Validity of Cyriax's Functional Examination for Diagnosing Shoulder Pain: A Diagnostic Accuracy Study

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Abstract

Objective: The purpose of this study was to compare the diagnostic accuracy of lesion localization between Cyriax's functional examination and ultrasonography in participants with and without shoulder pain.

Methods: A total of 206 adults aged 20 years and older with or without shoulder pain were included. All participants received Cyriax's functional examination by the first blinded physiatrist. Within a week, ultrasonography was performed by another blinded specialist. The diagnoses made by both methods, respectively, were compared finally. Sensitivity, specificity, and positive and negative predictive values were evaluated for the diagnosis of shoulder lesions between Cyriax's functional examination and ultrasonography.

Results: There was no significant difference between the 2 groups regarding age, sex, and body mass index. Moderate to high sensitivity (74.1%, 76.5%, and 66.7%) and high specificity (93.0%, 99.5%, and 99.0%) were in supraspinatus, subscapularis, and infraspinatus lesions, respectively. For the subacromial-subdeltoid bursitis, high sensitivity (90.4%) and moderate to high specificity (70.3%) was found. In contrast, low sensitivity (15.0%) and high specificity (100.0%) were found in the biceps lesions.

Conclusion: In this study, we found that Cyriax's functional examination had high sensitivity in detecting subacromial-subdeltoid bursitis and high specificity in rotator cuff lesion. (J Manipulative Physiol Ther 2019;42:407-415)

Key Indexing Terms: *Ultrasonography; Physical Examination; Shoulder Pain*

Introduction

Shoulder pain is a common musculoskeletal problem that causes substantial disability in daily living, work, leisure activity, and exercise. The presence of shoulder problems such as rotator cuff pathology is highly predictive of impaired health-related quality of life.[1] Lifetime prevalence of shoulder pain is 6.7% to 66.7%, and the prevalence of shoulder pain at general practitioners' offices is 2.36%, with a significant increase in rates in the elderly.[2,3]

Many tests are used for physical examination of the shoulder. The reliability and validity of the tests has been studied previously.[4,5] The painful arc test, Hawkins-Kennedy test, Neer sign test, empty can test, Yergason's test, Speed's test, and resisted test are widely used in clinical practice.[4] However, there is conflicting evidence of the reliability of each of the tests alone or combined.[5] Another meta-analysis suggested that one single test for diagnosis was not recommended; however, combinations of physical examination may contribute to better accuracy.[6] Therefore, a thorough history taking with comprehensive physical examination may provide useful information before diagnosis, evaluation (eg, image study), and treatment.

Dr. Cyriax developed a systemic approach to musculoskeletal medicine for diagnostic and therapeutic purposes. Based on Cyriax's diagnostic approach, functional examination of the shoulder consists of a series of tests to evaluate a shoulder problem.[7] It includes 3 arm elevation tests, 3 tests for glenohumeral joints, and 6 resisted tests.

Over the past 10 years, ultrasound (US) has been used extensively in the diagnosis of musculoskeletal disorders. High sensitivity and specificity of this tool has been reported in diagnosing rotator cuff tear (sensitivity 0.84-0.96; specificity 0.89-0.93) and bursitis (sensitivity 0.79-0.81; specificity 0.94-0.98).[8] In addition, the non-ionic, real-time, and accessible characteristics of US make it easily accepted by patients.[9] Not only rotator cuff lesions but also non-rotator cuff disorders such as bursitis, arthritis,

