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SHOULDER

# Diagnostic values of clinical tests for subscapularis lesions

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**Abstract** Subscapularis (SSC) lesions are often underdiagnosed in the clinical routine. This study establishes and compares the diagnostic values of various clinical signs and diagnostic tests for lesions of the SSC tendon. Fifty consecutive patients who were scheduled for an arthroscopic subacromial or rotator cuff procedure were clinically evaluated using the lift-off test (LOT), the internal rotation lag sign (IRLS), the modified belly-press test (BPT) and the belly-off sign (BOS) preoperatively. A modified classification system according to Fox et al. (Type I–IV) was used to classify the SSC lesion during diagnostic arthroscopy. SSC tendon tears occured with a prevalence of 30% (15 of 50). Five type I, six type II, three type IIIa and one type IIIb tears according to the modified classification system were found. Fifteen percent of the SSC tears were not predicted preoperatively by using all of the tests. In six cases (12%), the LOT and the IRLS could not be performed due to a painful restricted range of motion. The modified BPT and the BOS showed the greatest sensitivity (88 and 87%) followed by the IRLS (71%) and the LOT (40%). The BOS had the greatest specificity (91%) followed by the LOT (79%), mod. BPT (68%) and IRLS (45%). The BOS had the highest overall accuracy (90%). With the BOS and the modified BPT in particular, upper SSC lesions (type I and II) could be diagnosed preoperatively. A detailed physical exam using the currently available SSC tests allows diagnosing SSC lesions in the majority of cases preoperatively. However, some tears could not be predicted by preoperative assessment using all the tests.

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## Introduction

Although lesions of the subscapularis (SSC) tendon appear to be less frequent than those of the superior or postero-superior parts of the rotator cuff, the morbidity associated makes it necessary for the clinician to be aware and look for possible SSC injury during a physical exam of the shoulder [5, 9, 12, 21].

The SSC muscle acts as a strong internal rotator and dynamic anterior stabilizer of the glenohumeral joint, constituting the anterior part of the transverse force couple [5, 6–18, 23, 27, 28]. Being also a depressor of the humeral head, its rupture may result in decentralisation of the humeral head leading to impaired function of the glenohumeral joint. The prevalence of lesions of the SSC tendon reported in the literature ranges between 3.5 and 29.4% [2, 7, 11].

A variety of clinical signs and diagnostic tests have been published to evaluate the integrity of the musculotendinous unit of the SSC. The first of these was the lift-off test (LOT) by Gerber and Krushell [13] followed by the internal rotation lag sign (IRLS) published by Hertel et al. [15]. The belly-press test (BPT) described by Gerber et al. was modified by other authors who called it the Napoleon sign or the modified belly-press test [1, 12, 25, 26]. Scheibel et al. [24] later described the belly-off sign (BOS), and more recently the bear-hug test was published by Barth et al. [2].

Even with this multiplicity of tests, SSC lesions are still underdiagnosed in the clinical routine. This might be caused by the different diagnostic values of each particular test or by the isolated use of one of the tests described to detect the lesion present. The goal of this study is to establish and compare the diagnostic values of different clinical signs and diagnostic tests for SSC lesions. The hypothesis is that a well-considered use and combination of different clinical diagnostic maneuvers may increase their diagnostic performance.

## Methods

Fifty consecutive patients suffering from subacromial and/or glenohumeral impingement syndrome were scheduled for an arthroscopic procedure and included into this prospective descriptive study. Exclusion criteria were patients with calcifying tendinitis, shoulder stiffness, instability, osteoarthritis, previous surgery, and on the contralateral side, suspicion or evidence of rotator cuff tear and/or stiffness.

### Functional evaluation

Each patient underwent a complete physical examination of both shoulders by the senior author. The function of the SSC musculotendinous unit was assessed using the following four tests:

The LOT was performed by placing the hand of the affected arm on the back at the midlumbar region and by asking the patient to rotate the arm internally and to lift the hand posteriorly off the back (Fig. 1a, b) [13]. The test was considered positive if the patient was unable to do so.

