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Diagnostic Accuracy of Clinical Tests for the Different Degrees of Subacromial Impingement Syndrome

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Background: Several tests for making the diagnosis of rotator cuff disease have been described, but their utility for diagnosing bursitis alone, partial-thickness rotator cuff tears, and full-thickness rotator cuff tears has not been studied. The hypothesis of this study was that the degree of severity of rotator cuff disease affects the diagnostic values of the commonly used clinical tests.

Methods: Eight physical examination tests (the Neer impingement sign, Hawkins-Kennedy impingement sign, painful arc sign, supraspinatus muscle strength test, Speed test, cross-body adduction test, drop-arm sign, and infraspinatus muscle strength test) were evaluated to determine their diagnostic values, including likelihood ratios and post-test probabilities, for three degrees of severity in rotator cuff disease: bursitis, partial-thickness rotator cuff tears, and full-thickness rotator cuff tears. A forward stepwise logistic regression analysis was used to determine the best combination of clinical tests for predicting the various grades of impingement syndrome.

Results: The sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of the eight tests varied considerably. The combination of the Hawkins-Kennedy impingement sign, the painful arc sign, and the infraspinatus muscle test yielded the best post-test probability (95%) for any degree of impingement syndrome. The combination of the painful arc sign, drop-arm sign, and infraspinatus muscle test produced the best post-test probability (91%) for full-thickness rotator cuff tears.

Conclusions: The severity of the impingement syndrome affects the diagnostic values of the commonly used clinical tests. The variable accuracy of these tests should be taken into consideration when evaluating patients with symptoms of rotator cuff disease.

Level of Evidence: Diagnostic Level I. See Instructions to Authors for a complete description of levels of evidence.

The physical examination for rotator cuff disease remains important for the clinical assessment of patients who present with shoulder pain or weakness. Neer[1] described a physical examination sign that he said was not specific to rotator cuff disease but was helpful in making the diagnosis. He also described an injection test that confirmed the location of the pain as the subacromial space. Other physical examination signs that have been described as aids to diagnosing subacromial impingement include the Hawkins-Kennedy impingement sign[2], the painful arc sign[3,4], the supraspinatus muscle strength test[5,6], the Speed test[3], the drop-arm sign[3], the cross-body adduction test[3,7], and the infraspinatus muscle strength test[6].

Neer[1] also described three stages of impingement syndrome, noting that "the symptoms and physical signs in all three stages of impingement are almost identical, including the 'impingement sign' . . . , arc of pain, crepitus, and varying weakness." He stated that weakness was more severe in advanced cases, and he did not distinguish between partial-thickness and full-thickness rotator cuff tears in stage III[1].

The literature contains few reports on the diagnostic values of these clinical tests[3,6,8] (see Appendix). The studies that have been published have used different methodologies, and consequently the results have varied. Only two studies

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Fig. 1
The Neer impingement sign was performed with the patient standing. The scapula was stabilized by the examiner, and the arm was forward flexed until the patient reported pain or full elevation was reached.

have addressed the utility of the physical examination findings with regard to the different stages of subacromial impingement. MacDonald et al.[8] studied eighty-five patients and assessed the diagnostic values of the Neer and the Hawkins-Kennedy impingement signs for subacromial bursitis and for rotator cuff disease. Murrell and Walton[9] evaluated 400 patients who were undergoing arthroscopic shoulder surgery for a variety of diagnoses. Each of these studies divided the patients into two groups: those with bursitis and those with rotator cuff tears of any type. Neither study compared the diagnostic values of these tests for partial-thickness and full-thickness tears.

In a review of the English-language literature, we found no study that evaluated the physical examination findings for the three different degrees of rotator cuff disease: bursitis without a rotator cuff tear, a partial-thickness rotator cuff tear, and a full-thickness rotator cuff tear. The utility of the examination tests for these different conditions is important for those who treat patients with symptoms of rotator cuff disease. Our hypothesis was that the diagnostic value of these eight clinical tests for the differing conditions would vary. Our goal was to define which tests or combination of tests were the best diagnostic tools for these three conditions.

