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A concise evidence-based physical examination for diagnosis of acromioclavicular joint pathology: a systematic review

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Abstract

Objectives: The clinical examination of the shoulder joint is an undervalued diagnostic tool for evaluating acromioclavicular (AC) joint pathology. Applying evidence-based clinical tests enables providers to make an accurate diagnosis and minimize costly imaging procedures and potential delays in care. The purpose of this study was to create a decision tree analysis enabling simple and accurate diagnosis of AC joint pathology.

Methods: A systematic review of the Medline, Ovid and Cochrane Review databases was performed to identify level one and two diagnostic studies evaluating clinical tests for AC joint pathology. Individual test characteristics were combined in series and in parallel to improve sensitivities and specificities. A secondary analysis utilized subjective pre-test probabilities to create a clinical decision tree algorithm with post-test probabilities.

Results: The optimal special test combination to screen and confirm AC joint pathology combined Paxinos sign and O'Brien's Test, with a specificity of 95.8% when performed in series; whereas, Paxinos sign and Hawkins-Kennedy Test demonstrated a sensitivity of 93.7% when performed in parallel. Paxinos sign and O'Brien's Test demonstrated the greatest positive

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Declaration of interest
The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

likelihood ratio (2.71); whereas, Paxinos sign and Hawkins-Kennedy Test reported the lowest negative likelihood ratio (0.35).

Conclusion: No combination of special tests performed in series or in parallel creates more than a small impact on post-test probabilities to screen or confirm AC joint pathology. Paxinos sign and O'Brien's Test is the only special test combination that has a small and sometimes important impact when used both in series and in parallel. Physical examination testing is not beneficial for diagnosis of AC joint pathology when pretest probability is unequivocal. In these instances, it is of benefit to proceed with procedural tests to evaluate AC joint pathology. Ultrasound-guided corticosteroid injections are diagnostic and therapeutic. An ultrasound-guided AC joint corticosteroid injection may be an appropriate new standard for treatment and surgical decision-making.

Level of Evidence: II – Systematic Review.

Keywords

Acromioclavicular joint; physical examination; special tests; pathology; diagnosis; shoulder examination

Introduction

Shoulder pain is a common disabling condition [1–7]. The complex anatomy of the shoulder creates an amalgam of potential sources [3,4,6,8–12]. Common pain generators include pathology of the rotator cuff, proximal long head of the biceps, acromioclavicular (AC) joint, and glenohumeral joint [1,2,6,13].

Currently, a thorough shoulder examination encompasses a myriad of special maneuvers [11,14–17]. Moreover, technique, experience, and variability performing special tests complicate the examination [12,18–21]. With the low level of statistical accuracy and precision of the described special tests for diagnosing AC joint pathology, a combination of maneuvers is recommended to be more useful than isolated tests in these scenarios [14].

Diagnostic imaging has improved the speed and accuracy of diagnoses [22–24]. However, rising health-care costs are consequently partially attributable to increased utilization of diagnostic imaging [25]. To further complicate imaging studies, findings can be inconclusive or inaccurate [24]. A study by Gill et al. reported shoulder pathology was apparent on magnetic resonance imaging (MRI) in both symptomatic and asymptomatic shoulders and concluded imaging findings do not predict clinical symptoms [24]. In addition to the high direct cost of advanced imaging techniques, there may be increased indirect costs from delay in care, including additional follow-up visits to review imaging results, repeat clinical evaluations after inaccurate or incidental imaging findings, and associated costs related to adverse reactions [23–25].

Previous studies focused on the diagnostic accuracy of special tests; however, no special test is deemed superior to screen and confirm AC joint pathology [8,11,14–20,26,27]. A combination of special tests in series and in parallel may enable synergistic testing parameters to improve clinical decision-making. If so, creating a clinical tool based on pretest probabilities may enable the clinician to improve clinical diagnostic accuracy.

The purpose of this study was to conduct a systematic review to identify level I and II diagnostic clinical studies evaluating physical examination maneuvers for AC joint pathology and test the additive value of special test combinations in series and parallel testing. A secondary purpose was to create a decision-tree analysis based on statistical characteristics of the optimal combination of special tests for AC joint pathology and assigned subjective pre-test likelihood scenarios, enabling a simple clinical reference tool with post-test probabilities.