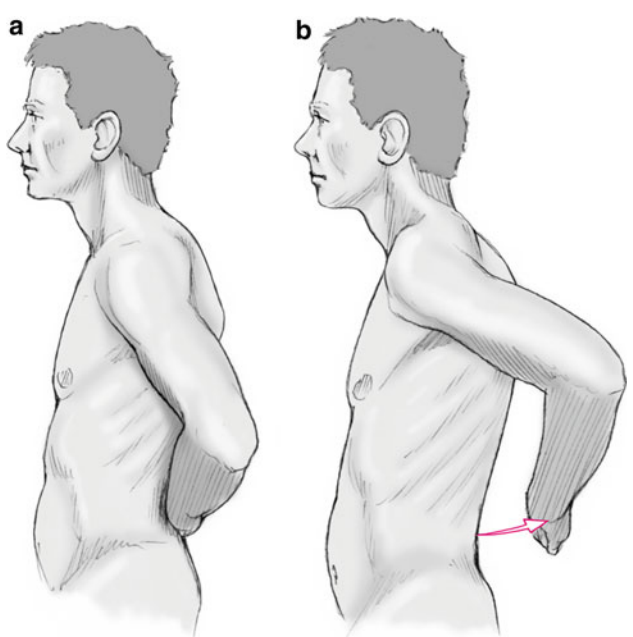


**Fig. 1** **a**, **b** Lift-off test (LOT) [23]

The presence of an IRLS was evaluated from the same starting position [15]. The affected arm of the patient was held by the examiner at almost maximum internal rotation. The back of the hand was passively lifted away from the body until almost full internal rotation was reached. The patient was then asked to actively maintain this position. The test was considered positive if the patient was unable to maintain this position and the hand dropped back to the lumbar region (Fig. 2a, b).

The BPT was performed with slight modification according to Scheibel et al. [25]. With the hand flat on the abdomen and the elbow close to the body, the patient was told to bring the elbow forward and straighten the wrist. The final flexion position or belly-press angle of the wrist was then measured by a goniometer as described for the Napoleon sign [5] (Fig. 3a, b). The test was considered positive when the measured belly-press angle at the wrist showed a side-to-side difference of at least 10°.

