Diagnostic Values of Tests for Acromioclavicular Joint Pain

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Background: This prospective study was performed to determine which clinical and imaging tests were most helpful for diagnosing acromioclavicular joint pain.

Methods: Of 1037 patients with shoulder pain, 113 who mapped pain within an area bounded by the midpart of the clavicle and the deltoid insertion were eligible for inclusion in the study. Forty-two subjects agreed to participate, and four of them were lost to follow-up. Twenty clinical tests, radiography, bone-scanning, magnetic resonance imaging, and an acromioclavicular joint injection test were performed on all patients. The patients were divided into two groups according to whether they had a ≥50% decrease in pain following the acromioclavicular joint injection. Statistical analysis, including multivariate regression analysis, was performed in order to evaluate the diagnostic effectiveness of the various tests.

Results: Acromioclavicular joint pain was confirmed in twenty-eight of the thirty-eight patients. The most sensitive tests were examination for acromioclavicular tenderness (96% sensitivity), the Paxinos test (79%), magnetic resonance imaging (85%), and bone-scanning (82%), but these studies had low specificity. In the stepwise regression model, with the response to the injection used as the dependent variable, bone-scanning and the Paxinos test were the only independent variables retained. Patients with a positive Paxinos test as well as a positive bone scan had high post-test odds (55:1) and a 99% post-test probability of having pain due to pathological changes in the acromioclavicular joint. The likelihood ratio for patients with one negative test and one positive test was indeterminate (0.4:1). Patients with both a negative Paxinos test and a negative bone scan had a likelihood ratio of 0.03:1 for having acromioclavicular joint pain, which basically rules out the disorder.

Conclusions: The highly sensitive tests had low specificity, and the highly specific tests had low sensitivity. However, the combination of a positive Paxinos test and a positive bone scan predicted damage to the acromioclavicular joint as the cause of shoulder pain with a high degree of confidence.

Level of Evidence: Diagnostic study, Level I-1 (testing of previously developed diagnostic criteria in series of consecutive patients [with universally applied reference "gold" standard]). See Instructions to Authors for a complete description of levels of evidence.

Disorders that cause a painful shoulder often exhibit similar clinical symptoms, thus confusing the differential diagnosis[1]. Acromioclavicular joint pain is a common shoulder problem[2]. Several clinical diagnostic tests have been developed for physical examination of the acromioclavicular joint. These include eliciting local tenderness at the joint, the active compression test (O'Brien sign), and cross-arm adduction. Imaging modalities including radiography, magnetic resonance imaging, and bone scans are often used to evaluate the acromioclavicular joint, but no data on their diagnostic values are available in the current literature, to our knowledge. The aims of this study were to evaluate the predictive value of clinical tests and imaging modalities for diagnosing acromioclavicular joint pain and to compare them with the Paxinos test, a clinical test in which the clavicle and acromion are compressed together.

Materials and Methods

Subjects

The protocol for this study was reviewed by the South East Health Human Research Ethics Committee (Southern Section, Sydney, Australia), which determined that, because the data were collected as part of the standard procedure of the Shoulder Clinic, the study did not require Committee approval. All 1037 patients with shoulder pain who attended the shoulder clinic of the senior author between August 1999 and

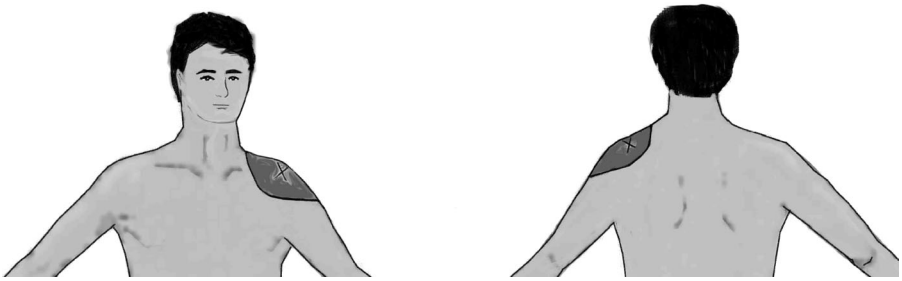

Fig. 1

Area of pain considered for inclusion in the study.