Materials and methods

A systematic review of the Medline, Ovid, and Cochrane Review databases utilizing the search terminology 'acromioclavicular,' 'AC,' 'acromio-clavicular,' 'joint,' 'clinical,' and 'examination' was conducted 24 January 2017. Search terminology was combined with the Boolean operators 'AND' and 'OR.' The findings were independently evaluated by three co-authors (KK, AD, MK) and any disagreement between co-authors was decided by the lead author (FM). The inclusion criteria included level of evidence I and II studies published in peer-reviewed scientific journals focused on the physical examination, specifically evaluation of the AC joint. The exclusion criteria consisted of studies that were non-English, not available in full-text, level of evidence III or lower, did not evaluate pathology of the AC joint, or did not apply a validated 'gold standard.' The reference lists of all studies that underwent full-text evaluation were further scrutinized by the three coauthors (KK, AD, MK) to find additional studies to evaluate.

Statistical data were extracted from the included studies. Pertinent extracted data included specificity and sensitivity for each special test described. Likelihood ratios were calculated based on the extracted data for the decision tree analysis [28–30].

The combination of special tests is based on the principles of series and parallel testing (Figure 1). Series testing is conducted in sequence and both must be positive to make the diagnosis [30]. The combination of special tests when performed in series results in an increased specificity by decreasing the number of false positives compared to the specificity of either special test individually [30]. Parallel testing is when both tests are performed simultaneously and either test can be positive to make a diagnosis [30]. The combination of special tests conducted in parallel results in an increased sensitivity by decreasing the number of false negatives compared to either individual test [30]. The statistical characteristics of a two-step combination of special tests were calculated.

A subjective pretest probability was established for the clinical decision tree analysis. The subjective pretest probability assigned by the clinician is based on the pretest clinical presentation of the patient and should consider disease prevalence, patient presentation, history of present illness, and past medical history. The subjective pretest probability options include very unlikely presence of disease (20%), unlikely presence of disease (40%), likely presence of disease (60%), and very likely presence of disease (80%). The clinical decision tree analysis calculates post-test diagnostic probability by combining the subjective pre-test probability established by clinician judgment and the statistical characteristics of physical examination combinations (Figure 2) [29,30]. If any special test combination demonstrated a significant effect on post-test diagnostic probabilities, a clinical decision tree algorithm would be established.

Results

The initial search through Medline, Ovid, and Cochrane Review databases identified 2525 studies, including 10 duplicates that were removed from consideration. Following PRISMA guidelines (Figure 3), identified studies were systematically evaluated. Sixteen ($N = 16$) additional studies were acquired for evaluation from reviewing references. Through the initial evaluation, 301 studies were excluded for non-English text with an additional 2117 studies eliminated for irrelevant titles or abstracts. Further evaluation of the remaining 113 articles identified 22 without available full-text and another 68 were excluded as the study objectives were not applicable. An additional 12 studies did not have applicable results and nine ($N = 9$) studies were excluded for not being a level I or II study.

Based on analysis of the two included studies (Table 1), the special tests evaluated were Paxinos sign, O'Brien's test (AC joint active compression), cross-body adduction, Hawkins–Kennedy, and AC joint tenderness to palpation (Table 2). The extracted statistical characteristics for the evaluated special tests are listed in Table 3.

Special test combinations were assessed through series and parallel testing strategies (Table 4(a,b)). Through series testing, the combination of O'Brien's Test and AC joint tenderness demonstrated the greatest specificity (96.7%). Although, the combination of Paxinos sign and O'Brien's test had the highest calculated positive likelihood ratio (2.71). These two combinations of special tests performed in series were the only special test combinations that demonstrated a small, but sometimes important positive likelihood ratio to impact post-test probabilities [30]. Through parallel testing, Paxinos sign and Hawkins–Kennedy Test demonstrated the greatest sensitivity (93.7%). The combination of Paxinos sign and Hawkins–Kennedy test had the lowest calculated negative likelihood ratio (0.35). However, similar to series testing, no special test combinations performed in parallel had a negative likelihood ratio that had more than a small and sometimes important impact on post-test probabilities [30].

