The Bear-Hug Test: A New and Sensitive Test for Diagnosing a Subscapularis Tear

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Purpose: It was our intent to devise a new clinical test that would more accurately diagnose subscapularis tears than the current clinical tests. This new test is called the bear-hug test. The purpose of this study was to assess the bear-hug test and compare it with the current tests of subscapularis function (lift-off, belly-press, and Napoleon tests). **Methods:** Between January 2004 and March 2004, 68 consecutive patients scheduled for an arthroscopic procedure were evaluated preoperatively; the preoperative clinical examination findings were then correlated with arthroscopic findings. Lift-off, belly-press, Napoleon, and bear-hug tests were included in the examination. Furthermore, for the belly-press and bear-hug tests, the strength was precisely quantified by means of an electronic digital tensiometer (Kern HBC). Diagnostic arthroscopy was the reference that determined the actual pathologic lesions. **Results:** Subscapularis tears occurred with a prevalence rate of 29.4%. Of the subscapularis tears, 40% were not predicted by preoperative assessment by use of all of the tests. The bear-hug test was found to be the most sensitive test (60%) of all of those studied (belly-press test, 40%; Napoleon test, 25%; and lift-off test, 17.6%). In contrast, all 4 tests had a high specificity (lift-off test, 100%; Napoleon test, 97.9%; belly-press test, 97.9%; and bear-hug test, 91.7%). No statistically significant difference was found between the area under the receiver operating characteristic curve of the bear-hug test and that of the belly-press test in diagnosing a torn subscapularis. However, the areas under the receiver operating characteristic curve for both the bear-hug test and the belly-press test were significantly greater than those for the lift-off and Napoleon tests ($P < .05$). Positive bear-hug and belly-press tests suggest a tear of at least 30% of the subscapularis, whereas a positive Napoleon test indicates that greater than 50% of the subscapularis is torn. Furthermore, a positive lift-off test is not found until at least 75% of the subscapularis is torn. **Conclusions:** The bear-hug test optimizes the chance of detecting a tear of the upper part of the subscapularis tendon. Moreover, because the bear-hug test represents the most sensitive test, it can be considered to be the most likely clinical test to alert the surgeon to a possible subscapularis tear. Performing all of the subscapularis tests is useful in predicting the size of the tear. **Level of Evidence:** Level I, diagnostic study: testing of previously developed criteria in a series of consecutive patients with arthroscopy used as the criterion standard. **Key Words:** Bear-hug test—Subscapularis—Rotator cuff tear—Shoulder—Rotator cuff tendon.

Despite the importance of the subscapularis as a major muscle of the rotator cuff, there are few clinical tests that can detect tears or dysfunction of this muscle-tendon unit. Gerber and colleagues described the lift-off test in 1991[1] and the belly-press test in 1996.[2] The Napoleon test, first described by Schwamborn and Imhoff[3] and further refined by Burkhart and Tehrany,[4] is a graded test related to the percentage of the tendon that is torn.

Tokish et al.,[5] in an electromyographic study, showed that the belly-press test activated the upper subscapularis muscle significantly more than the lift-off test whereas the lift-off test caused greater activation of the lower

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subscapularis muscle than the belly-press test. On the basis of this study, one would assume that recruitment and firing of upper subscapularis muscle fibers would be increased by active internal rotation of the shoulder with the elbow in a progressively more anterior position. By changing the arm from the position of the lift-off test (elbow posterior to the midline) to the position of the belly-press test (elbow anterior to the midline), recruitment of upper subscapularis fibers was increased. Even so, the 2 senior authors (S.S.B. and J.F.B.) noted arthroscopically that many tears of the subscapularis were not detected preoperatively by these 2 standard tests. They developed a new test to more accurately evaluate the upper part of the subscapularis tendon by internally rotating the shoulder while the elbow is held as far anterior to the body as possible.

This new test is called the bear-hug test. It uses resisted internal rotation as the palm is held on the opposite shoulder while the elbow is held in a position of maximal anterior translation (Fig 1).

One of the senior authors (S.S.B.) has shown in a previous study how important the subscapularis is for normal function of the shoulder.[4] It naturally follows that restoration of the subscapularis and its moment as a means of balancing the transverse plane force couple is essential in providing a stable fulcrum for glenohumeral motion.[6] Considering the importance of this muscle, it would be advantageous to the surgeon to be able to diagnose a subscapularis tear clinically before surgery is performed for a rotator cuff tear.