Materials and Methods

Between August 1992 and June 2003, 1127 patients who had shoulder surgery performed by the senior author (E.G.McF.) provided a thorough history, filled out a questionnaire, and underwent a complete physical examination within the four weeks before surgery. In addition, plain anteroposterior radiographs (internal rotation, external rotation, and axillary views) were made for each patient. All patients gave informed consent, and their findings and responses were entered into a database. The database and study were approved by our institutional review board. Of the 1127 patients, 214 patients who did not undergo arthroscopy were excluded from the study. The remaining 913 patients who underwent physical examination and diagnostic arthroscopy, both performed with the patient under general anesthesia, formed our initial study group. Surgical data for these study patients were recorded and added to the database at the time of operative intervention.

The physical examinations included eight clinical tests for impingement syndrome. All tests were performed with the patient standing. The first test was the Neer impingement sign[10] (Fig. 1). The scapula was stabilized by the examiner, and the arm was forward flexed by the examiner until the patient reported pain or until full elevation was reached. A positive test was considered to be pain in the anterior or lateral part of the shoulder, typically in a range of 90° to 140° of flexion.

The second test was the Hawkins-Kennedy impingement sign (Fig. 2), in which the arm was placed in 90° of for-

Fig. 2
The Hawkins-Kennedy impingement sign was performed with the patient standing. The arm was elevated to 90° and then was forcibly rotated medially.

Fig. 3
The supraspinatus muscle strength test was performed with the patient standing and the arm elevated to 90° in the scapular plane. The physician then resisted abduction with the patient's arm in internal or neutral rotation.

ward flexion and then gently rotated into internal rotation. The end point for internal rotation was either when the patient felt pain or when rotation of the scapula was felt or observed by the examiner. This test was considered to be positive if the patient had pain during the maneuver.

The third test was the painful arc sign[4] in which the patient was asked to actively elevate the arm in the scapular plane until full elevation was reached and then to bring the arm down in the same arc. The test was considered to be positive if the patient had pain or painful catching between 60° and 120° of elevation.

The fourth test was the supraspinatus muscle strength test performed according to the technique described by Jobe and Moynes[5] (Fig. 3). In this test, the physician resisted abduction with the arm of the patient elevated to 90° and internally or neutrally rotated[11]. If the patient gave way, the test was considered positive.

In the fifth test, the Speed test, the elbow was fully extended[12] and then the arm was elevated (passively or actively) to 90° and extended slightly horizontally (Fig. 4). With the forearm supinated, the examiner applied a downward force to the arm. The test was considered positive if the patient complained of pain during forward elevation.

In the sixth test, the cross-body adduction test[7] (Fig. 5), the arm was placed in 90° of forward flexion and then was adducted across the body by the examiner. The test was considered to be positive if it caused pain in the shoulder.

In the seventh test, the drop-arm sign described by Codman[13], the patient was asked to elevate the arm fully and then to slowly reverse the motion in the same arc. If the arm dropped suddenly or the patient had severe pain, the test was considered to be positive.

In the final test, the infraspinatus muscle strength test[6], the elbow was flexed to 90° and the arm was adducted to the trunk in neutral rotation (Fig. 6). The examiner then applied an internal rotation force to the arm while the patient resisted. The test was considered positive if the patient gave way because of weakness or pain or if there was a positive external rotation lag sign as described by Hertel et al.[14]. For the external rotation lag sign, the arm is positioned with the elbow at the side and flexed to 90°. The arm is then maximally externally rotated, and the patient is asked to hold this position. If the patient is unable to hold the arm in this position and it falls into internal rotation, it is considered to be a positive test.

Fig. 4
The Speed test was performed with the patient standing and the elbow fully extended. Then the arm was elevated to 90° and extended slightly horizontally.