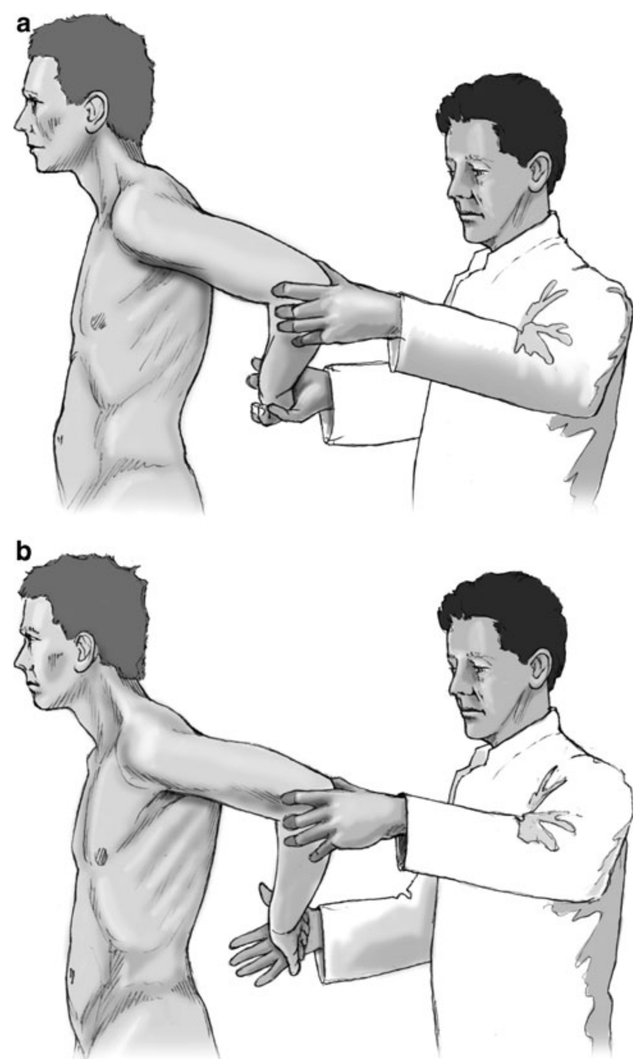


**Fig. 2** **a**, **b** Internal rotation lag sign (IRLS) [23]

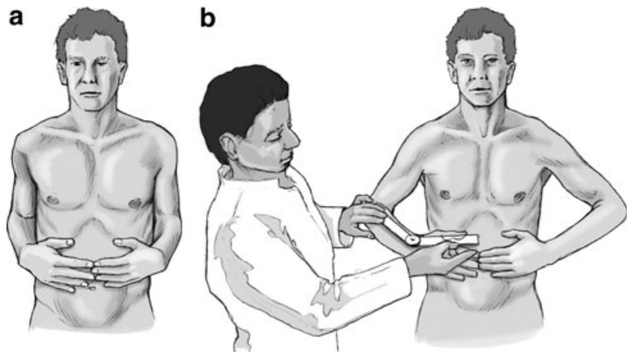


**Fig. 3** **a**, **b** Modified belly-press test (Mod. BPT) [23]

With the BOS, the arm of the patient was passively brought into flexion and maximum internal rotation with the elbow 90° flexed [24]. The elbow of the patient was supported by one hand of the examiner, while the other hand brought the arm into maximum internal rotation placing the palm of the hand on the abdomen. The patient was then asked to keep the wrist straight and actively maintain the position of internal rotation as the examiner releases the wrist. If the patient could not maintain that position, the wrist was flexed or lag occurred and the hand is lifted off the abdomen resulting in the BOS (Fig. 4a, b).

## Diagnostic arthroscopy

The risks and benefits of each scheduled procedure were explained to the patients who were also informed that their data could be used for research. All patients gave written informed consent before undergoing the procedure. General anesthesia was administered and the patient placed in the beach-chair position. A complete arthroscopic exploration of the glenohumeral joint and the subacromial space was performed through a standard posterior portal. To evaluate and classify the lesions of the SSC, a modification of the classification by Fox et al. [10] was used. In this modified classification system, a type I lesion represents a horizontal split tear or a partial tear of the articular side of the upper SSC tendon. A type II lesion is a complete tear of the upper 25% of the tendon. Type III lesions were subdivided into IIIa and IIIb with IIIa representing a complete tear of the upper 50% and IIIb representing a complete tear of the tendinous part of the musculotendinous insertion. Type IV equals a complete rupture of the SSC tendon.

Other pathologies like subacromial impingement, acromioclavicular joint arthritis, supraspinatus and infraspinatus lesions, SLAP lesions, pathologies of the tendon of the long head of the biceps and the pulley-system and Bankart lesions were recorded as well, to assess the specificity of the clinical tests.

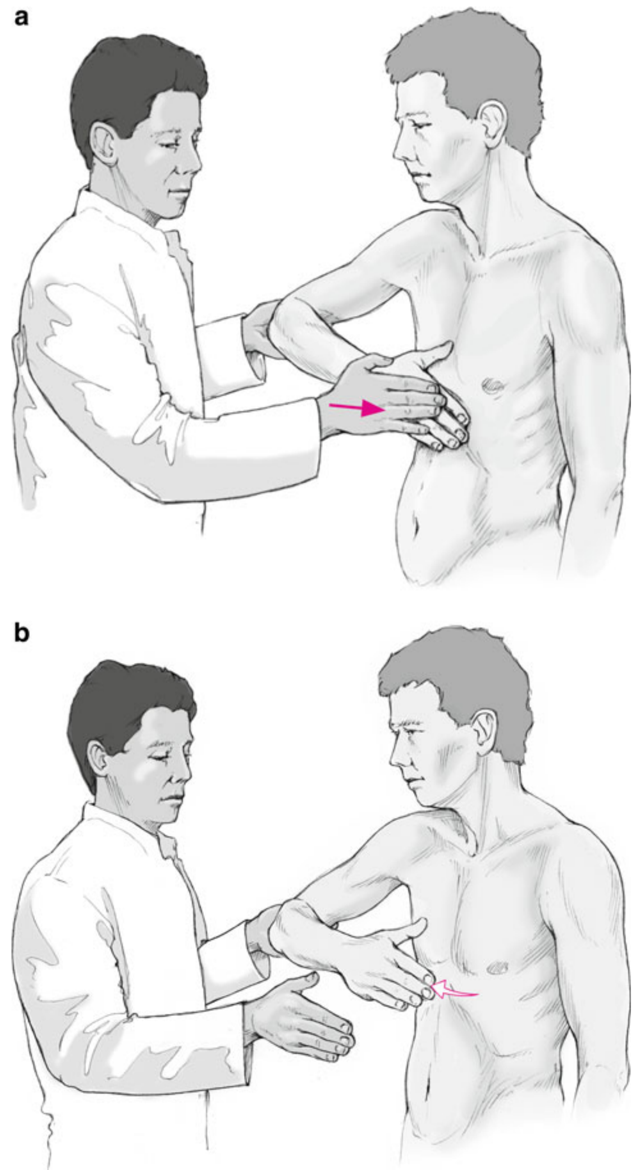


**Fig. 4** **a**, **b** Belly-off sign (BOS) [23]

## Statistical analysis

For the four tests, the numbers of true-positive, true-negative, false-positive and false-negative results were used to determine the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of each test.