The purpose of this study was to describe the bear-hug test and to compare it with the other standard tests of subscapularis function (lift-off, belly-press, and Napoleon tests). Our hypothesis was that the bear-hug test would be the most accurate of all tests for detecting relatively small tears of the upper subscapularis.

METHODS

The junior author (J.R.H.B.) undertook a prospective study involving all of the patients scheduled to undergo an arthroscopic procedure by one of the senior authors (S.S.B.) during a period of 3 months (from January 2004 to March 2004). Previously operative shoulders and stiff shoulders scheduled for a capsular release and lysis of adhesions were excluded from the study group. After exclusion of these patients, the study group comprised 68 shoulders. The mean age of the patients was 45.1 ± 14.7 years (median, 47 years; range, 16 to 76 years). There were 49 male and 19 female patients, and there were 42 right and 26 left shoulders. The dominant side was involved in 43 cases.

FIGURE 1. Starting position for performing bear-hug test. The palm of the involved side is placed on the opposite shoulder with the fingers extended, and the elbow is positioned anterior to the body.

Four tests were addressed to assess the function of the subscapularis: the lift-off test, the belly-press test, the Napoleon test, and the bear-hug test. The lift-off test, described by Gerber and Krushell[1] in 1991, was performed by placing the hand of the affected arm on the back (at the position of the midlumbar spine) and asking the patient to internally rotate the arm to lift the hand posteriorly off of the back. The test was considered positive if the patient was unable to lift the arm posteriorly off of the back or if he or she performed the lifting maneuver by extending the elbow or the shoulder. The belly-press test, described by Gerber et al.[2] in 1996, was performed with the arm at the side and the elbow flexed to 90°, by having the patient press the palm into his or her abdomen by internally rotating the shoulder. A resisted active internal rotation against the patient's belly was assessed and quantified by means of a digital tensiometer (Kern HBC; Kern & Sohn, Balingen-Frommern, Germany). The test was considered positive (1) if the patient showed a weakness in comparison to the opposite shoulder or (2) if he or she pushed the hand against the belly by means of elbow extension or shoulder extension (indicating an inability to achieve a force against the belly by means of active internal rotation produced by the subscapularis). The Napoleon test, a variation of the belly-press test, was performed by placing the hand on the belly in the same position in which Napoleon Bonaparte held his hand for portraits. We graded the

Napoleon test as negative (or normal) if the patient was able to push the hand against the stomach with the wrist straight, as positive if the wrist was flexed to 90° to push against the stomach, and as intermediate if the wrist was flexed from 30° to 60° to accomplish a belly press. In an attempt to simplify our results, in this study an intermediate Napoleon test was considered positive, because an intermediate test has been correlated with partial tears of the subscapularis.[4] The bear-hug test was performed with the palm of the involved side placed on the opposite shoulder and fingers extended (so that the patient could not resist by grabbing the shoulder) and the elbow positioned anterior to the body (Fig 1). The patient was then asked to hold that position (resisted internal rotation) as the physician tried to pull the patient's hand from the shoulder with an external rotation force applied perpendicular to the forearm (Fig 2). The test was considered positive if the patient could not hold the hand against the shoulder or if he or she showed weakness of resisted internal rotation of greater than 20% compared with the opposite side. If the strength was comparable to that of the opposite side, without any pain, the test was negative. A painful bear-hug test without weakness was recorded as a separate category but was presumed to be negative.

Strength was measured for the belly-press test and the bear-hug test by use of an electronic digital tensiometer (Kern HBC, version 1.0 01/02; Kern & Sohn). A resisted force was applied to the distal forearm, perpendicular to the plane of the forearm, by means of a padded sling attached to the tensiometer. The patient was asked to maintain maximal resistance against the tensiometer for 5 seconds to obtain a static result (in kilograms). Then, each test was performed on the opposite (normal) side for a comparison of side-to-side results.