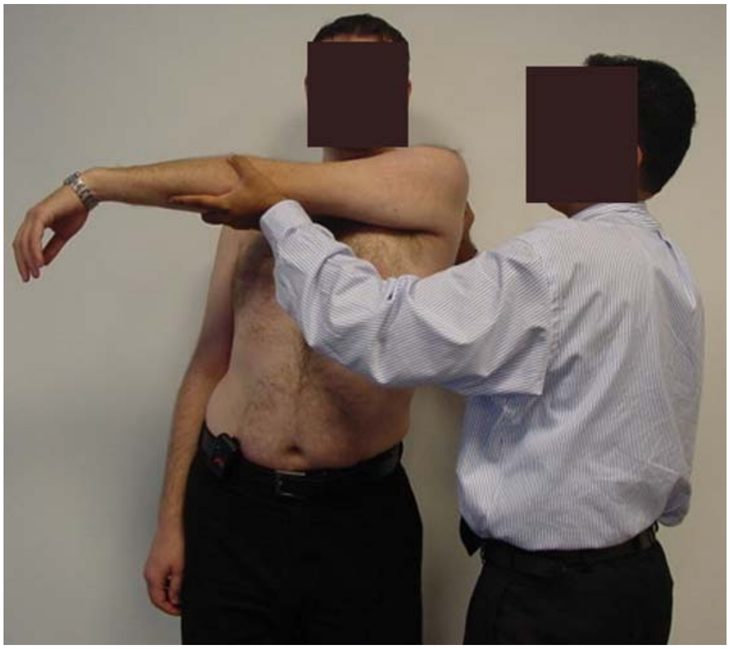

Fig. 5

The cross-body adduction test was performed with the patient standing and the arm elevated to 90°. Then the arm was adducted across the body.

Of the 913 patients who underwent arthroscopy, 361 were excluded for the following reasons: a history of shoulder surgery (126 patients); acromioclavicular arthritis, requiring excision of the distal part of the clavicle in conjunction with acromioplasty or rotator cuff repair, combined with impingement syndrome (seventy-three); an incomplete physical examination because of limited motion or extreme pain (sixty-three); superior labrum anterior-to-posterior lesions, requiring repair, combined with impingement syndrome (fifty-seven); or instability combined with impingement syndrome (forty-two). The remaining 552 patients formed our final study group.

To determine the diagnostic values of each of the eight clinical tests, the 552 patients were divided into a nonimpingement or an impingement group. The nonimpingement group consisted of 193 patients with normal rotator cuffs and a pathologic condition unrelated to impingement syndrome, such as instability (158 patients), isolated degenerative acromioclavicular arthritis (twenty-six), a supraspinatus ganglion cyst (five), nonspecific synovitis (three), and a superior labrum anterior-to-posterior lesion (one). The impingement group consisted of 359 patients with a diagnosis of impingement syndrome, regardless of the degree of severity. All patients in this group had a history of pain in the deltoid region or radiating down the arm and had at least temporary resolution of the pain with a subacromial injection of local anesthetic (a positive Neer impingement test). These 359 patients were subdivided into three groups according to the degree of disease severity. Group 1 included seventy-two patients who had a positive impingement test but no rotator cuff disease at the time of surgery and were judged to have subacromial impingement alone. Group 2 included seventy-two patients with a partial rotator cuff tear at the time of surgery, regardless of depth; this included patients with bursal-side tears (five) and joint-side partial tears (sixty-seven). Group 3 included 215 patients with a full-thickness rotator cuff tear, regardless of size; this included patients with small tears, large tears, massive tears, or multiple tendon tears. Radiographic assessment and the results of magnetic resonance imaging were not used to make the final diagnosis and were not included as variables in our study.

Fig. 6

The infraspinatus muscle strength test was performed with the patient standing, the elbow flexed at 90°, and the arm adducted to the trunk in neutral rotation. The examiner applied an internal rotation force to the arm while the patient resisted.

TABLE I Basic Setup for 2 × 2 Table to Calculate Diagnostic Values*

Test	Disease: Positive	Disease: Negative
Positive	True positive (TP)	False positive (FP)
Negative	False negative (FN)	True negative (TN)

*Diagnostic values were calculated with the following equations: sensitivity = TP/(TP + FN), specificity = TN/(FP + TN), positive predictive value = TP/(TP + FP), negative predictive value = TN/(FN + TN), overall accuracy = (TP + TN)/(TP + FP + FN + TN). The formulas for likelihood ratio, pretest probability, pretest odds, post-test odds, and post-test probability[18,19] are likelihood ratio = sensitivity/(1-specificity), pretest probability = prevalence of disease, pretest odds = pretest probability/[1-(pretest probability)], post-test odds for the target disorder = pretest odds × likelihood ratio, and post-test probability = post-test odds/[(post-test odds) + 1].

Statistical analysis was performed with use of Statistical Package for the Social Sciences (version 10.0; SPSS, Chicago, Illinois). Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of the eight identified clinical tests were calculated with the two-by-two table method (Table I). The likelihood ratios indicate the values of various tests for increasing the certainty of a diagnosis. In the case of a single test, a likelihood ratio of >10 is sufficient to rule in the target condition[15]. A forward stepwise logistic regression analysis was used to determine the best combination of clinical tests for predicting the various grades of impingement syndrome. The final diagnosis, as confirmed by arthroscopy, was used as the dependent variable. At each step, each of the eight clinical tests was added automatically to the regression model as the explanatory (predictor) variable. The level of significance for each clinical test was set at 0.05.

