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ORIGINAL ARTICLE

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Ultrasonographic findings of painful shoulders and correlation between physical examination and ultrasonographic rotator cuff tear

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Abstract The objectives of this study were to identify ultrasonographic (US) abnormalities and to compare physical examination with US findings, especially of rotator cuff abnormalities in patients with shoulder pain. A total of 120 patients with shoulder pain were prospectively studied. The physical examination of shoulders was performed as follows: (1) the area of tenderness; (2) the range of passive and active motion for abduction, forward flexion, external rotation, and internal rotation; (3) Neer and Hawkins's tests for shoulder impingement; and (4) maneuvers for determining the location of the tendon lesions. Transverse and longitudinal planes from the long head of the biceps, supraspinatus, infraspinatus, and subscapularis tendons, the subacromial-subdeltoid bursa, and the glenohumeral and acromioclavicular joints were included for US examination. The range of motion most affected by shoulder pain was abduction, followed by external rotation and forward flexion. The most frequent US finding was effusion in the long head of the biceps tendon. Among the rotator cuff tendons, supraspinatus was the most frequently involved. Physical examination had low sensitivity and specificity for the detection of tendon tear. US examination leads to an anatomical diagnosis of shoulder pain in many patients. Whether the US examination of the painful shoulder improves its treatment should be investigated.

Key words Rotator cuff · Shoulder pain · Tear · Tendinopathy · Ultrasonography

Introduction

Shoulder pain is one of the most common complaints encountered in rheumatologic practice and frequently results in considerable morbidity. In a Korean survey performed in a rural area among residents over 40 years of age, the prevalence of shoulder pain was 43%, with higher prevalence and higher average pain score among women compared with men.[1] Its cause is related to many different pathologies, and both articular structures and periarticular soft tissues may be involved. For this reason, it is often difficult to detect and identify the site of anatomical alteration with clinical examinations alone.[2] Many clinical diagnostic tests have been developed for the physical examination of the shoulder girdle, but the data on their diagnostic value are often controversial, and many tests suffer from lack of accuracy. For example, when 86 patients with long-standing shoulder pain were blindly examined by two trained doctors using tests for impingement, muscle weakness, muscle tenderness, and labral lesion, the agreement of clinical diagnosis was poor and the accuracy was low in comparison with arthroscopy and ultrasonography (US).[3] Although a complete history, physical examination, and review of plain radiographs by an experienced examiner were found to be sufficient for establishing the diagnosis and treatment plan for common shoulder disorders, magnetic resonance imaging (MRI) still had a significant impact on clinical decision making in a large subset of patients with shoulder pain.[4] Ultrasonographic evaluation is useful for diagnosing a variety of regional pain syndrome and soft tissue rheumatism, and has been increasingly employed in rheumatologic practice.[5] Given the great improvement in resolution achieved by high-frequency ultrasound, it is expected to serve as an important tool for the accurate evaluation of painful shoulder. The objectives of this study were (1) to identify US abnormalities and (2) to compare physical examination with US findings, especially of rotator cuff abnormalities in a large number of patients with shoulder pain.

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Patients and methods

We prospectively studied 120 patients with shoulder pain, visiting a university-affiliated rheumatology clinic. Sex, age, height, weight, body mass index, accompanying rheumatologic diagnosis (if applicable), duration, and the number of recurrences of shoulder pain were recorded. Previous diagnosis, if available, the site where that diagnosis was obtained (e.g., orthopedic private clinic), and the category of previous treatment were also recorded. Patients with rheumatoid arthritis were excluded from the study for a separate imaging study of rheumatoid shoulder. Patients who developed shoulder pain after previous trauma in the shoulder area were also excluded.