At the time of surgery, general anesthesia was administered and the patient was placed in the lateral decubitus position. A warming blanket was applied in each case to prevent hypothermia. Five to ten pounds of balanced suspension was used with the arm in 20° to 30° of abduction and 20° of forward flexion (Star Sleeve Traction System; Arthrex, Naples, FL). The senior author (S.S.B.) performed a complete arthroscopic exploration of the glenohumeral joint and the subacromial space through a standard posterior portal, with an arthroscopic pump maintaining pressure at 60 mm Hg. Evaluation of the subscapularis was carried out with both a 30° arthroscope and a 70° arthroscope. With manipulation of the arm into abduction and internal rotation, the subscapularis insertion and its footprint were easily visualized.[7] These maneuvers lift the fibers of the intact portion of the subscapularis away from the footprint, allowing excellent visualization of its insertion. An area of "bare footprint" indicated a partial or complete subscapularis tear. Subscapularis tear size was assessed by measuring the superior-to-inferior length of the bare footprint as an indicator of how much tendon was torn. This was then converted to a percentage of the complete insertion length by dividing it by 2.5 cm, the mean superior-to-inferior length of the subscapularis footprint (Tehrany et al., unpublished data, December 2000). For example, if

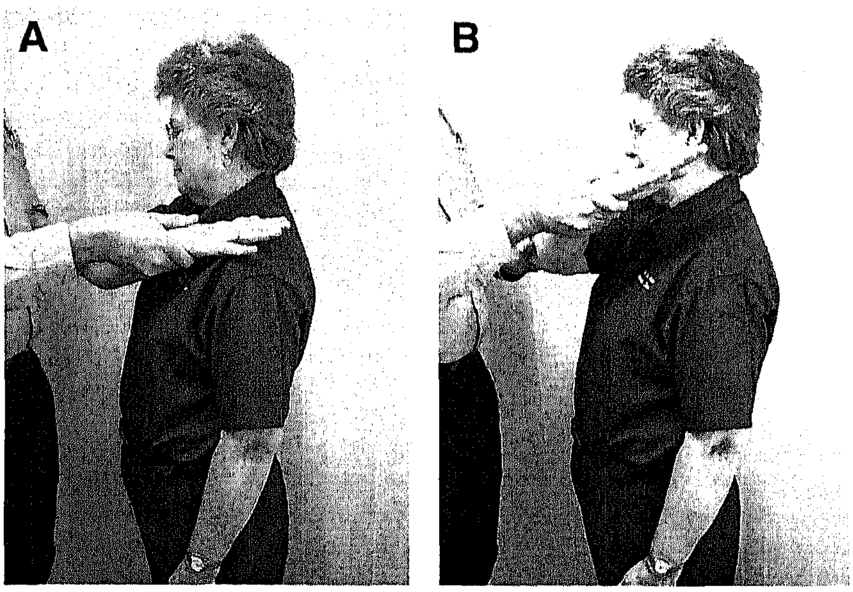

FIGURE 2. Bear-hug test. (A) The patient tries to hold the starting position by means of resisted internal rotation as the examiner tries to pull the patient's hand from the shoulder with an external rotation force applied perpendicular to the forearm. (B) A positive bear-hug test results when the patient cannot hold the hand against the shoulder as the examiner applies an external rotation force.

TABLE 1. *Results and Diagnostic Quality of Clinical Tests*

	Bear-Hug Test	Belly-Press Test	Lift-Off Test	Napoleon Test
True-positive tests	12	8	3	5
True-negative tests	44	47	46	47
False-positive tests	4	1	0	1
False-negative tests	8	12	14	15
Sensitivity (%)	60	40	17.6	25
Specificity (%)	91.7	97.9	100	97.9
PPV (%)	75	88.9	100	83.3
NPV (%)	84.6	79.7	76.7	75.8
Accuracy (%)	82.4	80.9	77.8	76.5
Area under ROC curve	0.758	0.715	0.588	0.615

the upper 1 cm of the footprint was bare, this represented a 40% tear (1.0/2.5) of the subscapularis.

Subacromial impingement, acromioclavicular joint derangement, supraspinatus lesions, infraspinatus lesions, SLAP lesions, biceps disorders, and Bankart lesions were recorded as well, to assess the specificity of the tests.