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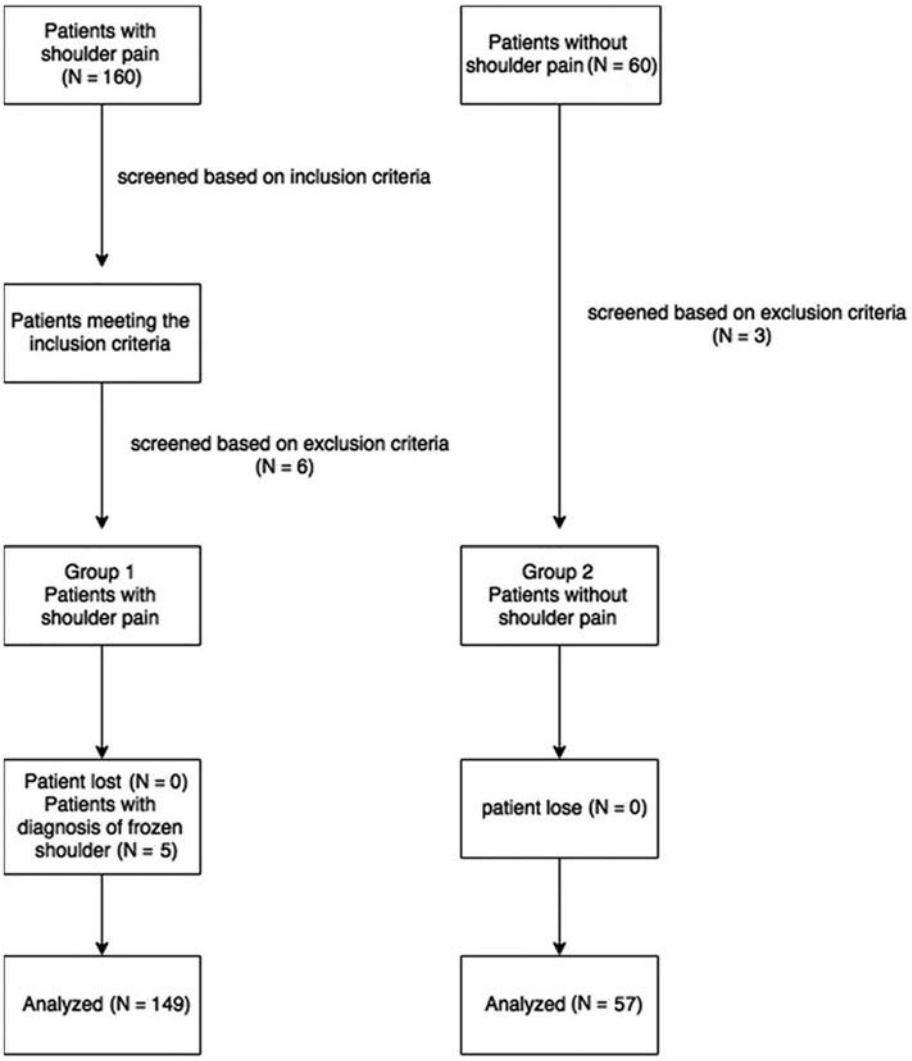

Fig 1. *Flowchart of study participants.*

and shoulder instability (eg, labral tear, avulsions of the tuberosities, or humeral head displacement) can be recognized.[10] Magnetic resonance imaging (MRI) after routine shoulder US was requested in only 5.2% of the patients.[11] Therefore, US is cost-effective as a first-line screening tool for shoulder complaints.[11,12]

Although Cyriax's functional examination and musculoskeletal US are commonly used in clinical practice, to the best of our knowledge, the validity of Cyriax's functional examination and its correlation with US findings have not been reported before. The aim of this study was to compare the clinical diagnosis of Cyriax's functional examination with US findings in patients with shoulder pain. We hypothesized the sensitivity and specificity of Cyriax's functional examination were comparable with US in detecting the lesion localization of the shoulder disorders.

Methods

Study Design

This was a prospective and observational study in patients with or without shoulder pain. The Shin Kong Wu Ho-Su Memorial Hospital institutional review board approved the study protocol, and patients provided written informed consent before enrollment. This study is reported according to the Standards for the Reporting of Diagnostic Accuracy Studies statement.