# Results

Fifty consecutive patients including 17 (34%) women and 33 (66%) men with a median age of 58 (standard deviation 11.6 years) were evaluated. The dominant side was involved in 31 cases (62%). Of the 28 cases of rotator cuff tears found at diagnostic arthroscopy, 15 were isolated or combined lesions of the SSC (54%). The overall prevalence of SSC tears was 30% in this study. Details of arthroscopic findings are shown in Table 1. Using the modified classification according to Fox et al. [10], the types of SSC lesions found during arthroscopy are shown in Table 2.

Fifteen percent of all SSC lesions could not be diagnosed preoperatively. Due to pain or a painful restricted range of motion, the LOT and the IRLS could not be performed in six cases.

The modified BPT and the BOS showed the greatest sensitivity (88 and 87%) followed by the IRLS (71%) and the LOT (40%). The BOS had the greatest specificity (91%) followed by the LOT (79%), modified BPT (68%) and IRLS (45%). The BOS had the highest overall accuracy (90%). With the BOS and the modified BPT in particular, upper SSC lesions (type I and II) could be diagnosed preoperatively. Details are shown in Table 3.

**Table 1** Findings on diagnostic arthroscopy

| | |
|---|---|
| Rotator cuff tears | 56% (28/50) |
| Combined SSC lesions | 18% (9/50) |
| Isolated SSC lesions | 12% (6/50) |
| Biceps tendon/pulley pathologies | 28% (14/50) |
| Subacromial impingement | 68% (34/50) |
| AC joint arthritis | 40% (20/50) |
| SLAP lesions | 8% (4/50) |

**Table 2** Types of SSC lesions according to a modified classification system based on Fox et al. [9]

| Type of SSC lesions | |
|---|---|
| Type I | 33% (5/15) |
| Type II | 40% (6/15) |
| Type IIIa | 20% (3/15) |
| Type IIIb | 6% (1/15) |
| Type IV | 0% (0/15) |

**Table 3** Results of clinical evaluation

| | LOT | IRLS | Mod. BPT | BOS |
|---|---|---|---|---|
| True-positive results | 6 | 10 | 14 | 13 |
| True-negative results | 23 | 18 | 23 | 32 |
| False-positive results | 6 | 12 | 11 | 3 |
| False-negative results | 9 | 4 | 2 | 2 |
| Sensitivity (%) | 40 | 71 | 80 | 86 |
| Specificity (%) | 79 | 60 | 88 | 91 |
| PPV (%) | 50 | 45 | 75 | 81 |
| NPV (%) | 71 | 81 | 91 | 94 |
| Accuracy (%) | 66 | 63 | 86 | 90 |

Six patients could neither do the LOT nor the IRLS

**Table 4** Positive test results according to the type of SSC lesion

| | LOT | IRLT | NT | BOT |
|---|---|---|---|---|
| Type I (5/15) | 0 | 0 | 2 | 2 |
| Type II (6/15) | 3 | 4 | 6 | 6 |
| Type IIIa (3/15) | 2 | 3 | 3 | 3 |
| Type IIIb (1/15) | 1 | 1 | 1 | 1 |

The correlation between the preoperative clinical findings and the type of SSC lesion found at arthroscopy are shown in Table 4.

## Discussion

The most important finding of the present study is the different diagnostic performance of the investigated clinical signs and diagnostic test for SSC lesions depending on the size of the SSC tear.

Different studies have shown that SSC tendon tears are more than just occasional lesions, however, isolated tears are still uncommon [4, 12]. Over the years, reports have shown a consistent increase in the prevalence rates [2, 4, 7, 11]. The prevalence of SSC tears in this present work is similar to those of other recently published arthroscopic studies [4, 28]. Earlier reports were based on findings at open surgical exploration, which makes detection of tears located on the articular side of the SSC difficult [7, 8, 11]. This might explain the much higher prevalence rates obtained from arthroscopic and cadaver studies [2–4, 22].