Diagnostic arthroscopy was critical for evaluation of the subscapularis and for quantification of the percentage that was torn. For the 4 tests, the number of true-positive tests, the number of true-negative tests, the number of false-positive tests, and the number of false-negative tests were calculated to determine the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of each test. McNemar tests were performed to compare the rates of sensitivity. Receiver operating characteristic (ROC) curves, which are graphic representations of corresponding sensitivity and specificity values, were plotted, and χ^2 tests were performed to determine whether the areas under the curves were greater than 0.50 (no precision) and also to ascertain the relative precision of the diagnostic tests. After the analysis was performed for the complete set of patients, the analysis was repeated to determine which test was more precise in detecting tears of less than 100% and less than 75% of the subscapularis. Finally, comparisons of the relative strength (in kilograms) of the operative and opposite shoulders measured by the tensiometer during the bear-hug and belly-press tests were performed by use of repeated-measures analyses of variance (ANOVAs). For all statistical tests, $P < .05$ was considered significant. The statistical analyses were performed with SPSS software (SPSS, Chicago, IL).

RESULTS

During diagnostic arthroscopy, we found 34 torn rotator cuffs, including 20 subscapularis tears (5 isolated subscapularis tears), 19 SLAP lesions, 4 anterior Bankart lesions, 4 posterior Bankart lesions, and 19 cases of pathologic biceps (13 requiring biceps tenodesis, 3 requiring biceps tenotomy, 1 requiring biceps debridement, and 2 that had chronic complete ruptures). The prevalence rate of subscapularis tears in our study group was 29.4% (20 of 68). A pathologic biceps was found in 14 patients (70%) with subscapularis tears (9 treated cases with biceps tenodesis, 3 treated cases with biceps tenotomy, and 2 spontaneous ruptures).

The bear-hug test missed 8 torn subscapularis tendons (8 false-negatives), whereas the belly-press test missed 12 (12 false-negatives) (Table 1). In contrast, the bear-hug test yielded 4 false-positive tests (i.e., 4 patients with a positive bear-hug test but a normal subscapularis tendon on arthroscopic evaluation), and the belly-press test yielded 1 false-positive test. The 4 patients with false-positive bear-hug tests had the following pathologies discovered at arthroscopy: a supraspinatus tear associated with a SLAP lesion and a posterior Bankart lesion, a supraspinatus tear with a massive bone cyst on the greater tuberosity, supraspinatus and infraspinatus tears associated with a pathologic biceps, and a supraspinatus tear.

The lift-off test yielded 14 false-negatives and no false-positives. The Napoleon test yielded 15 false-negatives and 1 false-positive (Table 1). One of the cases with a false-positive bear-hug test initially had a negative bear-hug test on her examination in the office. However, she reinjured that shoulder in an accident 2 days before surgery and then demonstrated a weak painful shoulder with a positive bear-hug test on physical examination performed immediately before

TABLE 2. *Sensitivity, Specificity, PPV, and NPV of Each Test*

	Bear-Hug Test	Belly-Press Test	Lift-Off Test	Napoleon Test
Sensitivity (%)	60	40	17.6	25
Specificity (%)	91.7	97.9	100	97.9
PPV (%)	75	88.9	100	83.3
NPV (%)	84.6	79.7	76.7	75.8

surgery. In retrospect, her false-positive bear-hug test was probably a result of the acute injury that occurred just before surgery.

Sensitivity

The sensitivity was 60% for the bear-hug test, 40% for the belly-press test, 17.6% for the lift-off test, and 25% for the Napoleon test (Table 2). The sensitivity for the bear-hug test was significantly greater than that for the lift-off ($P < .035$) and Napoleon ($P < .020$) tests but not for the belly-press test ($P > .10$). A power analysis based on the sample results suggested that a 50% increase in the sample size, resulting in at least 10 additional cases with subscapularis tears, would be sufficient to detect a significant difference in the sensitivities of the bear-hug and belly-press tests by the McNemar test at the .05 level with a power of 80%.

Specificity

The specificity was 91.7% for the bear-hug test, 97.9% for the belly-press test, 100% for the lift-off test, and 97.9% for the Napoleon test.

Accuracy

The accuracy was 82.4% for the bear-hug test, 80.9% for the belly-press test, 77.8% for the lift-off test, and 76.5% for the Napoleon test.

PPV

The PPV was 75% for the bear-hug test, 88.9% for the belly-press test, 100% for the lift-off test, and 83.3% for the Napoleon test.