Physical examination

Physical examination of shoulder was performed systemically by one blinded rheumatologist (YS) as follows: (1) the area of tenderness in the glenohumeral joint, acromio-clavicular joint, bicipital groove, and subacromial space; (2) the range of passive and active motion for abduction, forward flexion, external rotation, and internal rotation measured with a goniometer; (3) Neer and Hawkins's tests for shoulder impingement; and (4) maneuvers for determining the location of the tendon lesions (Jobe's test for supraspinatus, Patte's test for infraspinatus, Gerber's lift-off test for subscapularis, and Yegarson's test for the long head of the biceps brachii). For the impingement maneuver of Neer,[6,7] the examiner stands behind the seated patient and uses one hand to prevent rotation of the scapula while passively raising the patient's arm with the other hand to produce both forward elevation and abduction in order to reduce the space between the greater tuberosity and the anteroinferior aspect of the acromion. In Hawkins's test,[8] the examiner stands facing the patient, and after raising the patient's arm to 90° of strict forward elevation with the elbow in 90° flexion, rotates the arm medially by lowering the forearm. These tests are positive when patients experience pain during the maneuvers. In Jobe's maneuver,[9] the examiner stands facing the patient, and the patient places both arms in 90° abduction and 30° horizontal adduction, in the plane of the scapula, with the patient's thumbs pointing downward in order to produce the medial rotation of the shoulder; the examiner then pushes the patient's arms downward when asking the patient to resist the pressure. For Patte's maneuver,[10] the examiner supports the patient's elbow in 90° flexion while the patient is asked to rotate the arm laterally in order to compare the strength of lateral rotation. Jobe and Patte's maneuvers can produce three types of responses: (a) the absence of pain, indicating that the tested tendon is normal; (b) the ability to resist despite pain, denoting tendinitis; (c) the inability to resist with gradual lowering of the arm or forearm, indicating tendon rupture. In Gerber's lift-off test,[11] the patient is asked to place the hand against the back at the level of the waist with the elbow in 90° flexion. The examiner pulls the hand to about 5–10 cm from the back while maintaining the 90° bend in the elbow. The patient is then asked to hold the position without the help of the examiner. This test is positive if the hand cannot be lifted off the back, denoting the complete rupture of the subscapularis tendon. In Yergason's test,[12] pain along the course of the biceps tendon produced by resisted supination of the forearm denotes bicipital tendinitis.

US examination

Ultrasonographic examination was performed by a rheumatologist (HK) experienced in ultrasonography and blinded to the clinical test. A linear array 7 MHz transducer (HDI 5000, ATL Ultrasound, Bothell, WA, USA) was used. Investigations included transverse and longitudinal planes from the long head of the biceps, the supraspinatus, infraspinatus, and subscapularis tendons; the subacromial-subdeltoid bursa; and the glenohumeral and acromioclavicular joints. The tendon thickness, the homogeneity of the fibrillar pattern, and the presence of calcification were noted. In all patients, the images of both shoulders were obtained in order to compare US findings between two shoulders. The US examination technique for shoulder is widely described.[6,13] The biceps tendon was examined with the patient seated with the elbow flexed to 90° and the forearm half pronated on the lap. On the anterior aspect of the shoulder, the long head of biceps tendon was imaged as an oval-shaped echogenic structure, surrounded by a 1-mm to 2-mm thick hypoechoic halo of fluid within the synovial sheath. Anteromedial to the biceps tendon, the hyperechoic subscapularis tendon was identified with a slight external rotation of the glenohumeral joint. A dynamic view of the subscapularis tendon was obtained when the shoulder of the patient was moved into external rotation. Acromioclavicular joint was examined with the transducer, oriented along the coronal plane, and the small amount of intra-articular fluid, if present, was noted. The supraspinatus tendon was examined with the patient's shoulder in hyperextension and full internal rotation with the dorsum of the hand placed in the small of the back in order to expose the supraspinatus from underneath the acromion. These tendons appear as a hyperechoic fibrillar layer, convex shaped on transverse images and convex, tapered and inserting at the greater tuberosity on longitudinal views, deep into the deltoid muscle. The subacromial-subdeltoid bursa was imaged as a hypoechoic line of a thickness of less than 2 mm with a variable amount of peribursal echogenic fat between the deltoid muscle and the supraspinatus and infraspinatus tendons. The infraspinatus tendon and glenohumeral joint were examined with the patient's hand placed on the contralateral shoulder, and the transducer was oriented in the axial plane until the head of the humerus was seen adjacent to the posterior glenoid labrum. The distance of greater than 2 mm between the deeper fibers of the infraspinatus muscle and the labrum was considered as the presence of a joint effusion. For dynamic scanning for the evaluation of impingement syndrome, the patient's elbow was flexed to 90°. The patient was guided into active forward flexion and abduction of the glenohumeral joint, and the degree of humeral depression that occurs, and "bunching" or cog-wheel hesitation of the rotator cuff tendons or gradual distension of the bursa was noted.

Statistical analysis

Data are presented as mean ± standard deviation (SD) for continuous variables and as frequency (%) for categorical variables. A *P* value was calculated by Student's *t* test for continuous variables or by Chi-squared test for categorical variables. A *P* value of less than 0.05 was considered to be statistically significant, and all statistical analyses were performed using SPSS for Windows (Version 10.0, Chicago, IL, USA).

Results

Table 1 shows the baseline demographic characteristics of the subjects. The mean duration of shoulder pain was 16.1 months. The involvement was bilateral in 56 patients (46.7%), left in 44 (36.7%), and right in 20 (16.7%). Fifty-seven (47.5%) patients visited another hospital for their shoulder pain, and 19 were diagnosed with frozen shoulder, five with shoulder tendinitis, and three with rheumatoid arthritis. Forty-five (37.5%) patients had been treated previously, which included oral medication in 23, acupuncture and moxibustion in 13, and shoulder injection in 9. Simple X-ray findings of the shoulder included 83 (69.2%) normal findings, 32 (26.7%) degenerative changes, 4 calcific tendinitis (3.3%), and 1 (0.8%) osteoblastic bony metastasis of prostate cancer.

