study on the diagnostic validity of four SSC tests including 312 patients. The authors excluded 40 patients with biceps pathology (instability and partial tears). As both lesions are closely related and frequently

Table 3 Overview of results from the literature for the diagnostic value of subscapularis tests (n.r.: not reported. *Modified Belly Press Test)

Test	References	*n*	Sensitivity	Specificity
Lift Off Test	Gerber and Krushell [19]	159	1.00	0.89
	Hertel et al. [22]	100	0.62	1.00
	Barth et al. [5]	68	0.18	1.00
	Bartsch et al. [6]	50	0.40	0.79
	Barth et al. [4]	141	0.74	n.r.
	Yoon et al. [37]	312	0.12	1.00
	Present study	106	0.35	0.98
Internal Rotation Lag Sign	Hertel et al. [22]	100	0.97	0.96
	Bartsch et al. [6]	50	0.71	0.45
	Yoon et al. [37]	312	0.20	0.97
	Present study	106	0.41	0.91
Belly Press Test	Barth et al. [5]	68	0.40	0.98
	Bartsch et al. [6]*	50	0.88	0.68
	Barth et al. [4]	173	0.76	n.r.
	Yoon et al. [37]	312	0.28	0.99
	Present study	106	0.34	0.96
Belly Off Sign	Bartsch et al. [6]	50	0.87	0.91
	Present study	106	0.37	0.97
Bear Hug Test	Barth et al. [4]	68	0.60	0.92
	Barth et al. [4]	164	0.82	n.r.
	Yoon et al. [37]	165	0.19	0.99
	Present study	106	0.52	0.85

encountered accompanying each other, the study population from Yoon et al. may therefore not be representative for all patients with SSC pathology. In the study by Barth et al. [4], three tests were evaluated on a subgroup of patients in their multicenter study. The authors did not report test specificity. Bartsch et al. [6] studied four clinical tests including the Belly Press Test in a modified version, converting the flexion angle of the wrist. The test was considered positive if a side-to-side difference of at least 10° was encountered, introducing inaccuracy due to the possibility of bilateral SSC affection. Their modified Belly Press Test nevertheless was found to have the greatest sensitivity in their study at 88%.

The problem with SSC tears is their definition and recognition, however. Including Fox–Romeo grade 1 lesions will blur the results for any diagnostic test as these types of lesions may not lead to weakness of the SSC muscle. Therefore, lag signs (Internal Rotation Lag Sign or Belly Off Sign) may not be able to detect a type 1 lesion. Nevertheless, type 1 lesions may be of therapeutic importance as they may progress to upper rim tears or indicate subcoracoid impingement or biceps instability [3, 25]. In the current study, an attempt was made to compensate this problem by calculating the results for any kind of lesion as compared to Fox–Romeo grade 2–4 tears.

In the present study, 5 grade 2 tears completely escaped the preoperative clinical examination. Previous studies came to comparable results. In a study from the French Arthroscopy Society by Barth et al. [4], 24% of all cases with SSC tears had negative clinical test results. Fifteen percent were not to be detected by clinical examination in the study by Bartsch et al. [6]. Furthermore, a correlation was found between the number of positive tests and tear severity in the present study. In other words: the bigger the tear, the greater the chance clinical tests will be positive. Barth et al. [4] stratified weakness found upon clinical examination into 3 grades. They described a correlation between the severity of weakness found during the Lift Off, Belly Press, and Bear Hug Tests and the severity of the SSC lesion according to the SFA classification. The weakness of preoperative clinical examination nevertheless appears to be the detection of grade 2 tears. Barth et al. suggested that the Bear Hug Test was especially useful for detecting these upper rim tears. This is supported by the findings of the present study analysing grade 2 tears exclusively. In an electromyographic study, Chao et al. [11] concluded the Bear Hug Test at 45° of flexion to be a valuable diagnostic tool for the upper SSC, while performing the test at 90° would give more information about the lower SSC muscle. Pennock et al. [26] on the other hand could not find a greater activation of superior than inferior SSC fibres using any SSC test.

The limitations of the present study comprise the limited number of high-grade SSC lesions, which nevertheless compare favourably to the studies cited. Furthermore, like previous studies, reliability of the clinical tests was not studied. Clinical examination will, however, always be subject to examiner, patient, and time-dependent variations. While the battery of clinical tests was felt to be comprehensive, newer diagnostic tests, e.g. the Belly Press Test in the supine position as proposed by Takeda et al., could not be included into the present study as they were published after the beginning of the conduction of the study [24, 32]. Also, recognizing SSC tears has been shown to be a challenge. Reaching the SSC footprint via traditional, open lateral approaches to the posterosuperior rotator cuff posed a surgical challenge. Exposure of the tendon attachment areas has become far more straightforward using arthroscopic approaches. While the footprint of the supra- and infraspinatus is readily visible via a standard posterior viewing portal, visualization of the SSC footprint is obstructed by the humeral head [12, 28]. Several techniques have been advocated to enhance exposure of the SSC footprint, e.g. utilization of a 70° arthroscope or using an assistant for the posterior lever push manoeuvre [8, 23]. Switching arthroscopes will be rather difficult if standard cameras with sterile drapes are used as opposed to camera heads that can be sterilized. The authors of the present study therefore used to switch the camera to an anterosuperolateral portal to visualize the SSC footprint, while they found exposure to be equally good using a position of slight forward flexion and internal rotation with a slightly higher standard posterior viewing portal. Posterior pressure applied to the proximal portion of the humerus is added if necessary. With this technique, the authors have been able to routinely expose the entire SSC footprint (Figs. 1, 2).

Conclusion

Nevertheless, as shown by previous publications, the present study found the Bear Hug Test to have the greatest sensitivity for SSC lesions and would therefore recommend using this test in everyday practice. Using more than one test will improve overall sensitivity. Furthermore, if more than one test is found to be positive, suspicion for a higher-grade SSC tear may be raised. Nevertheless, even in the presence of a negative clinical examination, a high index of suspicion has to be maintained in order not to miss SSC tears.

Compliance with ethical standards

Conflict of interest No conflict of interest related to the present study has to be reported for any of the authors.

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Ethical approval IRB approval was obtained for this study by the Ethics Committee of the University of Ulm.

Informed consent Informed consent has been obtained from all study participants.

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