NPV

The NPV was 84.6% for the bear-hug test, 79.7% for the belly-press test, 76.7% for the lift-off test, and 75.8% for the Napoleon test.

Area Under ROC Curve

The area under the ROC curve was 0.758 ($P <$ .001) for the bear-hug test, 0.715 ($P < .010$) for the belly-press test, 0.588 ($P > .25$) for the lift-off test, and 0.615 ($P > .10$) for the Napoleon test. When compared directly, the areas under the ROC curves for the bear-hug and belly-press tests were not significantly different ($P > .30$), but for both the bear-hug ($P < 40$) and belly-press ($P < .050$) tests, the areas under the ROC curves were significantly greater than those for the lift-off and Napoleon tests.

Tears of Less Than 100% of Subscapularis

After exclusion of 3 patients with 100% tears, each of whom was correctly classified by the bear-hug and belly-press tests, corresponding reductions in sensitivity, PPV, accuracy, and area under the ROC curve were noted for the two tests. The bear-hug test had a sensitivity of 52.9%, PPV of 69.2%, accuracy of 81.5%, and area of 0.723 ($P < .010$). The belly-press test had a sensitivity of 29.4%, PPV of 83.3%, accuracy of 80%, and area of 0.637 ($P > .09$). However, the areas ($P > .10$) and sensitivities ($P > .10$) were not significantly different.

Tears of Less Than 75% of Subscapularis

After exclusion of an additional 3 patients with 75% tears, 2 of whom were correctly classified by the bear-hug and belly-press tests, corresponding reductions in sensitivity, PPV, and area under the ROC curve were noted for the two tests. The bear-hug test had a sensitivity of 50.0%, PPV of 63.6%, and area of 0.708 ($P < .020$). The belly-press test had a sensitivity of 21.4%, PPV of 75.0%, and area of 0.597 ($P > .25$). However, the areas ($P > .08$) and sensitivities ($P >$ .10) were not significantly different.

Strength Measured With Tensiometer for Bear-Hug Test

In all patients, we measured a mean strength of 9.6 ± 3.9 kg (median, 10 kg; range, 1 to 17 kg) on the involved operative side and a mean strength of 11.6 ± 3.4 kg (median, 12 kg; range, 4 to 18 kg) on the opposite side (Table 3). In the 20 patients with a torn subscapularis tendon, we measured a mean strength of 8.1 ± 4.2 kg (median, 8.5 kg; range, 1 to 16 kg) on the involved operative side and a mean strength of 11.4 ± 3.6 kg (median, 11.5 kg; range, 4 to 18 kg) on the opposite side. In the 48 patients without a torn subscapularis tendon, we measured a mean strength of

10.3 ± 3.6 kg (median, 10 kg; range, 3 to 17 kg) on the involved operative side and a mean strength of 11.6 ± 3.3 kg (median, 12 kg; range, 5 to 8 kg) on the opposite side.

Strength Measured With Tensiometer for Belly-Press Test

In all patients, we measured a mean strength of 9.9 ± 4.2 kg (median, 10 kg; range, 1 to 18 kg) on the involved operative side and a mean strength of 11.8 ± 3.6 kg (median, 11 kg; range, 4 to 18 kg) on the opposite side. In the 20 patients with a torn subscapularis tendon, we measured a mean strength of 7.9 ± 4.2 kg (median, 7.5 kg; range, 1 to 16 kg) on the involved operative side and a mean strength of 11.4 ± 3.7 kg (median, 11.5 kg; range, 4 to 18 kg) on the opposite side. In the 48 patients without a torn subscapularis tendon, we measured a mean strength of 10.8 ± 3.9 kg (median, 11 kg; range, 4 to 18 kg) on the involved operative side and a mean strength of 12.0 ± 3.5 kg (median, 11 kg; range, 5 to 18 kg) on the opposite side.