Results

The diagnostic values of the eight clinical tests for overall subacromial impingement syndrome, regardless of the degree of rotator cuff disease, are summarized in Table II. The diagnostic values of the eight clinical tests for the three degrees of severity of the rotator cuff disease are summarized in Table III. These results show that the physical findings for rotator cuff disease vary with disease severity.

For patients in the impingement group (that is, those with any type of rotator cuff disease), the painful arc sign was the most sensitive test (73.5%) and it had the highest negative predictive value (61.5%) and the highest overall accuracy (76.1%) in detecting impingement (Table II). The infraspinatus muscle strength test was the most specific (90.1%) and had the highest positive predictive value (90.6%) for rotator cuff disease of any type. The post-test probabilities of the eight clinical tests for any degree of impingement were generally high (>0.70).

The patients in the impingement group were divided into three subgroups. For patients in Group 1 (that is, those with rotator cuff tendinitis or bursitis but no rotator cuff tears), the Neer impingement sign was the most sensitive (85.7%) and it had the highest positive predictive value (20.9%) and the highest negative predictive value (95.7%). The cross-body adduction test was the most specific (79.7%) and had the highest overall accuracy (73.1%). The drop-arm sign had the lowest sensitivity (13.6%).

For the patients in Group 2 (that is, those with partial-thickness rotator cuff tears only), both the Neer and the Hawkins-Kennedy impingement signs were highly sensitive (75.4%), but their specificity was only 48% and 44%, respectively. The Neer impingement sign had the highest positive predictive value (18.1%) and the highest negative predictive value (92.6%) of all of the tests studied. The cross-body adduction test was the most specific (78.5%) and had the highest overall accuracy (70.8%). The positive predictive values of the eight clinical tests for partial-thickness rotator cuff tears were generally very low (<20%), although the negative predictive values were generally high (>86%).

For patients in Group 3 (that is, those with full-thickness rotator cuff tears), a different pattern of examination results was seen. The painful arc sign was the most sensitive (75.8%) and had the highest negative predictive value (76.4%), and the drop-arm sign was the most specific (87.5%). The infraspinatus

TABLE II Overall Diagnostic Values of the Eight Clinical Tests for Subacromial Impingement Syndrome Regardless of the Severity of Rotator Cuff Disease ➤

	Sensitivity *(%)*	Specificity *(%)*	Positive Predictive Value *(%)*	Negative Predictive Value *(%)*
Neer sign	68.0	68.7	80.4	53.2
Hawkins-Kennedy sign	71.5	66.3	79.7	55.7
Painful arc sign	73.5	81.1	88.2	61.5
Supraspinatus muscle test	44.1	89.5	88.4	46.8
Speed test	38.3	83.3	80.5	42.9
Cross-body adduction test	22.5	82.0	69.3	36.9
Drop-arm test	26.9	88.4	81.0	39.7
Infraspinatus muscle test	41.6	90.1	90.6	45.8

muscle strength test and the supraspinatus muscle strength test had the highest positive predictive values (69.1% and 68.0%, respectively) and the highest overall accuracy (70.1% and 70.0%, respectively).

The results of the logistic regression analysis are summarized in Table IV. The Neer impingement sign was the only test to predict bursitis alone or partial-thickness rotator cuff tears. Other clinical tests did not significantly increase the ability of the regression analysis to predict bursitis alone or partial-thickness rotator cuff tears. The painful arc sign, drop-arm sign, and infraspinatus muscle test were retained as variables in the logistic regression analysis to predict full-thickness rotator cuff tears. The Hawkins-Kennedy impingement sign, the painful arc sign, and the infraspinatus muscle strength test were retained as variables in the logistic regression analysis to predict overall impingement syndrome. The results of the logistic regression analysis showed that combinations of clinical tests increased the likelihood ratios and the post-test probabilities for overall impingement syndrome and full-thickness rotator cuff tears (Table V).

The logistic regression analysis showed that if the Hawkins-Kennedy impingement sign, the painful arc sign, and the infraspinatus muscle test were all positive, the likelihood ratio was 10.56, and the post-test probability was 0.95 for any degree of impingement syndrome. In other words, the likelihood that a patient who tested positive on all three tests would have impingement syndrome of some degree was >95%. If these three tests were all negative, the likelihood ratio was 0.17 and the post-test probability was 0.24, indicating that the likelihood that a patient who had negative findings on all three tests would have impingement syndrome of any degree was <24%.