August 2002 were asked to map, on a pictorial diagram of the human body (both anterior and posterior), the point of maximal shoulder pain and the sites of pain radiation. One hundred and thirteen patients who localized the pain within the area bounded by the midpart of the clavicle and the deltoid insertion on this diagram (Fig. 1) were eligible for inclusion in the study. This area was chosen because it represents the site map for pain following provocative injection into the acromioclavicular joint[3]. Exclusion criteria included (1) previous distal clavicular or acromioclavicular joint surgery, (2) clavicular fracture (acute or nonunion), (3) previous or known allergies to lidocaine or the radiopaque contrast medium, (4) pregnancy, (5) any other contraindication to magnetic resonance imaging or nuclear scanning, (6) objections to participating in the study, or (7) markings on the pain diagram that extended beyond the area defined in Figure 1. Forty-two patients met the criteria for inclusion in this prospective study. Four of them were lost to follow-up, leaving thirty-eight patients (sixteen men and twenty-two women) for data analysis over the two-year follow-up period.

Instruments and Tests

Information including age, gender, occupation, and hand dominance was obtained from each patient. A questionnaire provided information on the duration, severity, and timing of the pain and the nature and timing of any injury to the extremity sustained prior to the onset of the shoulder problem. All subjects were given a systematic clinical examination consisting of twenty tests[4]. Each was examined for atrophy of the supraspinatus, infraspinatus, and deltoid muscles; tenderness of the sternoclavicular joint, acromioclavicular joint, subacromial region, and biceps region; passive range of motion of the neck and of the shoulder in forward flexion, abduction, and internal and external rotation measured by visual estimation[5]; the Paxinos sign (see below); the O'Brien sign[6]; the drop arm sign[7]; impingement during internal rotation[8] and during external rotation; and weakness, in internal and external rotation, of the supraspinatus[9] and of the subscapularis with the lift-off test. Strength was assessed with the use of manual muscle tests and graded on a scale of 0 to 5[8].

Paxinos sign: The examiner performed the test for the Paxinos sign with the patient sitting comfortably on the examining couch and the affected arm by the side of the chest wall. The examiner's hand was placed over the affected shoulder such that the thumb rested under the posterolateral aspect of the acromion and the index and long fingers of the same or contralateral hand were placed superior to the midpart of the ipsilateral clavicle (Fig. 2). The examiner then applied pressure to the acromion with the thumb, in an anterosuperior direction, and inferiorly to the midpart of the clavicular shaft with the index and long fingers. The test response was considered positive if pain was felt or increased in the region of the acromioclavicular joint and negative if there was no change in the pain level. The test response was recorded on a form designed for the study. Each practitioner who examined the pa-

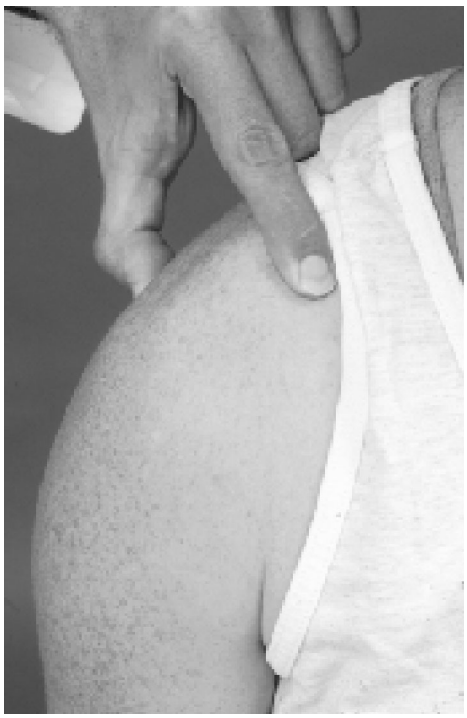

Fig. 2

The position of the examiner's hand for the Paxinos test.

TABLE I Sensitivity, Specificity, Predictive Values, Accuracy, and Likelihood Ratios for the Clinical and Imaging Diagnostic Tests

	Sensitivity *(%)*	Specificity *(%)*	Positive Predictive Value *(%)*	Negative Predictive Value *(%)*	Accuracy *(%)*	Likelihood Ratio for Positive Test *(%)*
Paxinos test	79	50	61	70	65	1.58
Acromioclavicular joint tenderness	96	10	52	71	53	1.07
O'Brien test	16	90	62	52	53	1.60
Radiographs	41	90	80	60	66	4.10
Bone scan	82	70	73	80	76	2.73
Magnetic resonance imaging	85	50	63	77	68	1.70

tient was blinded to the result of the acromioclavicular joint injection, which served as the standard criterion.