Comparisons of Strength Measures

A 2-way repeated-measures ANOVA was performed to determine whether mean strength was significantly different for the involved operative side compared with the opposite side, as well as whether this difference was influenced by the type of test (bear-hug or belly-press test) performed. The side–by–test type interaction was not significant ($P > .60$), nor was the main effect of test type ($P > .15$), whereas the main effect of side was statistically significant ($P < .001$), indicating that the mean strength of the involved side was significantly lower than that of the opposite side regardless of the type of test. A 3-way repeated-measures ANOVA was performed to determine whether mean strength was influenced by the absence or presence of a torn subscapularis tendon in addition to the factors of side and test type. The tear-by-side by test type interaction was not significant ($P > .40$), nor was the tear-by-test type interaction ($P > .20$), whereas the tear-by-side interaction was significant ($P < .005$). To interpret the tear-by-side interaction, the corresponding bear-hug and belly-press strength measures were averaged, and separate paired Student *t* tests comparing involved versus opposite sides were performed for cases with and without a torn subscapularis tendon, followed by unpaired Student *t* tests comparing the group of cases with a torn subscapularis tendon versus the group of tear-free cases, which were performed for the involved-side and opposite-side strength measures separately. The mean strength of the involved side was significantly lower than that of the opposite side in the group with tears ($P < .001$) and the group without tears ($P < .001$). The mean strength of the involved side in the group with tears was significantly lower than that in the group without tears ($P < .015$); however, the mean strength of the opposite side in the group with tears was not significantly different than that in the group without tears ($P > .60$). To further illustrate the tear-by-side interaction, strength differences for the opposite side minus the involved side were calculated for each case, and an unpaired Student *t* test was performed comparing the mean side strength differences for the group with tears versus the group without tears. Patients with tears had a significantly greater mean difference in strength measures for the involved and opposite sides compared with patients without tears ($P < .015$).

In terms of the agreement among the 136 pairs of strength measurements, the bear-hug and belly-press tests varied by 1 kg or less in 85 (62.5%), whereas 44 (32.4%) varied by 2 to 3 kg and 7 (5.1%) varied by 4 to 5 kg. The mean belly-press minus bear-hug strength difference was 0.3 ± 1.8 kg, which was not significantly different from 0 ($P > .09$), and the high level of agreement between bear-hug and belly-press strength measures was further confirmed by the Pearson *r* value of 0.89 for the 136 pairs.

TABLE 3. *Strength Measured With Tensiometer for Bear-Hug and Belly-Press Tests*

	Strength (kg)	
	Bear-Hug Test	Belly-Press Test
All patients		
Operative shoulder	9.6 ± 3.9	9.9 ± 4.2
Opposite shoulder	11.6 ± 3.4	11.8 ± 3.6
Patients with tears		
Operative shoulder	8.1 ± 4.2	7.9 ± 4.2
Opposite shoulder	11.4 ± 3.6	11.4 ± 3.7
Patients without tears		
Operative shoulder	10.3 ± 3.6	10.8 ± 3.9
Opposite shoulder	11.6 ± 3.3	12.0 ± 3.5

Relation of Tear Size to Strength

With regard to subscapularis tears found during arthroscopic exploration, the percentage of the tendon that was torn was less than or equal to 30% in 9 patients, 50% in 5 patients, 75% in 3 patients, and complete (ie, 100%)

in 3 patients. As one might expect, the larger the tear size, the weaker the subscapularis was in both the bear-hug and belly-press tests (Table 4).

DISCUSSION

Of the 34 torn rotator cuffs in this study, 20 had a subscapularis tear (58.8%). The prevalence of subscapularis tears in this study (29.4%) was much greater than that reported in some previous studies in the literature (3.5% reported by Codman[8] and 4% reported by Deutsch et al.[9]). This discrepancy deserves an explanation. The aforementioned studies were both clinical studies, with subscapularis tears being discovered at the time of open surgery. In contrast, an anatomic cadaveric study by Sakurai et al.[10] (46 specimens) found almost as many subscapularis tears (17 subjects, or 37.0% of the series) as supraspinatus tears (20 subjects, or 43.5% of the series). Moreover, in a data registry study (based on all of the arthroscopic procedures performed during a certain period of time), Bennett[11] reported a prevalence of subscapularis tears (27%) that was very similar to ours (29.4%). Therefore one may conclude that open surgical exploration underestimates the frequency of subscapularis tears because it cannot detect many of these tears, which may be visible only from the articular side. This makes sense if one considers that the roof of the bicipital tunnel is formed by a portion of the coracohumeral ligament, which forms a conjoined fascial sheet with the subscapularis tendon.[12] Therefore a nonretracted tear of a portion of the subscapularis will not be visible from the bursal perspective, which is the view that is seen by the surgeon performing an open procedure. In contrast, this same nonretracted tear is easily visible arthroscopically as a disruption of the subscapularis tendon from its footprint on the lesser tuberosity. We believe that our thorough arthroscopic evaluation, using both 30° and 70° arthroscopes, led to our diagnosis of subscapularis tears at a rate that is more in keeping with the prevalence found in anatomic studies.