Participants

We prospectively enrolled the participants with or without shoulder pain in this study from July 2014 to December 2015. All of the participants were ≥20 years old. Group 1 included patients with unilateral or bilateral shoulder pain from the Shin Kong Wu Ho-Su Memorial Hospital outpatient clinic of the department of physical

Elevation
- Active elevation (or abduction) of both arms
- Passive elevation (or abduction)
- Painful arc (slowly active abduction)

Glenohumeral joint
- Passive scapulohumeral abduction
- Passive lateral (or external) rotation
- Passive medial (or internal) rotation

Resisted movements
- Adduction of the shoulder
- Abduction of the shoulder
- Lateral rotation of the shoulder
- Medial rotation of the shoulder
- Flexion of the elbow
- Extension of the elbow

Fig 2. *Summary of the Cyriax's functional examination of the shoulder.*

medicine and rehabilitation. The control group, group 2, consisted of participants who had had no shoulder problems over 12 months and were patients' families or hospital staff. The exclusion criteria were as follows: patients who were pregnant or who had chronic inflammatory joint disease; infections or tumors of the shoulder; severe medical, neurologic, or musculoskeletal diseases; previous fractures or surgery of shoulder; and referred pain from cervical origin or visceral organs. Participants in both groups received Cyriax's functional examination after history-taking by the first physiatrist and were examined with US in 1 week by the secondary physiatrist. Clinical diagnosis was made by 2 methods, respectively. Figure 1 shows the flowchart of study participants.

Cyriax's Functional Examination

The examination included 3 arm elevation tests (active elevation, passive elevation, and painful arc), 3 tests for glenohumeral joint (passive scapulohumeral abduction, passive lateral rotation, and passive medial rotation), and 6 resisted tests (adduction, abduction, lateral rotation, and medial rotation of the shoulder; flexion and extension of the elbow) (Fig 2).[7] Pain, range of motion, and end-feel were assessed in passive elevation and 3 tests for glenohumeral joint, and pain and weakness were noted in 6 resisted tests. In Cyriax's functional examination of the shoulder, there are 2 kinds of passive elevation. One is *passive elevation*, which is done by bringing the patient's arm toward the head and pushing the arm as far as possible. The procedure tests the end-feel and the range of motion of both the glenohumeral joint and scapulothoracic joint. To isolate range of motion at the glenohumeral joint, the lower angle of the scapula was immobilized and the patient's arm was lifted toward the head until the scapula started to move. The procedure is termed *passive glenohumeral abduction*. Pain and range of motion were graded from mild to moderate to severe according to severity to compare with each test. End-feel was classified into elastic, hard, and empty based on the

- Arthritis = Limited range with capsular pattern. (Proportional limitation of the three passive scapulohumeral movements including some limitation of abduction, more limitation of external rotation and less limitation of internal rotation.)
- Acute subacromialbursitis = Active and passive elevation is hardly possible and an 'empty end- feel" is found on passive elevation.
- Chronic subdeltoid bursitis = Painful arc or pain at terminal range in the absence of limitation of movement. May provoke limitation of movement in a non-capsular way. All resisted movements are painless or equally painful.
- Tendinitis = No limitation of movement. Pain on resisted movements.
- Incomplete tendon tear = No limitation of movement. Pain and weakness on resisted movements.
- Complete tendon tear = No limitation of movement. Weakness on resisted movements (Nerve lesions should be ruled out first.)
- Acromioclavicular (AC) lesion = Pain on passive horizontal adduction and tenderness at AC joint. No limitation of movement. Resisted movements are usually painless.
- Instability = Excess range of movements.

Fig 3. *Interpretation of Cyriax's functional examination of the shoulder. Abnormality with the associated definition.*

assessor. Passive horizontal adduction of the shoulder also was performed to detect possible acromioclavicular (AC) lesion.[7] The detailed interpretation of Cyriax's functional examination of the shoulder joint is listed in Figure 3.[7]

US Examination

The US examination was administered by a board-certified ultrasonographer in musculoskeletal medicine who did not know the findings of Cyriax's functional examination. The LOGIQ P5 machine (General Electronic Company, Milwaukee, Wisconsin) with a 5- to 12-MHz linear array transducer was used during the exams.