If the painful arc sign, drop-arm sign, and infraspinatus muscle test were all positive, the likelihood ratio was 15.57, the post-test probability was 0.91, and a full-thickness rotator cuff tear could be ruled in. If these three tests were all negative, the likelihood ratio was 0.16, the post-test probability was 0.09, and the probability of a full-thickness rotator cuff tear would be very low.

To analyze the effect of patient age on the results, as suggested by Murrell and Walton[9], we divided all patients into two groups according to age: those who were sixty years or older and those who were younger than sixty years[9]. For the three degrees of rotator cuff disease, a significant correlation was found only between the age of the patient and the presence of a full-thickness rotator cuff tear ($p < 0.0001$). For full-thickness rotator cuff tears, if three tests (the painful arc sign, drop-arm sign, and infraspinatus muscle test) were positive and the patients were sixty years old or older, the likelihood ratio was 28.00 and the post-test probability was 0.95. If these three tests were negative and patients were less than sixty years old, the likelihood ratio was 0.09 and the post-test probability was 0.06.

Discussion

Our study compares favorably with other studies in the literature on this subject, although our methodology differed in several ways. Previous studies have used a positive response to a Neer impingement sign, a positive finding on a magnetic resonance image, or a positive ultrasound evaluation as the standard for diagnosing rotator cuff problems[3,16]. Four previous studies have used surgical findings as inclusion criteria, but those studies did not have a control group or did not stratify the patient groups by the degree of disease[6,8,9,17].

The study that was most similar in method to ours was reported by Murrell and Walton[9], who prospectively studied 400 patients with and without rotator cuff tears. They prospectively performed twenty-three different clinical tests on each of the 400 patients, all of whom subsequently underwent arthroscopy. The three tests found to be most diagnostic for rotator cuff disease were weakness in external rotation, weakness in abduction, and a positive Neer or Hawkins-Kennedy impingement sign. Murrell and Walton[9] found that a patient who tested positive on all three tests, or who tested positive on any two of the three tests and was more than sixty years old, had a 98% likelihood of having a partial or full-thickness rotator cuff tear.

Our finding that most tests for rotator cuff disease have greater sensitivity than specificity is supported by other studies in the literature[3,8]. Many of the physical examination tests studied can be positive in the presence of other shoulder conditions, and the clinician should consider the results of the examination on the basis of the clinical presentation of the patient.

TABLE II *(continued)*

Overall Accuracy *(%)*	Pretest Probability	Pretest Odds	Likelihood Ratio	Post-Test Odds	Post-Test Probability
68.3	0.65	1.86	2.17	4.04	0.80
69.7	0.65	1.86	2.12	3.94	0.80
76.1	0.65	1.86	3.89	7.23	0.88
60.2	0.65	1.86	4.20	7.81	0.89
54.4	0.65	1.86	2.29	4.26	0.81
47.8	0.65	1.86	1.25	2.33	0.70
48.6	0.65	1.86	2.32	4.32	0.81
58.7	0.65	1.86	4.20	7.81	0.89

TABLE III The Diagnostic Values of the Eight Clinical Tests for Three Different Degrees of Severity of Rotator Cuff Disease in Impingement Syndrome ➤

Clinical Test by Group	Sensitivity *(%)*	Specificity *(%)*	Positive Predictive Value *(%)*	Negative Predictive Value *(%)*
Group 1 (bursitis)				
Neer sign	85.7	49.2	20.9	95.7
Hawkins-Kennedy sign	75.7	44.5	17.4	92.2
Painful arc sign	70.6	46.9	12.3	93.8
Supraspinatus muscle test	25.0	66.9	8.8	87.4
Speed test	33.3	69.8	14.1	87.6
Cross-body adduction test	25.4	79.7	14.9	88.5
Drop-arm test	13.6	77.3	8.0	86.0
Infraspinatus muscle test	25.0	68.9	9.4	87.7
Group 2 (partial-thickness rotator cuff tear)				
Neer sign	75.4	47.5	18.1	92.6
Hawkins-Kennedy sign	75.4	44.4	17.0	92.2
Painful arc sign	67.4	47.0	14.9	91.3
Supraspinatus muscle test	32.1	67.8	11.6	88.4
Speed test	33.3	70.6	16.1	88.8
Cross-body adduction test	16.7	78.5	9.9	86.9
Drop-arm test	14.3	77.5	8.0	86.8
Infraspinatus muscle test	19.4	69.1	10.1	87.7
Group 3 (full-thickness rotator cuff tear)				
Neer sign	59.3	47.2	41.3	64.9
Hawkins-Kennedy sign	68.7	48.3	45.2	71.2
Painful arc sign	75.8	61.8	61.0	76.4
Supraspinatus muscle test	52.6	82.4	68.0	71.0
Speed test	39.9	75.3	50.3	66.6
Cross-body adduction test	23.4	80.8	44.6	61.5
Drop-arm test	34.9	87.5	65.0	66.8
Infraspinatus muscle test	50.5	84.0	69.1	70.5