To diagnose subscapularis tears, we found a significantly higher sensitivity ($P < .035$) and larger area under the ROC curve ($P < .040$) with the bear-hug test than with the lift-off test or Napoleon test. In addition, the bear-hug test had a 20% higher sensitivity than the belly-press test, although the sample size of 20 cases with subscapularis tears was not sufficient to detect this difference statistically, and the areas under the ROC curves for the bear-hug and belly-press tests differed by only 4.3%. When cases were re-

TABLE 4. *Clinical Examination Findings Related to Size of Subscapularis Tear*

Clinical Examination*				Strengh Measurment (kg)				
Bear-Hug Test	Napoleon Test	Belly-Press Test	Lift-Off Test	Belly-Press Test: Ipsilateral	Belly-Press Test: Contralateral	Bear-Hug Test: Ipsilateral	Bear-Hug Test: Contralateral	Arthroscopy (% Subscapularis)
0	0	0	0	16	18	16	18	30
Painful	0	0	0	10	13	9	13	30
Painful	0	0	0	11	15	12	12	30
0	0	0	0	13	12	15	15	30
Painful	0	0	0	6	10	8	9	30
0	0	0	0	15	16	11	12	30
Painful	0	0	0	7	9	8	11	30
1	0	0	0	10	16	10	16	30
1	0	1	0	6	12	9	14	30
1	0	Painful	0	11	9	11	11	50
1	0	0	0	8	6	9	8	50
1	0	0	Impossible	7	12	5	12	50
1	Intermediate	1	Impossible	2	7	1	4	50
1	0	1	Impossible	1	4	2	6	50
1	0	1	1	5	12	7	14	75
0	0	0	0	10	11	11	6	75
1	Intermediate	1	0	8	17	8	16	75
1	1	1	1	6	8	3	9	100
1	Intermediate	1	0	3	11	4	11	100
1	1	1	1	2	10	2	11	100

*For the clinical examination findings, 0 indicates a negative test and 1 indicates a positive test.

stricted to tears of moderate size (<75% of the subscapularis), the bear-hug test had a 28.6% higher sensitivity than the belly-press test, and the area under the ROC curve was 11.1% larger than for the belly-press test, indicating an improvement in diagnostic quality for the bear-hug test relative to the belly-press test for less severe tear cases, although the sample size of 14 cases was not sufficient to detect these differences statistically. Therefore the bear-hug test is the most reliable test on clinical examination for detecting a lesion of the upper part of the subscapularis tendon, and a positive bear-hug test should alert the surgeon to pay particular attention to the subscapularis on arthroscopic evaluation.

The specificity was higher for the lift-off test (100%) than for the other tests. This means that, if the lift-off test is positive, one can be sure that a torn subscapularis tendon is present. Moreover, with a positive lift-off test, a lesion of greater than or equal to 75% can be suspected. However, one must consider that the test was impossible to perform in 5 cases because of pain and loss of internal rotation. None of these 5 patients could reach above S1. However, in 3 of these 5 patients, a torn subscapularis tendon was found arthroscopically.

Objective strength measured with the tensiometer showed that the mean strength on the involved side with the belly-press test (9.9 ± 4.2 kg) was in close agreement with the mean strength registered when the bear-hug test was performed (9.6 ± 3.9 kg). Significantly greater mean differences in strength between the involved side and the opposite side in patients with tears compared with patients without tears were noted ($P < .015$).