Ultrasound examinations were conducted in the seated position, and the long head of biceps tendon, subscapularis tendon, coracoacromial ligament, AC joint, supraspinatus, infraspinatus tendons, and glenoid labrum were examined sequentially.[13] However, owing to low sensitivity (63%) of US in diagnosing labrum pathology and lack of labral tests in Cyriax's functional examination, we did not list the glenoid labrum disease in our results.[14] Because US examination is widely available and has good sensitivity and specificity, we use US findings as a gold standard in our study. The detailed US criteria of the shoulder joint lesions are listed in Figure 4.[15,16]

Statistical Analysis

Data analysis was performed using a statistical software program (SPSS Statistics, version 15.0) (SPSS Inc, Chicago, Illinois). The demographic data of the 2 groups are expressed as mean ± standard deviations. For the

- Joint effusion = Abnormal hypoechoic or anechoic intraarticular material that is displaceable and compressible.
- Synovial hypertrophy = Abnormal hypoechoic intraarticular tissue that is non-displaceable and poorly compressible and may exhibit Doppler signal.
- Tendinopathy = Thickened, heterogeneous, and/or hypoechoic tissue within the tendon.
- Tenosynovitis = Hypoechoic or anechoic thickened tissue within the tendon sheath, which is viewed in two perpendicular planes.
- Erosion = An intraarticular discontinuity of the bone surface that is visible in two perpendicular planes.
- Bursitis = Hypoechogenic fluid-filled bursa greater than 2 mm in thickness.
- Partial-thickness tendon tear = Partial-thickness interruption of tendon fibers with or without hypoechoic material filling the defect.
- Full-thickness tendon tear = A defect that extends from the joint side to the bursal side of the tendon with or without hypoechoic fluid.
- Incomplete tendon tear = An incomplete tear of the tendon involves the tear of partial width of the tendon which can be partial- or full-thickness.
- Complete tendon tear = A complete tear of the tendon involves the whole width of the tendon.

Fig 4. *Ultrasonographic criteria of the shoulder joint lesion. Abnormality with the associated definition.*

continuous variables, the Mann-Whitney U test was used because the Kolmogorov-Smirnov test did not show a normal distribution. The categorical variables in both groups were compared using the χ^2 test. Sensitivity, specificity, and positive and negative predictive values were evaluated for the diagnosis of shoulder lesions between Cyriax's functional examination and US. The significance level of 0.05 was selected. The outcome measures were conducted after data collection completed. Sample size was calculated according to the methods for diagnostic accuracy studies.[17] When expected sensitivity and specificity was set at 0.90 and the lower confidence limit was set at 0.75, at least 70 cases and 27 controls were required to keep precision of CI estimates.

Results

A total of 220 participants with or without shoulder pain were included. No adverse reaction or discomfort was noted in all patients. Six patients in group 1 were excluded owing to previous surgeries (3) and previous fractures (3), and 3 participants in group 2 were excluded for reasons of previous surgeries (2) and pregnancy (1). Finally, there were 149 people (mean age 58.0 ± 11.8) in group 1 and 57 people (mean age 57.0 ± 11.2) in group 2. There was no significant difference between the 2 groups regarding age, sex, and body mass index (Table 1).

The diagnosis of Cyriax's functional examination included lesions of the biceps, subscapularis, supraspinatus, infraspinatus tendons, and acromioclavicular joint and subacromial-subdeltoid (SASD) bursitis. The diagnosis by US contained more detailed information about shoulder lesions, such as tendinopathy, biceps tenosynovitis, tendon sheath effusion, calcific tendinopathy, partial-thickness tear, and full-thickness tear of the rotator cuff (Table 2). In the shoulder-pain group, the most common diagnosis by Cyriax's functional examination was SASD bursitis (n = 131). Among patients with clinical SASD bursitis, 27 (20.6%) patients had normal thickness (<2 mm) of the SASD bursa in the US images. In total, 94 patients had rotator cuff or biceps tendon lesions, including 69 supraspinatus lesions, 14 subscapularis lesions, 12 infraspinatus lesions, and 3 biceps lesions. There was no positive finding from Cyriax's functional examination in the control participants.

In US examination, there were 115 patients with distended SASD bursa, 81 supraspinatus lesions, 17 subscapularis lesions, 15 infraspinatus lesions, and 20 biceps lesions in group 1. Among rotator cuff lesions, the most common disease was supraspinatus tendinopathy. The most common sonographic findings in asymptomatic patients were fluid in the biceps long head tendon (10.5%) and distended SASD bursa (19.3%). Tendinopathy and partial-thickness tear were rarely found in asymptomatic patients.