Our results could have been influenced by the use of a control group that consisted of patients with other conditions that required shoulder surgery. It is common in case-control series to use as controls other patients undergoing surgery for an unrelated problem, and both the studies by Murrell and Walton[9] and MacDonald et al.[8] used this approach[18,19].

Discrepancies between our study and others in the literature may have resulted from several factors. First, few previous studies have examined the results of these tests in our three distinct groups: no rotator cuff tear, partial-thickness rotator cuff tear, or full-thickness rotator cuff tear. Second, the distribution of rotator cuff tears in our study may have differed from that in other studies. Finally, the variability in the degree of symptoms at the times of examination could have influenced our results.

One limitation of our study is that we did not investigate the reliability and reproducibility of the physical examinations. In a study by Young et al.[20] in England, an orthopaedic consultant and senior registrar each examined fifty patients with rotator cuff disease. They reported no significant difference between the findings of the two examiners for any of the signs studied, which included the drop-arm test, the Neer and the Hawkins-Kennedy impingement signs, weakness in abduction and external rotation, the painful arc sign, the Speed test, the Yergason test, and the Gerber lift-off test.

Another limitation of our study was that we did not evaluate every test described for the diagnosis of rotator cuff disease (for example, lag signs[14], the lift-off test[21], and the hornblower sign[22]). It is possible that the inclusion of those tests or combinations thereof might have influenced the results reported in the present study. In addition, we did not evaluate the usefulness of the physical examination for predicting the surgical result. It is possible that the clinical value of these tests could be altered by including the surgical results in the analysis.

We also did not analyze the use of imaging as part of the decision-making process. Although plain radiographs, arthrograms, ultrasound, and magnetic resonance imaging were used, the results were not included in our analysis because the scans were performed at multiple locations with use of sequences that were not standardized or consistent for the entire cohort. A review of the literature revealed that the sensitivity, specificity, and accuracy of ultrasound for making the diagnosis of rotator cuff

TABLE III *(continued)*

Overall Accuracy *(%)*	Pretest Probability	Pretest Odds	Likelihood Ratio	Post-Test Odds	Post-Test Probability
54.2	0.13	0.15	1.69	0.25	0.20
48.7	0.13	0.15	1.36	0.20	0.17
49.2	0.13	0.15	1.33	0.20	0.17
62.1	0.13	0.15	0.76	0.11	0.10
65.1	0.13	0.15	1.10	0.17	0.15
73.1	0.13	0.15	1.25	0.19	0.16
69.2	0.13	0.15	0.60	0.09	0.08
63.9	0.13	0.15	0.80	0.12	0.11
51.3	0.13	0.15	1.44	0.22	0.18
48.5	0.13	0.15	1.36	0.20	0.17
49.4	0.13	0.15	1.27	0.19	0.16
63.7	0.13	0.15	1.00	0.15	0.13
66.5	0.13	0.15	1.13	0.17	0.15
70.8	0.13	0.15	0.78	0.12	0.11
69.9	0.13	0.15	0.64	0.10	0.09
64.1	0.13	0.15	0.63	0.10	0.09
51.8	0.41	0.69	1.12	0.77	0.44
56.1	0.41	0.69	1.33	0.92	0.50
68.0	0.41	0.69	1.98	1.37	0.58
70.0	0.41	0.69	3.00	2.07	0.67
61.6	0.41	0.69	1.62	1.12	0.53
58.0	0.41	0.69	1.22	0.84	0.46
66.5	0.41	0.69	2.79	1.93	0.66
70.1	0.41	0.69	3.16	2.18	0.69

tears have been reported to range from 57% to 100%, 63% to 100%, and 73% to 96%, respectively[23-27].