In performing the bear-hug test, we also recorded a painful test without weakness but did not count it as a positive test because of its subjective nature. However, we found a high rate of association of this painful bear-hug test with small (30%) upper subscapularis tears (Table 4). Even though a painful bear-hug test may be impossible to quantify, its presence should alert the surgeon to the possibility of a subscapularis tear. Therefore, during the arthroscopic exploration of patients with a painful bear-hug test, particular attention must be paid to the subscapularis insertion on the lesser tuberosity to avoid missing a hidden lesion of the subscapularis.[7,11]

The confluence of the superolateral border of the subscapularis with the biceps sling and upper bicipital groove constitutes a unique and complex anatomic landscape. The medial sling of the biceps, which functions as a pulley for the tendon of the long head of the biceps as it enters the bicipital tunnel, is composed of elements of the medial head of the coracohumeral ligament and the superior glenohumeral ligament.[12] The humeral insertional footprint for the medial sling is located adjacent to the subscapularis footprint at its most proximal aspect. Practically speaking, the medial sling of the biceps and the superolateral corner of the subscapularis share the same general insertion point so that, if the sling is disrupted, the biceps may subluxate medially and cause tearing of the upper subscapularis. Activation of a subluxated biceps during the bear-hug test may cause excessive shear stresses on an already-damaged upper subscapularis, explaining the pain and weakness observed in this study when the bear-hug test was being performed. We found 14 pathologic biceps lesions associated with our 20 subscapularis tears (70%). This association is not surprising if one considers the intimate anatomic association of these two structures.

Four patients were found to have false-positive bear-hug tests (PPV, 75%). All of these patients had a supraspinatus tear. We believe that by increasing forward elevation of the shoulder to maximize the anterior positioning of the elbow, supraspinatus fibers may be activated to a greater degree with the bear-hug test than with the belly-press test. Tokish et al.[5] showed a slight increase in activation of the supraspinatus with the belly-press test in comparison to the lift-off test. A greater increase in supraspinatus activation could be expected with the bear-hug test in comparison to the lift-off and belly-press tests because of the greater forward elevation of the shoulder when one is performing the bear-hug test.

This study also confirmed that by performing all of the subscapularis tests, the size of the tear could be suspected preoperatively. Positive bear-hug and belly-press tests were found with upper-third subscapularis tears, whereas a tear of 50% or more of the subscapularis was necessary to produce a positive Napoleon test and a 75% tear of the subscapularis was necessary to produce a positive lift-off test (Table 4). We believe that all of these tests should be performed during the clinical examination to optimize the surgeon's preoperative ability not only to diagnose a subscapularis tear but also to predict the size of the tear.

We believe that the more sensitive a test is, the more useful it is in alerting the surgeon to the specific pathology for which he or she is testing. The quality of increased sensitivity makes the bear-hug test uniquely valuable in the surgeon's diagnostic armamentarium.

We acknowledge some weaknesses to this study. First of all, the Napoleon intermediate-category patients were assigned by use of a certain degree of extrapolation. This extrapolation may have affected data comparisons by pooling Napoleon intermediate tests with the binary values of the other tests. Second, we used the mean superior-to-inferior length of the subscapularis footprint (2.5 cm) as the denominator in determining what percentage of the subscapularis was torn. The footprint length will obviously vary depending on the size of the patient. However, with a study group of 68 patients, we believe that the large sample size will most likely result in a mean footprint close to that found in our previous anatomic cadaveric study. Finally, the order of the tests was the same in each patient and for each shoulder. This order is satisfactory for side-to-side comparisons of strength, because each side of an individual patient is tested in the same order. However, there could be a fatigue factor contributing to weakness in the later tests. The belly-press test was done next to last in this study, and the bear-hug test was done last. Because these 2 tests showed the greatest specificity, despite being tested last (and therefore being more susceptible to fatigue), we believe that our conclusions are justified.

We have recently read a description of the belly-off sign for subscapularis tears.[13] However, at the time we performed our study, we were not aware of this sign, so it was not tested in our study.

CONCLUSIONS

The bear-hug test is the most sensitive clinical test for subscapularis function. Clinical examination should include the lift-off test, belly-press test, Napoleon test, and bear-hug test to optimize the chance of detecting and predicting the size of a subscapularis tear. Positive bear-hug and belly-press tests suggest a tear of at least 30% of the subscapularis, whereas a positive Napoleon test indicates that greater than 50% of the subscapularis is torn. Furthermore, a positive lift-off test is not seen until at least 75% of the subscapularis is torn. Even so, 40% of subscapularis tears were missed clinically on preoperative physical examination in this study. Therefore particular care should be taken at the time of diagnostic arthroscopy to clearly visualize the insertion of the subscapularis on the humerus.

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