The positive and negative tests in 2 examinations of the participants were listed in Table 3. The sensitivity, specificity, and positive and negative predictive values of Cyriax's functional examination in the diagnosis of shoulder pain are listed in Table 4. The sensitivity was high in the diagnosis of SASD bursitis (90.4%) but low in biceps tendinopathy (15.0%). However, specificity was relatively high in biceps tendinopathy and rotator cuff lesions. Among 94 patients who had rotator cuff disease, 76 (80.9%) had SASD bursitis. Asymptomatic participants had fluid in the biceps long head tendon or distended SASD bursa. No adverse event occurred after diagnostic injection.

Discussion

Our results showed that the sensitivity and specificity of Cyriax's functional examination to diagnose supraspinatus lesions were 74.1% and 92.8%, subscapularis lesions were 76.5% and 99.5%, infraspinatus lesions were 66.7% and 99.0%, biceps tendon lesions were 15.0% and 100%, and SASD bursitis were 90.4% and 70.3%. The findings in this study have better sensitivity and specificity than previously reports. Naredo et al[18] showed a relatively low sensitivity to diagnose rotator cuff lesion, tendinitis or tear, SASD bursitis, and biceps tendinitis by physical examination. Park et al[19] reported that previous studies found the sensitivity of the empty can test for the diagnosis of supraspinatus tear was 32.1% to 52.6% and the specificity was 67.8% to 82.4%. Early studies, which used the infraspinatus muscle test to diagnose infraspinatus tear, reported the sensitivity and specificity for partial-thickness tear were 19.4% and 69.1%, respectively, and for full-thickness tear were 50.5% and 84%.[20]

Table 1. *Demographic Data*

Item	Group 1 (n = 149)	Group 2 (n = 57)	*P*
Female	81 (54%)	31 (54%)	>.99 [a]
Right side	93 (62%)	30 (58%)	.20 [a]
Age (y)	58.0 ± 11.8 (56.11-59.89)	57.0 ± 11.2 (54.09-59.91)	.35 [b]
Body height (cm)	161 ± 7.9 (159.73-162.27)	156 ± 5 (154.7-157.3)	.65 [b]
Body weight (kg)	61.8 ± 9.9 (60.21-63.39)	63.6 ± 12.5 (60.35-66.85)	.58 [b]
BMI (kg/m^2)	23.6 ± 2.9 (23.13-24.07)	24.1 ± 3.7 (23.14-25.06)	.67 [b]

Values are n (%), mean ± standard deviation (95% confidence interval).
BMI, body mass index.
[a] χ^2 test.
[b] Mann-Whitney U test.

The diagnostic value of Cyriax's functional examination lies in its comprehensiveness to examine the inert and contractile tissue as compared with any single physical examination. Furthermore, many studies have discussed the reliability and diagnostic accuracy of combining multiple physical examinations for the diagnosis of shoulder pain but have found some limitations. Michener et al found that the reliability of combining more than 3 tests to diagnose subacromial impingement syndrome was higher than any single test including the Neer, Hawkins-Kennedy, painful arc, empty can, and external rotation resistance tests.[20] In addition, the severity of the symptoms affects the diagnostic values of these tests. The functional examination of the shoulder by Cyriax focuses on functional anatomy to detect whether the lesion originates from the muscle, tendon, ligament, bursa, or bone. Accordingly, we try to use its concepts in clinical practice and prove the accuracy by US.

In our study, the diagnostic accuracy of Cyriax's functional examination is high compared with that of US, except for SASD bursitis. The term *bursitis* used to describe the thickened bursa either caused by fibrosis or fluid accumulation in the US or MRI images has been discussed in early literature. We found that the thickening of the SASD bursa is frequently found in healthy participants who were asymptomatic. This result was similar to previous studies. Naranjo et al[21] and Girish et al[22] reported that 29% and 78% of asymptomatic shoulder patients had a thickened SASD bursa, respectively. In contrast, we found patients who were diagnosed with SASD bursitis by functional examination had normal thickness of the bursa in US. The result was consistent with the false-negative cases in early literature.[23] Because on a molecular level, increased substance P and cytokines have been associated with painful sensation in the subacromial bursitis,[24] the inconsistency can be further solved by diagnostic block. The US findings should be carefully correlated with clinical examination, particularly in SASD bursitis.