O'Brien sign: The test for the O'Brien sign[6] is designed primarily to detect labral tears, but it is also purported to detect abnormality of the acromioclavicular joint when performed as described here. The physician, standing behind the patient, asks the patient to forward flex the affected arm 90° with the elbow held in full extension. The arm is adducted 10° to 15° medial to the sagittal plane of the body and then is internally rotated so that the thumb points downward while the examiner applies uniform downward force to the arm. With the arm maintained in the same position, the maneuver is repeated with the palm fully supinated. The test is positive if the first maneuver causes pain on top of the shoulder or pain localized to the acromioclavicular joint and the pain is less intense or is absent with the second maneuver. O'Brien et al. reported that thirty-two (52%) of sixty-two patients who had a positive result for an acromioclavicular joint abnormality with this technique had radiographic confirmation of the abnormality[6].

Reference Test Standard

For the reference test standard, an acromioclavicular joint infiltration test was performed, under imaging control, on all patients by an experienced musculoskeletal radiologist who was blinded to the patients' clinical data. Before infiltration of the joint, a plain anteroposterior radiograph of the acromioclavicular joint and direct lateral radiographs of the involved shoulder were made. A 25-gauge 1.5-in (38.1-mm) needle was inserted into the acromioclavicular joint, through the direct anterior approach, under full aseptic conditions. Care was taken to prevent leakage by first injecting 0.5 mL of Omnipaque 240 (iohexol, 240 mg/mL) into the acromioclavicular joint. An anteroposterior radiograph was made to confirm the needle position in the joint. With the needle left in position, 1 mL of 2% (v/v) lidocaine and 1 mL (40 mg) of methylprednisolone were injected.

Patients were sent back to the clinic (with the radiologist's injection form) for evaluation by the initial examiner. Patients who felt that the superior shoulder pain had been alleviated by at least 50% within ten minutes after the lidocaine injection were considered to have acromioclavicular joint pain; i.e., they had a positive reference test standard. Patients who did not have at least 50% relief were considered to not have acromioclavicular joint pain. This response was entered onto a post-injection assessment sheet.

Imaging Studies

Radiographs: Plain radiographs were evaluated for any abnormalities of the acromioclavicular joint, including joint space narrowing, marginal osteophytes, or subchondral cysts. An experienced musculoskeletal radiologist classified the radiographs of the acromioclavicular joint as normal or abnormal.

Magnetic resonance imaging: All shoulders were examined with a 1.5-T magnetic resonance imaging scanner (Signa; GE Medical Systems, Milwaukee, Wisconsin). Spin-echo T1-weighted images and fast-spin-echo T2-weighted images in the coronal and sagittal planes were obtained in 3-mm-thick, 1-mm-gap slices with a 10 to 15-cm field of view and 256 × 128-pixel matrix size. A combination of dual-phased-array coils and a small field of view achieved high-resolution magnetic resonance imaging scans. A musculoskeletal radiologist experienced in magnetic resonance imaging ranked the acromioclavicular joint as normal or abnormal.

Bone-scanning: A nuclear bone scan of the acromioclavicular joint was done with technetium-HDP 800-MBq dynamic and blood pool imaging, with delayed imaging at two hours with use of a gamma camera with parallel-hole, low-energy, all-purpose collimators in anterior and posterior views with pin-hole imaging in the anterior view. All scans were performed at the same center and reported on by one radiologist. Again, the images of the acromioclavicular joint were graded as normal or abnormal.

Statistical Analysis

Sensitivity, specificity, positive and negative predictive values, likelihood ratios, pre-test odds and probabilities, and post-test odds and probabilities of the clinical diagnostic tests were determined with the methods described by Sackett et al.[10]. A likelihood ratio expresses the odds of a diagnostic test result being found in a patient with, as opposed to a patient without, abnor-

TABLE II Retained Independent Variables in the Stepwise Regression Model

Group	Coefficient	Standard Coefficient	Standard Error	P Value
Constant	0.164	—	0.173	—
Paxinos test	0.319	0.319	0.149	0.040
Bone scan	0.527	0.581	0.135	<0.001

mality of the acromioclavicular joint. In the case of single tests, the formula for determining the likelihood ratio (LR) is LR = sensitivity/1 − specificity. For comparing test combinations between patients with and without acromioclavicular joint abnormality, the likelihood ratio is comparable with the relative risk (the proportion of patients with acromioclavicular joint pain/proportion of patients without acromioclavicular joint pain). Pre-test probability = prevalence; pre-test odds = pre-test probability/1 − (pre-test probability); post-test odds for the target disorder = pre-test odds × likelihood ratio; and post-test probability = post-test odds/post-test odds + 1[10].