Table 2 shows the physical examination findings for the 176 painful shoulders. Range of motion most affected by shoulder pain in our patients was abduction, followed by external rotation and forward flexion. Impingement sign tested by Neer's or Hawkins's tests was positive in 50% the shoulders, with both tests positive in 41 (23.3%), only Neer's test positive in 40 (22.7%), and only Hawkin's test positive in 6 (3.4%) shoulders. For the physical examination of individual muscles, positive Jobe's test, indicating supraspinatus lesion, was the most common, followed by Yegarson's test (biceps) and Patte's (infraspinatus) test.

Table 3 lists US findings for the painful shoulders. The mean thickness of rotator cuff tendon in our patients was as follows: supraspinatus 0.75 cm (SD 0.15 cm) and 0.71 cm (SD 0.06 cm) for right and left shoulders of men, respectively, 0.62 (SD 0.15) and 0.63 (SD 0.14) for right and left shoulders of women, infraspinatus 0.38 cm (SD 0.10 cm) and 0.34 cm (SD 0.19 cm) for right and left shoulders of men, 0.33 (SD 0.08) and 0.36 (SD 0.07) for right and left shoulders of women, and subscapularis 0.56 cm (SD 0.08 cm) and 0.52 cm (SD 0.07 cm) for right and left shoulders of men, 0.48 (SD 0.10) and 0.49 (SD 0.11) for right and left shoulders of women, respectively. The most frequent finding in our patients with painful shoulder was effusion in the long head of the biceps tendon, which was observed in 41.5% of the patients. Among the rotator cuff tendons, except for the

Table 1. Baseline characteristics of the subjects ($n = 120$)

Age	59.0 ± 11.3 (range 37–77)
Sex (men/women)	28/92
Rheumatologic diagnosis (%)	
Osteoarthritis	72 (60)
Gout	5 (4.2)
Sjögren's syndrome	3 (2.5)
Adult-onset Still's disease	1 (0.8)
None	39 (32.5)
Radiographic findings (%)	
Normal	83 (69.2)
Degenerative change	32 (26.7)
Calcific tendonitis	4 (3.3)
Osteoblastic change	1 (0.8)
Duration of shoulder pain (months)	16.1 ± 25.5 (range 1–120)

Table 2. Positive physical examination findings of 176 painful shoulders (%)

Tenderness	
Glenohumeral	49 (27.8)
Subacromial	105 (59.7)
Bicipital	55 (31.3)
Acromioclavicular	19 (10.8)
Limitation of motion	
Forward flexion	60 (34.1)
Abduction	92 (52.3)
External rotation	60 (34.1)
Internal rotation	12 (6.8)
Passive motion range greater than active	23 (13.0)
Impingement test	
Neer	81 (46.0)
Hawkins	47 (26.7)
Individual muscle test	
Jobe's (supraspinatus)	76 (43.2)
Patte's (infraspinatus)	24 (13.6)
Lift-off (subscapularis)	12 (6.8)
Yegarson's (biceps)	40 (22.7)

Table 3. Ultrasonographic (US) examination findings of 176 painful shoulders (%)

Long head of the biceps tendon	
Effusion	73 (41.5)
Rupture	4 (2.3)
Subdeltoid effusion	25 (14.2)
Supraspinatus tendon	
Thickening	17 (9.7)
Thinning	37 (21)
Tears	
Partial thickness	28 (15.9)
Full thickness	24 (13.6)
Calcification	15 (8.5)
Impingement	33 (18.8)
Infraspinatus	
Thickening	2 (1.1)
Thinning	1 (0.6)
Tears	
Partial thickness	0 (0)
Full thickness	0 (0)
Subscapularis	
Thickening	1 (0.6)
Thinning	5 (2.8)
Tears	
Partial thickness	16 (9.1)
Full thickness	0 (0)
Glenohumeral effusion	29 (16.5)
Humeral bony irregularity	25 (14.2)
Acromioclavicular joint effusion	5 (2.8)

Table 4. Clinical parameters associated with tendon tear

	Tear ($n = 28$)	No tear ($n = 92$)
Age (years)	65	57.2
Women (%)	85	74
Duration of shoulder pain (months)	13.6	16.9
Abnormal radiography of shoulder (%)*	75	17.4
Presence of osteoarthritis (%)	71.4	52.6

*Statistically significant difference between tear and nontear groups ($P < 0.05$)