The special tests combinations with the most significant likelihood ratios were utilized to calculate post-test probabilities according to the assigned subjective pre-test probabilities established (Figure 4(a, b)). Paxinos sign and O'Brien's test had the greatest post-test probabilities if both tests (series testing) were positive (40.4%, 64.4%, 80.2%, and 91.6% at the four established pre-test probabilities). Paxinos sign and Hawkins-Kennedy test had the smallest post-test probabilities if both tests (parallel testing) were negative (14.1%, 30.5%, 49.6%, and 72.4%, respectively).

Discussion

The AC joint has multiple anatomic connections with the shoulder [1,2,8,10]. Due to the complex anatomy of the shoulder, the physical examination can be of poor diagnostic value in select patients, especially when coupled with a non-specific history and clinical presentation [1,2,8,10,14,16]. In many instances, clinicians rely on imaging to aid in accurate diagnosis of shoulder pathology. Unfortunately, up to 93% of individuals over the age of 30 may demonstrate asymptomatic AC joint osteoarthritis on MRI [13,31]. The high rate of potential asymptomatic AC joint findings on advanced imaging stresses the importance of the optimal physical examination to discern if the AC joint osteoarthritis is the true source of pain. In addition, timely advanced imaging may not be readily available in all medical practices. A reliable physical examination with maximal diagnostic accuracy of AC joint pathology may allow for a timely, accurate diagnosis in-office and simultaneously initiate point-of-care treatment with an intra-articular injection. The purpose of this study was to conduct a systematic review to identify clinical studies evaluating the diagnostic accuracy of physical examination maneuvers for AC joint pathology. A secondary purpose was to create a decision-tree algorithm based on the evidence-based clinical examination for AC joint pathology and clinician-assigned, subjective pre-test likelihood probabilities.

This systematic review revealed a paucity of high-level evidence regarding physical examination maneuvers to accurately screen or diagnose AC joint pathology. In addition, the combination of special tests demonstrated a minimal ability to impact post-test probabilities based off of pre-test probabilities. The current literature reinforces challenges that physicians face, especially those with limited experience evaluating the shoulder [32]. No individual special test demonstrated ideal special test characteristics with a high sensitivity and specificity. For example, O'Brien's test (AC joint active compression) had the highest reported specificity, but also had the lowest reported sensitivity. Utilizing a variety of special tests in a disorganized fashion may provide a murky clinical picture leading to patient mismanagement. Particularly for AC joint pathology, the combination of physical examination tests in series and in parallel analysis demonstrated minimal improvement in overall sensitivity and specificity compared to any individual special test, but not both in the same testing strategy. This is demonstrated in the statistical characteristics of Paxinos sign and O'Brien's test (Specificity: 0.96, Sensitivity: 0.82), significantly greater compared to either test individually. However, these statistical characteristics are only from the best combination from series (Specificity: 0.96, Sensitivity: 0.11) or parallel (Specificity: 0.46, Sensitivity: 0.82) testing. Despite improved statistical characteristics, the combination of special tests has minimal effect on post-test probabilities.

Previous epidemiological studies described the values of likelihood ratios required to create potentially significant changes from pre-test to post-test probabilities [30,33]. If the likelihood ratios are not large or small enough to impact post-test probabilities, the value of the studied diagnostic tool is limited and a potential waste of resources [30,32]. The findings of our evidence-based clinical examination provided limited benefit to post-test probabilities. For test combinations performed in parallel, small and only sometimes important likelihood ratios were calculated that demonstrate minimal effect on post-test probabilities [30,33]. These findings reinforce that to accurately diagnose AC joint pathology, prevalence of pathology, patient presentation, history of present illness, and past medical history (all which are important to assign a pre-test probability) are as important to screen for AC joint pathology than any combination of special tests. In addition, for test combinations performed in series, there were only two test combinations that were classified as small, but sometimes demonstrate important change [30,33]. Since there are minimal, nonsignificant changes to the pre-test probability with the evidence-based AC joint physical examination, there was limited benefit to create the decision tree algorithm.