To investigate the value of clinical and imaging tests for predicting pain due to acromioclavicular joint abnormality, forward stepwise regression was used with the result of the acromioclavicular joint infiltration as the dependent variable. At each step, an explanatory variable was automatically added to the model, provided that the variable was significant. All statistical calculations were performed with SigmaStat for Windows (SPSS, Chicago, Illinois).

Results

Of the thirty-eight patients who indicated that the pain was localized around the acromioclavicular joint, as opposed to spreading down the arm or up toward the neck, twenty-eight were confirmed to have acromioclavicular joint abnormality by their response to the acromioclavicular joint injection. Thus, the prevalence of acromioclavicular joint abnormality in this patient population was 74%. This high prevalence indicates that a pain diagram is itself a good screening tool for acromioclavicular joint pain. Ten patients had no relief of pain after the injection. These positive and negative (control) groups were compared with regard to their responses to the clinical and imaging tests.

The most sensitive clinical test for identifying acromioclavicular joint abnormality as the cause of shoulder pain was examination for local acromioclavicular joint tenderness (96% sensitivity), followed by the Paxinos test (79%). Magnetic resonance imaging (85%) was the most sensitive type of diagnostic imaging, followed by the bone scan (82%).

The tests that best identified patients without an acromioclavicular joint abnormality (i.e., the most specific tests) were the O'Brien test and radiographs; each had a specificity of 90%. The O'Brien sign and the Paxinos sign had positive predictive values of 62% and 61%, respectively. Positive predictive values were higher for radiographs (80%) and bone scans (73%). The highest negative predictive values were for bone scans and magnetic resonance imaging scans (80% and 77%, respectively), followed by acromioclavicular tenderness and the Paxinos test (71% and 70%, respectively).

Accuracy values were highest for bone scans (76%), magnetic resonance imaging scans (68%), and radiographs (66%), followed by the Paxinos test (65%). When each test was considered on its own, radiographs were found to have the highest likelihood ratio (4.1:1) as a result of the high specificity. The diagnostic values for these tests are summarized in Table I.

Stepwise regression analysis was carried out with use of the response to the injection as the dependent variable and age, the Paxinos test, the O'Brien test, acromioclavicular joint tenderness, radiographs, bone-scanning, and magnetic resonance imaging as the independent variables. Age, the O'Brien test, acromioclavicular joint tenderness, radiographs, and magnetic resonance imaging did not significantly add to the ability of the equation to predict who had true acromioclavicular joint pain. Thus, they were not included in the final equation. The only independent variables retained in the stepwise regression model were bone-scanning and the Paxinos test (Table II).

Table III shows the values for r, the multiple correlation coefficient, and r^2, the coefficient of determination for stepwise regression, which are both measures of how well the regression model describes the data. The standard error of the estimate is a measure of the actual variability about the regression plane of the underlying population. When only bone-scanning was taken into account, r^2 was 0.26. When the Paxinos test result was also included, r^2 increased to 0.35. These values are modest. With the alpha set at 0.05, the power of the performed test was 0.967.

Twenty-eight of the thirty-eight people who indicated that their pain was located at the acromioclavicular joint and

TABLE III Fit of the Regression Model to the Data

	R	R^2	Delta R^2	Standard Error of the Estimate	Variable in Model
Bone scan	0.506	0.256	0.256	0.377	1
Paxinos test	0.593	0.352	0.0964	0.358	2

TABLE IV Comparison of Subjects with and without Acromioclavicular Joint Pain*

	Proportion of Subjects with Acromioclavicular Joint Pain† (N = 28)	Proportion of Subjects without Acromioclavicular Joint Pain† (N = 9)	Likelihood Ratio††
Paxinos test and bone scan both positive	(N = 17) 0.61	(N = 0) 0.01	55:1; diagnosis established
One test positive and the other test negative	(N = 11) 0.40	(N = 8) 0.90	0.44:1; intermediate-to-low likelihood of diagnosis
Paxinos test and bone scan both negative	(N = 0) 0.003	(N = 1) 0.12	0.03:1; diagnosis ruled out

*One subject was excluded because of missing bone-scan data. †Calculated by adding 0.1 to each cell entry in the 2 × 2 table, as for the odds ratio[14]. ‡According to Sackett (personal communication), a likelihood ratio of ≥10 is sufficient to establish the target condition.

radiated to the marked area had pain relief from local lidocaine injection. As the prevalence and the pre-test probability are equal, the pre-test probability that patients from this population had acromioclavicular joint pain was 74%.