The morbidity associated with this injury makes it pertinent for the clinician to consider the possibility of SSC injury in evaluating any patient with an anterior shoulder pain or injury. It has been shown that delay in treatment of this lesion results in fatty degeneration and atrophy of the muscle, which worsen the outcome after surgery [12, 14].

The specific function and relative contribution of the SSC muscle to shoulder motions remain unclear. Several EMG studies have demonstrated conflicting findings regarding its function [18, 29]. Moreover, several investigators have shown that the upper and lower portions of the SSC muscle are independently innervated and activated [16, 17, 19]. In addition, partial ruptures of the upper portion of the SSC muscle, the so-called "hidden lesion," are increasingly recognized as a source of shoulder pain and dysfunction [30].

This study compared the ability of the various clinical tests at detecting SSC tears of different severities. Type I and type II lesions were the commonest type in this series. It was observed that as the severity of the SSC tendon injury increased, so did the chances of the clinical tests at identifying these cases preoperatively as shown in Table 4.

The modified BPT and BOS detected all the lesions type II and above, whereas the IRLS only identified all the type IIIa and IIIb lesions. The fifteen percent of lesions missed preoperatively by all four clinical tests is an improvement on the 40% missed in a similar clinical and arthroscopic study by Barth et al. [2].

The modified BPT and the BOS consistently showed better results in terms of the sensitivity, specificity, positive and negative predictive values as well as accuracy, compared to the other two tests. Moreover, when compared with the respective contralateral shoulders, the BOS and the modified BPT enabled a preoperative diagnosis of upper SSC lesions (Type I and II) where the LOT and the IRLS still remained negative.

The difficulty assessing the LOT and IRLS in patients with shoulder pain or stiffness is recognized in the literature. The LOT has been reported to be highly sensitive for major SSC tears although it is also notorious for missing partial tears [2, 12, 15, 20, 23, 28]. This might be due to the fact that the LOT activates more the lower muscle fibers compared to the BPT that activates more the upper muscle fibers [28].

The findings from our clinical tests are comparable to those of Barth et al. [2] who found the highest specificity in the BPT and Napoleon test while the bear-hug test demonstrated the highest sensitivity. The bear-hug was first described in that paper and was not tested in this present study since we were not aware of the sign at the time we performed our study.

The explanation for the discrepancies in results obtained from other studies of this nature is not clear. Especially, in the LOT there are actually various modifications to the test, each of which evaluates different parts of the SSC and the rotator cuff thereby producing varying results in the same shoulder. This study employed the maximum extension variant of the LOT. This also could account for the inconsistencies with other reports.

Furthermore, Stefko et al. [27] have shown remarkable activity of other potential internal rotators (latissimus dorsi, teres major and pectoralis major) and extensors (triceps and posterior deltoid) during the LOT. These findings may also be true for the IRLS. In contrast, less activity of other internal rotators may be associated with the modified BPT and the BOS. Tokish et al. [28] suggested by an electromyographic study that bringing the elbow more anteriorly increases the activity of the upper fibers of the SSC. These findings may explain the superior results of the modified BPT and the BOS especially in detecting partial tears of the upper portion of the SSC tendon. The present results found the modified BPT and BOS particularly reliable in identifying tears of at least 25% or more of the SSC, whereas the IRLT detected all tears at least 50% of the upper SSC.

This study has certain limitations. First of all, a highly selected patient population including patients with classic symptoms for subacromial or glenohumeral impingement syndrome with or without rotator cuff tears was evaluated. Regarding the exclusion criteria of this study, these are all factors that would potentially negatively influence the test results. Including those factors would certainly decrease their diagnostic values. Another weakness of the study is that it does not include any data concerning intra- or interobserver reliability. This of course would have increased the quality of this study. However, all have been performed by a single examiner in a standardized matter. Another limitation is that we did not graduate the results of the LOT and the IRLS as previously described, which may have increased their diagnostic performance. Finally, as already mentioned, the bear-hug test as described by Barth et al. [10] is not included in this evaluation.

## Conclusion

A detailed physical exam using the currently available SSC tests allows diagnosing SSC lesions in the majority of cases preoperatively. A combination of different clinical diagnostic maneuvers increases their diagnostic performance. However, some tears could not be predicted by preoperative assessment using all the tests.

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