The importance of our findings are dependent on the goal of the clinician. If a screening test is desired, the combination of Paxinos sign and Hawkins–Kennedy test have a sensitivity of 0.93 if both special tests are negative. However, the clinical benefit of special tests in series may be limited to confirm the diagnosis of AC joint pathology. Another diagnostic option for AC joint pathology is a corticosteroid injection (CSI) at the AC joint. The reduction of shoulder pain after an AC joint CSI is both diagnostic and therapeutic. Landmark-guided cadaveric AC joint injections have found varying accuracy at infiltrating the AC joint from 40% to 72% [1,34–36]. Recently, greater ultrasound availability in-office increased the number of office imaging studies and procedures performed [37]. With the addition of ultrasound-guidance to AC joint injections, the accuracy of injections in the AC joint has improved to 90–100% [1,34–36]. The utilization of special tests in combination for the physical examination may benefit clinicians to diagnose and manage patients when US is not easily available, surgery is not considered, or the clinician or patient are hesitant regarding AC joint injections. For orthopedic surgeons with US available in-office, an US-guided AC joint injection may be a new standard for surgical decision-making as a diagnosis based on history and physical examination may be insufficient. The use of US allows the patient and clinician to monitor real-time results, cheaper, and quicker than other common imaging modalities like MRI or fluoroscopic-guided injections [37–39]. The findings of special tests in combination in parallel and series testing proves that two tests are statistically better than any individual test; however, physical examination testing is not beneficial for diagnosis of AC joint pathology when pre-test probability is unequivocal. In these instances, it is of benefit to proceed with procedural tests to evaluate AC joint pathology.

This study is not without limitations. With a paucity of high-level studies addressing physical examination of the shoulder as it relates to a ‘gold standard,’ the authors must depend on what has been previously reported in the literature; however, the apparent lack of importance of the special tests in accurate diagnosis of AC joint pathology is still important. To prevent inaccurate language translations, only articles published in English were evaluated. There may have been important studies that were erroneously missed for this reason that may have affected the calculation of statistical characteristics and post-test probabilities.

Conclusion

No combination of special tests performed in series or in parallel creates more than a small impact on post-test probabilities to screen or confirm AC joint pathology. Paxinos sign and O’Brien’s test is the only special test combination that has a small and sometimes important impact when used both in series and in parallel. Physical examination testing is not beneficial for diagnosis of AC joint pathology when pre-test probability is unequivocal. In these instances, it is of benefit to proceed with procedural tests to evaluate AC joint pathology. Ultrasound-guided corticosteroid injections are diagnostic and therapeutic. An ultrasound-guided AC joint corticosteroid injection may be an appropriate new standard for treatment and surgical decision-making.

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In Series Testing†		
Sensitivity	=	Sensitivity Test A x Sensitivity Test B
Specificity	=	(Specificity Test A + Specificity Test B) - (Specificity Test A * Specificity Test B)
In Parallel Testing‡		
Sensitivity	=	(Sensitivity Test A + Sensitivity Test B) - (Sensitivity Test A * Sensitivity Test B)
Specificity	=	Specificity Test A * Specificity Test B

Figure 1.
Statistical characteristics of series and parallel testing.

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$$\text{Pre-Test Odds} = \text{Pre-Test Probability} / (1 - \text{Pre-Test Probability})$$

$$\text{Post-Test Odds} = \text{Pre-Test Odds} * \text{LR}$$

$$\text{Post-Test Probability} = \text{Post-Test Odds} / (\text{Post-Test Odds} + 1)$$

Figure 2.

Formulas for calculation of post-test probabilities for the clinical decision tree algorithm.