The present study showed that the clinical examinations for disorders of the rotator cuff vary according to the degree of disease. Combinations of examinations provide greater accuracy and are recommended in the evaluation of patients with rotator cuff disease. Our results should not be extrapolated to other patient populations, particularly athletes who throw overhead or patients with painful, multidirectional laxity[28]. Additional study is needed to determine whether including the imaging results with the physical examination results can increase the reliability of a diagnosis of rotator cuff disease and perhaps influence the course of treatment.

In conclusion, the best combination of tests for mak-

TABLE IV Multiple Logistic Regressions Model Analysis of Clinical Tests According to Different Stages of Impingement Syndrome

Disease Stage	Clinical Test	P Value
Bursitis	Neer impingement sign	<0.0001
Partial-thickness rotator cuff tear	Neer impingement sign	0.007
Full-thickness rotator cuff tear	Painful arc sign	<0.0001
	Drop-arm sign	0.024
	Infraspinatus muscle test	0.006
Overall impingement syndrome	Hawkins-Kennedy impingement sign	<0.0001
	Painful arc sign	<0.0001
	Infraspinatus muscle test	<0.0001

TABLE V The Likelihood Ratios and Post-Test Probabilities for Combining Clinical Tests According to Logistic Regression Analysis Results

Category	No. (%) of Patients with Positive Test Results		Pretest Probability	Pretest Odds	Likelihood Ratio	Post-Test Odds	Post-Test Probability
	Subject	Control					
Overall impingement syndrome*							
All three tests positive	61/231 (26.4)	3/121 (2.5)	0.65	1.86	10.56	19.64	0.95
Two of three tests positive	86/231 (37.2)	9/121 (7.4)	0.65	1.86	5.03	9.36	0.90
One of three tests positive	60/231 (26.0)	35/121 (28.9)	0.65	1.86	0.90	1.67	0.63
None of three tests positive	24/231 (10.4)	74/121 (61.2)	0.65	1.86	0.17	0.32	0.24
Full-thickness rotator cuff tear†							
All three tests positive	50/153 (32.7)	4/195 (2.1)	0.39	0.64	15.57	9.96	0.91
Two of three tests positive	53/153 (34.6)	19/195 (9.7)	0.39	0.64	3.57	2.28	0.69
One of three tests positive	36/153 (23.5)	58/195 (29.7)	0.39	0.64	0.79	0.51	0.33
None of three tests positive	14/153 (9.2)	114/195 (58.5)	0.39	0.64	0.16	0.10	0.09

*A total of 352 patients (231 in the subject group and 121 in the control group) who underwent all three tests (the Hawkins-Kennedy impingement sign, the painful arc sign, and the infraspinatus muscle test) were included in this analysis. The subject group included patients with bursitis, partial-thickness rotator cuff tear, or full-thickness rotator cuff tear; the control group was the nonimpingement group. †A total of 348 patients (153 in the subject group and 195 in the control group) who underwent all three tests (the painful arc sign, drop-arm sign, and the infraspinatus test) were included in this analysis. The subject group included patients with a full-thickness rotator cuff tear only; the control group included patients without impingement and patients with bursitis or a partial-thickness rotator cuff tear.

ing the diagnosis of impingement disease of any degree are a positive Hawkins-Kennedy impingement sign, a positive painful arc sign, and weakness in external rotation with the arm at the side. To diagnose a full-thickness rotator cuff tear, the best combination of tests, when all three are positive, are the painful arc, the drop-arm sign, and weakness in external rotation.

Appendix

eA A table summarizing other studies on diagnostic tests for the impingement syndrome is available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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References

1. Neer CS 2nd. Impingement lesions. Clin Orthop Relat Res. 1983;173:70-7.

2. Hawkins RJ, Kennedy JC. Impingement syndrome in athletes. Am J Sports Med. 1980;8:151-8.

3. Calis M, Akgun K, Birtane M, Karacan I, Calis H, Tuzun F. Diagnostic values of clinical diagnostic tests in subacromial impingement syndrome. Ann Rheum Dis. 2000;59:44-7.

4. Kessel L, Watson M. The painful arc syndrome. Clinical classification as a guide to management. J Bone Joint Surg Br. 1977;59:166-72.

5. Jobe FW, Moynes DR. Delineation of diagnostic criteria and a rehabilitation program for rotator cuff injuries. Am J Sports Med. 1982;10:336-9.