The high prevalence of clinical SASD bursitis in our study can be attributed to 2 reasons. First, diagnosis of clinical bursitis is based on irritation of the inflamed bursa during passive or active range of motion. However, patients with a small tear of the rotator cuff may present with signs of impingement without positive findings on resistive tests. As a result, patients with some rotator cuff diseases may be falsely classified as having SASD bursitis.[25,26] Second, the clinical presentation of SASD bursitis or subacromial impingement syndrome is quite similar to the early phase of adhesive capsulitis. Therefore, Cyriax's functional examination might not differentiate these conditions and resulted in false-positive cases.[27]

Theoretically, Cyriax's functional examination can help us to differentiate tendinopathy from complete tendon tear. In complete tendon tear, weakness is more prominent than painful sensation, whereas both pain and weakness are often present in tendinopathy or incomplete tear. On US examination, incomplete tear was further classified as full-thickness tear and partial-thickness tear. However, it is common in patients with shoulder problems to experience weakness, which is not caused by tendon tear but an inflammation process. On the other hand, patients with SASD bursitis only tend to use less force to avoid bursa irritation, whereas rotator cuff tear is associated with true weakness. In Cyriax's functional examination, passive range of motion in patients with SASD bursitis may induce pain at the preterminal to terminal range in one or multiple directions with a soft or empty-end feel, which is different from the presentation of adhesive capsulitis or isolated tendinopathy. Similarly, resistive tests sometimes cause a mild degree of pain in more than one direction owing to irritation of the SASD bursa. Therefore, weakness and pain from tendinopathy, full-thickness incomplete tear, partial-thickness tear, or bursitis can be difficult to differentiate. Therefore, we only classified the site of the lesions instead of the underlying pathology by physical examination in our study.

It is a challenge to diagnose a biceps long head lesion by physical examination or US only. Chen et al reported the sensitivity of diagnosing biceps tendinitis was 32% for

Table 2. *Cyriax's Functional Examination and Ultrasonographic Findings in Patients With Painful Shoulder*

Diagnosis	Cyriax's Functional Examination	US
SASD bursitis	131	115
SS lesion	69	81
SS tendinopathy	-	27
SS calcified tendinopathy	-	22
SS partial-thickness tear	-	9
SS full-thickness tear	-	23
SC lesion	14	17
SC tendinopathy	-	10
SC calcified tendinopathy	-	2
SC partial-thickness tear	-	3
SC full-thickness tear	-	2
IS lesion	12	15
IS tendinopathy	-	5
IS calcified tendinopathy	-	5
IS partial-thickness tear	-	0
IS full-thickness tear	-	5
Biceps lesion	3	20
Biceps tendinopathy	3	4
Biceps tendon sheath Effusion	-	14
Biceps tenosynovitis	-	2
AC joint lesion	1	2

Values are numbers of participants.
AC, acromioclavicular; *IS*, infraspinatus; *SASD*, subacromial-subdeltoid; *SC*, subscapularis; *SS*, supraspinatus; *US*, ultrasonography.

Yergason's test, 62.5% for Speed's test, and 57% for bicipital groove tenderness when regarding US findings as the gold standard. Similar to our results, the specificity of these 3 tests was 78% for Yergason's test, 60% for Speed's test, and 72% for bicipital groove tenderness.[28] The low sensitivity in diagnosing biceps lesions in our study may be a result of several reasons. First, because the prevalence of biceps tendinopathy is low in our study, measurement in a small sample may create statistical bias. Second, we excluded patients with adhesive capsulitis, which sometimes combines with biceps tendinopathy or contributes to biceps tendon sheath effusion in US findings. Fluid in the biceps long head tendon sheath was 69.23% in adhesive capsulitis and up to 56.69% in rotator cuff tears in previous studies.[29] Third, we did not apply power Doppler sonography routinely when examining the biceps tendon. Although US examination is the gold standard in our study, we still need clinical correlation (eg, pain or weakness on resisted elbow flexion or forearm supination) to confirm the diagnosis of biceps tendinopathy. More cases and further studies are needed.