Using the regression model tests (i.e., the Paxinos test and bone-scanning) in combination increased their predictive abilities. In our study, almost 61% of the patients had a positive result on both tests. All of these patients had had a positive response to the lidocaine injection. No patient who had a positive response to the injection had a negative result on both tests. Table IV shows the likelihood ratios for patients with different results from this test combination.

According to our results, if a new patient who had indicated that the pain was located at the acromioclavicular joint and radiating to the marked area had a positive Paxinos test as well as a positive bone scan, the odds that that patient had acromioclavicular joint pain as opposed to another type of shoulder pain would be 55:1. With these odds, the post-test probability is more than 99%; i.e., one can have 99% confidence that acromioclavicular joint pain is present if both tests are positive. On the other hand, this condition could not be predicted if the bone scan and the Paxinos test produced one positive result and one negative result (Table IV, row 2). In that case, additional tests would be required (e.g., an acromioclavicular injection test). If the patient had a negative result on both the Paxinos test and the bone scan, acromioclavicular joint damage could be ruled out as the source of the pain (Table IV, row 3).

Discussion

Two major findings in this study were that (1) a large proportion of patients who localized the pain to an area bounded by the midpart of the clavicle and the deltoid insertion had pain due to an acromioclavicular joint abnormality that responded to injection of a local anesthetic and corticosteroid and (2) the predictive values of clinical tests and imaging modalities for determining acromioclavicular joint abnormality were either highly sensitive or highly specific but not both. Each test was, by itself, relatively poor at predicting the acromioclavicular joint as the cause of shoulder pain. However, the combination of two tests—namely, the bone scan and the Paxinos test—was highly predictive for acromioclavicular joint abnormality ($p < 0.001$).

This report also describes the Paxinos test, which is an acromioclavicular joint compression test that assists in differentiating the condition of acromioclavicular joint pain from other causes of shoulder pain. Unlike the test for the O'Brien sign or the cross-arm adduction test, which are based on the principle of driving or rotating the scapula toward the midline by horizontal adduction of the arm and/or internal rotation of the shoulder to compress the acromioclavicular joint and elicit pain, this test maneuver involves direct compression of the acromioclavicular joint surfaces. We found the Paxinos test to be more sensitive than the O'Brien test. The cross-arm adduction test may be positive in other shoulder disorders, such as those involving posterior capsular tightness, an impingement lesion, or a rotator cuff tear[2].

Several investigators[11-13] have found that radiographs and magnetic resonance imaging are not specific for the acromioclavicular joint. They have noted that changes suggestive of degeneration that are seen on imaging studies may be asymptomatic. Stein et al.[11] found that forty-one (82%) of fifty asymptomatic shoulders were seen to have changes in the acromioclavicular joint on magnetic resonance imaging. Also, the high sensitivity and low specificity of magnetic resonance imaging suggest that a positive scan cannot establish a diagnosis of acromioclavicular joint pain. We found that bone scans were quite efficient for the diagnosis of acromioclavicular joint pain as they had relatively high sensitivity and specificity.

This study is unique because, to our knowledge, no one has previously compared the values of different tests used to diagnose acromioclavicular joint pain. Our study of patients with shoulder pain consisted of adults of all ages and both sexes.

Two potential weaknesses of this study deserve mention. First, the study group consisted of a relatively small number of patients who fulfilled the inclusion criteria. Second, there was no interobserver validation of the grading system that we used.

In conclusion, direct compression of the acromioclavicular joint (the Paxinos test) is a good clinical diagnostic tool, and bone-scanning is the best imaging modality for the diagnosis of acromioclavicular joint pain. When both of these tests are positive in a patient with shoulder pain, the diagnosis of acromioclavicular joint pain is virtually certain. ■

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