6. Leroux JL, Thomas E, Bonnel F, Blotman F. Diagnostic value of clinical tests for shoulder impingement syndrome. Rev Rhum Engl Ed. 1995;62:423-8.

7. McLaughlin HL. On the "frozen" shoulder. Bull Hosp Joint Dis. 1951;12:383-93.

8. MacDonald PB, Clark P, Sutherland K. An analysis of the diagnostic accuracy of the Hawkins and Neer subacromial impingement signs. J Shoulder Elbow Surg. 2000;9:299-301.

9. Murrell GAC, Walton JR. Diagnosis of rotator cuff tears. Lancet. 2001;357:769-70. Erratum in: Lancet. 2001;357:1452.

10. Neer CS 2nd. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. J Bone Joint Surg Am. 1972;54:41-50.

11. Malanga GA, Jenp YN, Growney ES, An KN. EMG analysis of shoulder positioning in testing and strengthening the supraspinatus. Med Sci Sports Exerc. 1996;28:661-4.

12. Gilcreest EL, Albi P. Unusual lesions of muscles and tendons of the shoulder girdle and upper arm. Surg Gynecol Obstet. 1939;68:903-17.

13. Codman EA. The shoulder. Rupture of the supraspinatus tendon and other lesions in or about the subacromial bursa. Boston: Thomas Todd; 1934. Rupture of the supraspinatus tendon; p 123-77.

14. Hertel R, Ballmer FT, Lambert SM, Gerber C. Lag signs in the diagnosis of rotator cuff rupture. J Shoulder Elbow Surg. 1996;5:307-13.

15. Walton J, Mahajan S, Paxinos A, Marshall J, Bryant C, Shnier R, Quinn R, Murrell GAC. Diagnostic values of tests for acromioclavicular joint pain. J Bone Joint Surg Am. 2004;86:807-12.

16. Naredo E, Aguado P, De Miguel E, Uson J, Mayordomo L, Gijon-Banos J, Martin-Mola E. Painful shoulder: comparison of physical examination and ultrasonographic findings. Ann Rheum Dis. 2002;61:132-6.

17. Holtby R, Razmjou H. Validity of the supraspinatus test as a single clinical test in diagnosing patients with rotator cuff pathology. J Orthop Sports Phys Ther. 2004;34:194-200.

18. Altman DG. Practical statistics for medical research. London: Chapman and Hall; 1991. Some common problems in medical research; p 396-439.

19. Dawson B, Trapp RG. Basic and clinical biostatistics. 3rd ed. New York: Lange Medical Books/McGraw-Hill; 2001. Reading the medical literature; p 304-33.

20. Young C, Nanda R, Liow RYL, Rangan A. Diagnostic accuracy of clinical signs in rotator cuff disease. Proceedings of the British Elbow and Shoulder Society [abstract]. J Bone Joint Surg Br. 2003;85 Suppl 1:69.

21. Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle. Clinical features in 16 cases. J Bone Joint Surg Br. 1991;73:389-94.

22. Walch G, Boulahia A, Calderone S, Robinson AHN. The ‘dropping’ and ‘hornblower’s’ signs in evaluation of rotator-cuff tears. J Bone Joint Surg Br. 1998;80:624-8.

23. Teefey SA, Hasan SA, Middleton WD, Patel M, Wright RW, Yamaguchi K. Ultrasonography of the rotator cuff. A comparison of ultrasonographic and arthroscopic findings in one hundred consecutive cases. J Bone Joint Surg Am. 2000;82:498-504.

24. Brandt TD, Cardone BW, Grant TH, Post M, Weiss CA. Rotator cuff sonography: a reassessment. Radiology. 1989;173:323-7.

25. Roberts CS, Beck DJ Jr, Heinsen J, Seligson D. Review article: diagnostic ultrasonography: applications in orthopaedic surgery. Clin Orthop Relat Res. 2002;401:248-64.

26. Wallny T, Wagner UA, Prange S, Schmitt O, Reich H. Evaluation of chronic tears of the rotator cuff by ultrasound. A new index. J Bone Joint Surg Br. 1999;81:675-8.

27. Pattee GA, Snyder SJ. Sonographic evaluation of the rotator cuff: correlation with arthroscopy. Arthroscopy. 1988;4:15-20.

28. McFarland EG, Kim TK, Park HB, Neira CA, Gutierrez MI. The effect of variation in definition on the diagnosis of multidirectional instability of the shoulder. J Bone Joint Surg Am. 2003;85:2138-44.