Among the imaging methods used for the evaluation of the shoulder disorders, US is popular because it is real-time, inexpensive, radiation-free, and noninvasive. Although physical examination poses some uncertainty in diagnosing shoulder pathology, US provides direct evidence of pathology, dynamic examination, and assistance in US-guided diagnostic injection. Good sensitivity (0.84-0.96) and specificity (0.89-0.93) of US has been reported in diagnosing rotator cuff tears.[9] Although magnetic resonance arthrography is the most sensitive and specific method for diagnosing rotator cuff tears, US is not inferior to MRI based on surgical findings.[12,30] But owing to limitations of manpower and availability of ultrasonography, physical examination and ultrasound could not be done in the same day in all participants. Therefore, possible morphologic changes could be missed, especially in the active condition. In brief, we consider US the preferred tool for diagnosing shoulder disorders.

Cyriax used selective tension tests to examine the contractile tissue at the midrange position and avoid 2-jointed muscle activation. However, we cannot test only 1 muscle without the other muscle contracting entirely in a specific movement. For instance, when we tested the subscapularis muscle with resisted maximal medial rotation of the shoulder, the pectoralis major, teres major, and latissimus dorsi muscles also fired. Besides, Cyriax's functional examination focused on range of motion and resisted movement, which can further differentiate the pathology located in the capsule, inert structures, or contractile tissues. However, it did not include specific tests for labrum disorders in either basic examination or accessory tests of the shoulder. Therefore, the authors suggest labral tests such as the O'Brien test, crank test, and dynamic labral shear test be performed to rule out labrum pathology.

In our study, we recruited not only painful shoulder but also asymptomatic patients for detecting false-positive cases. Among the 57 participants without shoulder pain, 9 participants had thickened SASD bursa, 1 supraspinatus tendinopathy, 1 subscapularis tendinopathy, and 5 biceps tendon sheath effusion. Milgrom et al reported that the prevalence of rotator cuff tear in asymptomatic participants at the seventh decade was more than 50%.[31] In this study, there were no participants with asymptomatic rotator cuff tear. The reason may be that the average age of our patients was relatively young and our sample size was small. There

Table 3. *The Positive and Negative Tests in Cyriax's Functional Examination and US Examination of the Participants*

SASD Bursitis

		US		
		-	+	Total
Cyriax's	-	64	11	75
	+	27	104	131
Total		91	115	206

SS Lesion

		US		
		-	+	Total
Cyriax's	-	116	21	137
	+	9	60	69
Total		125	81	206

SC Lesion

		US		
		-	+	Total
Cyriax's	-	188	4	192
	+	1	13	14
Total		189	17	206

IS Lesion

		US		
		-	+	Total
Cyriax's	-	189	5	194
	+	2	10	12
Total		191	15	206

Biceps Tendinopathy

		US		
		-	+	Total
Cyriax's	-	186	17	203
	+	0	3	3
Total		186	20	206

Cyriax's, Cyriax's functional examination; *IS*, infraspinatus; *SASD*, subacromial-subdeltoid; *SC*, subscapularis; *SS*, supraspinatus; *US*, ultrasound examination.

Table 4. *Comparison of Cyriax's Functional Examination and Ultrasonographic Findings*

Diagnosis	S (%)	Sp (%)	PPV (%)	NPV (%)
SASD bursitis	90.4 (83.53-95.13)	70.3 (59.84-79.45)	79.4 (71.45-85.96)	85.3 (75.27-92.44)
SS lesion	74.1 (63.14-83.18)	92.8 (86.77-96.65)	87.0 (76.68-93.86)	84.7 (77.53-90.25)
SC lesion	76.5 (50.1-93.19)	99.5 (97.09-99.99)	92.9 (66.13-99.82)	97.9 (94.75-99.43)
IS lesion	66.7 (38.38-88.18)	99.0 (96.29-99.87)	83.3 (51.59-97.91)	97.4 (94.12-99.16)
Biceps lesion	15.0 (3.21-37.89)	100.0 (98.04-100.0)	100.0 (29.24-100.0)	91.6 (86.93-95.05)