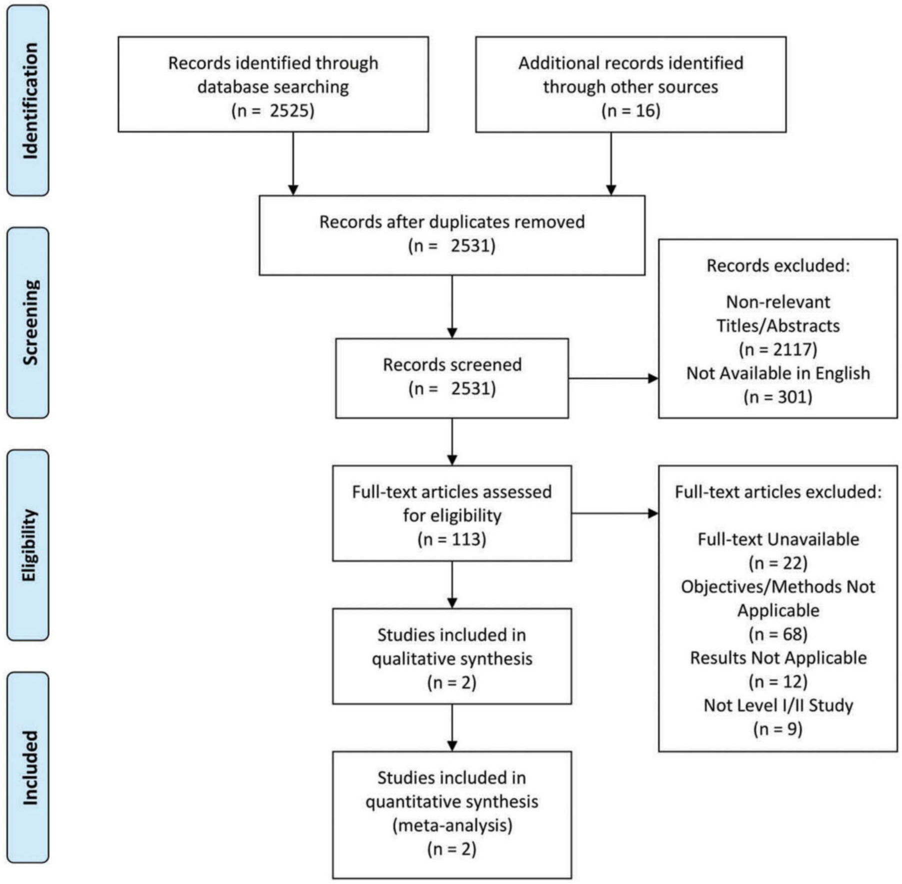
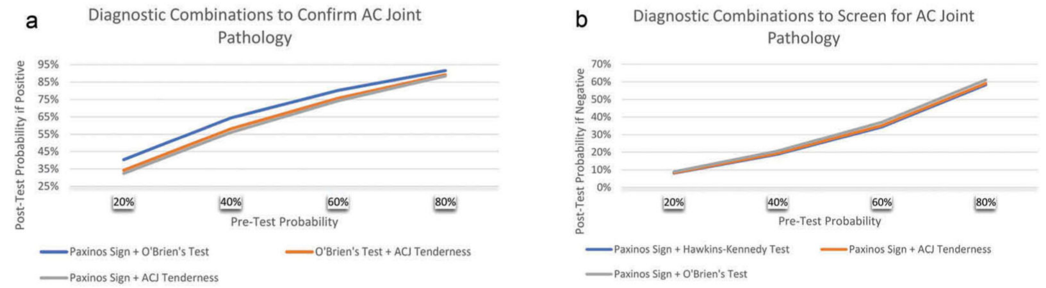


Figure 3.

PRISMA systematic review diagram: The figure displays the process and rationale for study omission from the systematic review.



Pre-Test Probability	Paxinos Sign + O'Brien's Test	O'Brien's Test + ACJ Tenderness	Paxinos Sign + ACJ Tenderness
	Post-Test Probability if Positive [95% CI]	Post-Test Probability if Positive [95% CI]	Post-Test Probability if Positive [95% CI]
20%	40% [29-53%]	34% [22-50%]	32% [28-37%]
40%	64% [53-74%]	58% [44-71%]	56% [51-61%]
60%	80% [71-87%]	76% [63-85%]	74% [70-78%]
80%	92% [84-96%]	89% [79-95%]	88% [85-91%]

Pre-Test Probability	Paxinos Sign + Hawkins-Kennedy Test	Paxinos Sign + ACJ Tenderness	Paxinos Sign + O'Brien's Test
	Post-Test Probability if Negative [95% CI]	Post-Test Probability if Negative [95% CI]	Post-Test Probability if Negative [95% CI]
20%	8% [5-13%]	8% [6-12%]	9% [7-12%]
40%	19% [13-26%]	19% [15-25%]	21% [17-28%]
60%	34% [26-43%]	35% [30-42%]	37% [32-42%]
80%	58% [48-68%]	59% [52-66%]	61% [56-66%]

Figure 4.

Diagnostic effect of special test combinations on post-test probabilities of the three strongest combinations in series (a) and parallel (b) testing.

Table 1.

Studies included.

Title	Authors	Journal	Level of evidence (study design)	Year	Number of subjects	Clinical exams and special tests evaluated	Gold-standard utilized by study
Diagnostic values of tests for acromioclavicular joint pain	Walton et al. [8]	The Journal of Bone and Joint Surgery	I (Prospective, diagnostic study)	2004	$n = 38$	• Paxinos sign • AC joint tenderness • O'Brien's/active compression	AC joint infiltration test under imaging control
Shoulder pain in primary care: diagnostic accuracy of clinical examination tests for non-traumatic acromioclavicular joint pain	Cadogan et al. [27]	BMC Musculoskeletal Disorders	I (Prospective, diagnostic study)	2013	$n = 153$	• Cross-body adduction • O'Brien's/active compression • Hawkins-Kennedy • AC joint tenderness	Fluoroscopically guided injection of local anesthetic into AC joint 1-week after imaging investigations

AC: acromioclavicular

Table 2.

Description of diagnostic tests.

Diagnostic test		Description	Positive test
AC joint tenderness	**1**	Direct palpation of the AC joint	Pain upon palpation at the AC joint
O'Brien's test/active compression test	**1**	Patient's arm in 90° of forward flexion with the examiner behind the patient	Pain at the AC joint when the examiner applies a force toward the floor and the patient attempts to resist the downward force
	2	Patient is passively taken into 10–15° of adduction in complete IR	
	3	Examiner applies force toward the floor and the patient attempts to resist the downward force	
Hawkins-Kennedy Test	**1**	Patient's arm in 90° of forward flexion with the elbow flexed to 90° and the scapula fixed	Pain upon performing described IR maneuver and may be as small as a 'resulting facial expression' demonstrating discomfort
	2	Examiner performs IR of the GH joint	
Cross-body adduction test	**1**	Passively abduct patient's arm to 90°	Pain upon maneuver when the patient's arm is moved across the chest
	2	Cross arm across the patient's chest with arm in IR	
Paxinos sign	**1**	Place examiner's hand on the affected shoulder with thumb under the posterolateral aspect of the acromion, index and long fingers rest superior to the clavicle	PPain or any increase of pain upon compression of the AC joint
	2	Examiner exerts a force superiorly and inferiorly on the clavicle simultaneously	

AC: acromioclavicular; IR: internal rotation; GH: glenohumeral.

Table 3.

Statistical characteristics of physical examination special tests.

Special tests	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Positive likelihood ratio	Negative likelihood ratio
Paxinos sign	0.79	0.50	0.61	0.70	1.58	0.42
AC joint tenderness[a]	0.48	0.60	0.26	0.84	1.31	0.78
O'Brien's/active compression[a]	0.14	0.92	0.31	0.79	1.70	0.94
Cross-body adduction	0.64	0.26	0.13	0.81	0.86	1.39
Hawkins-Kennedy	0.70	0.36	0.15	0.88	1.09	0.84

AC: acromioclavicular.

[a]Weighted-analysis of statistical characteristics.

Table 4.

Results of optimal physical examination test combinations in (a) series and (b) parallel.

(a) Test combinations	**Sensitivity**	**Specificity**	**PLR**
Paxinos sign + O'Brien's test	0.11	0.96	2.71[a]
O'Brien's test + ACJ tenderness	0.07	0.97	2.08[a]
Paxinos sign + AG tenderness	0.38	0.80	1.91[b]
O'Brien's test + H-K	0.10	0.95	1.87[b]
O'Brien's test + CB ADD	0.09	0.94	1.48[b]
AG tenderness + H-K	0.34	0.75	1.32[b]
(b) Test combinations	**Sensitivity**	**Specificity**	**NLR**
Paxinos sign + H-K	0.94	0.18	0.35[a]
Paxinos sign + AG tenderness	0.89	0.30	0.3 6[a]
Paxinos sign + O'Brien's test	0.82	0.46	0.3 9[a]
Paxinos sign + CB ADD	0.92	0.13	0.5 8[b]
AG tenderness + H-K	0.84	0.22	0.72[b]
CB ADD + H-K	0.89	0.09	1.15[b]
AG tenderness + CB ADD	0.81	0.16	1.19[b]

PLR: positive likelihood ratio; H–K: Hawkins–Kennedy; CB ADD: cross-body adduction; ACJ: acromioclavicular joint; NLR: negative likelihood ratio.

Interpretation of likelihood ratios:

[a]Small, sometimes important;

[b]Small, rarely important.