Data presented as mean (95% confidence interval).
IS, infraspinatus; *NPV*, negative predictive value; *PPV*, positive predictive value; *S*, sensitivity; *SASD*, subacromial-subdeltoid; *SC*, subscapularis; *Sp*, specificity; *SS*, supraspinatus.

were 2 asymptomatic participants with both rotator cuff tendinopathy and biceps tendon sheath effusion, which was consistent with previous studies.[32]

The inter-rater and intrarater reliability of Cyriax's functional examination varied. Previous literature had reported the intertester reliability of Cyriax's evaluation in

assessing patients with shoulder pain with results of "almost perfect."[33] However, Hayes et al showed the both intrarater and inter-rater reliability of resisted tests was not generally acceptable for the shoulder.[34] The reason for the difference could be the amount of resisted strength the examiners and the patients performed. Nevertheless, Karen et al reported that high reliability can be achieved by intensively training the evaluators and standardizing the magnitude of the applied resistance.[34,35] In this study, we used a single evaluator to keep comparability between the 2 groups. Compared with a similar study by Naredo et al,[16] our study has a larger sample size.

Clinical Applications

Although Cyriax's functional examination had high sensitivity in detecting SASD bursitis and high specificity in rotator cuff lesion, we suggest that additional labral tests should be performed because Cyriax's functional examination did not include them. In addition, we could not identify the exact pathology by this method, whereas US can cover this limitation. As well, clinical bursitis may not be demonstrated on ultrasonographic image, and abnormal ultrasonographic findings (eg, thickened SASD bursa, effusion in biceps long head tendon sheath) may be shown in asymptomatic participants. For clinical practice, we suggest that a combination of Cyriax's functional examination and US findings would be helpful in identifying the causes of shoulder dysfunction.

Limitations

Frozen shoulder was excluded in this study because it is mainly diagnosed by physical examination. In our study, we excluded 5 patients with adhesive capsulitis. Among the 5 patients, 3 had biceps tendon sheath effusion, 2 had thickened coracohumeral ligaments, and 1 had supraspinatus tendinopathy in US. According to Homsi et al, thickened coracohumeral ligaments are highly suggestive of adhesive capsulitis**,** and biceps tendon sheath effusion indicates abnormalities of the shoulder joint.[36] Second, the number of patients with AC joint disease was relatively small so that clinical significance could not be achieved. Third, the normal participants we enrolled were mainly from the family of the patients and might not represent the general population, although the confounding factors including lifestyle, environment, and education level might be adjusted. Fourth, there was only 1 assessor performing Cyriax's functional examination in our study so that subjective bias might have existed. In addition, possible ultrasonographic bias might exist because it was not done with Cyriax's functional examination on the same day in all participants. Finally, the labrum disorders were not mentioned in our study owing to lack of specific labral tests in Cyriax's functional examination and low sensitivity of US in detecting labrum pathology.

Conclusion

In this study we found that Cyriax's functional examination had high sensitivity in detecting SASD bursitis and high specificity in rotator cuff lesion.

Funding Sources and Conflicts of Interest

The authors acknowledge the financial support provided by the Shin Kong Wu Ho-Su Memorial Hospital. No conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): L.-F.H.
Design (planned the methods to generate the results): Y.-C.K., L.-F.H.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): L.-F.H.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): Y.-C.K., L.-F.H.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): Y.-C.K., L.-F.H.
Literature search (performed the literature search): Y.-C.K.
Writing (responsible for writing a substantive part of the manuscript): Y.-C.K., L.-F.H.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): L.-F.H.

Practical Applications

- In this cross-sectional and diagnostic accuracy study, Cyriax's functional examination has strength in localizing lesions at contractile or inert tissue through a series of simple tests.
- This examination showed high sensitivity in detecting SASD bursitis and high specificity in rotator cuff lesion.
- A combination of Cyriax's functional examination and US findings provided the most useful information in patients with shoulder pain.

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