Table 5. Sensitivity and specificity of physical examination for the detection of US tendon tears (%)

	Sensitivity	Specificity
Any tear		
Glenohumeral tenderness	42.9	80
Subacromial tenderness	71.4	46.7
Limitation of motion		
Forward flexion	14.3	56.7
Abduction	42.9	43.3
External rotation	7.1	53.3
Internal rotation	0	90
Specific tendon tear		
Jobe's test (supraspinatus)	30.8	51.6
Gerber's lift off test (subscapularis)	6.25	22.5
Patte's test (infraspinatus)	nd[a]	86.4
Yegarson's test (biceps)	75	81.4

[a]Sensitivity of Patte's test for the detection of infraspinatus was not examined because no patients exhibited infraspinatus tendon tear

teres minor which was not included in our US examination, supraspinatus was the most frequently involved, with tendon tear observed in 52 (29.5%) of the shoulders. Subscapularis tendon tear was observed in 16 shoulders (9.1%), with 12 shoulders exhibiting both supraspinatus and subscapularis tears. Infraspinatus tear was not observed. Impingement sign as depicted by "bunching" or cog-wheel hesitation of the rotator cuff tendons during active forward flexion and abduction of the glenohumeral joint was noted in 33 (18.8%) shoulders. Calcification in the supraspinatus tendon was observed in 15 (8.5%) shoulders, among which only 6 showed calcification in the simple X-ray. Glenohumeral joint effusion was noted in 16.5% of the shoulders and acromioclavicular joint effusion in 2.8%. Twenty-five shoulders exhibited subdeltoid effusion, of which 12 depicted full and 8 partial tear of the supraspinatus tendon. Figures 1 and 2 show frequent US abnormalities detected in our patient group. Table 4 shows the clinical parameters associated with tendon tear. Patients with tendon tear were significantly older than those without. In addition, simple radiography findings showed more abnormalities in patients with tendon tear. Degenerative changes, including humeral osteophytes, narrowing of glenohumeral joint space, bone cysts, and sclerosis, were observed in 20 (67.9%) and 12 (13.0%) patients with or without tendon tear, respectively. Other changes included calcification in four patients (one with tendon tear and three without tendon tear) and osteoblastic change in a patient without tendon tear. Sex and the duration of shoulder pain were not significantly associated with the presence of tendon tear. Although the presence of osteoarthritis tended to be higher in patients with tendon tear, the difference did not reach statistical significance. Table 5 shows the sensitivity and specificity of physical examination for the detection of US tendon tear. As is shown, most of the tests for the examination of shoulder joint and rotator cuff yielded low sensitivity and specificity.

Discussion

In this study of patients with shoulder pain, US abnormalities in the shoulder were common, with 31.8% of the shoulders showing rotator cuff tendon tears. The most frequent US finding of shoulder joints in our patients was effusion in the long head of the biceps tendon. Among the rotator cuff tendons, supraspinatus was the most frequently involved, followed by subscapularis, although infraspinatus tendon tear was not noted. Physical examination traditionally used for the diagnosis of shoulder pain had low sensitivity and specificity for the detection of rotator cuff tendon tear.

The frequency of abnormal US findings of painful shoulder joints differs depending on the patient population studied. In a European study evaluating 425 patients with a mean age of 57.9 years, US abnormalities were found in a total of 94.1% of patients, with the supraspinatus tendon showing the most frequent abnormalities, followed by the long head of the biceps and acromioclavicular joints.[14] In line with our results, alterations were detected in the various structures of the shoulder, including glenohumeral joint, subacromial–subdeltoid bursa, and periarticular tendons. In a Korean US study evaluating 49 patients with shoulder pain and positive impingement sign, 32.7% had abnormalities.[15] The partial thickness tear of supraspinatus tendon was the most frequent finding, followed by biceps effusion, fluid collection in subacromial bursa, and full thickness tear of the supraspinatus. In another Korean US study evaluating 21 asymptomatic baseball players, 3 (14.3%) showed abnormality in the dominant shoulder, with focal bony irregularity at the insertion of the supraspinatus, focal low echoic lesion in the supraspinatus, and fluid collection in acromioclavicular joint in one subject each.[16] The high prevalence of tendon tear in our patients might be related to higher age and selection bias associated with rheumatologic practice. In the majority of the studies, patients had been followed up at our clinic before the US examination for a rheumatologic condition, and only 32.5% of the patients were examined solely because of shoulder pain. Although errors in the detection and measurement of rotator cuff tears by US examination do occur, a recent report comparing ultrasonography and arthroscopy has shown that the majority of errors involved missing of tendon tear.[17] In addition, we diagnosed tendon tear conservatively only after verifying defects in echo in the two perpendicular directions.

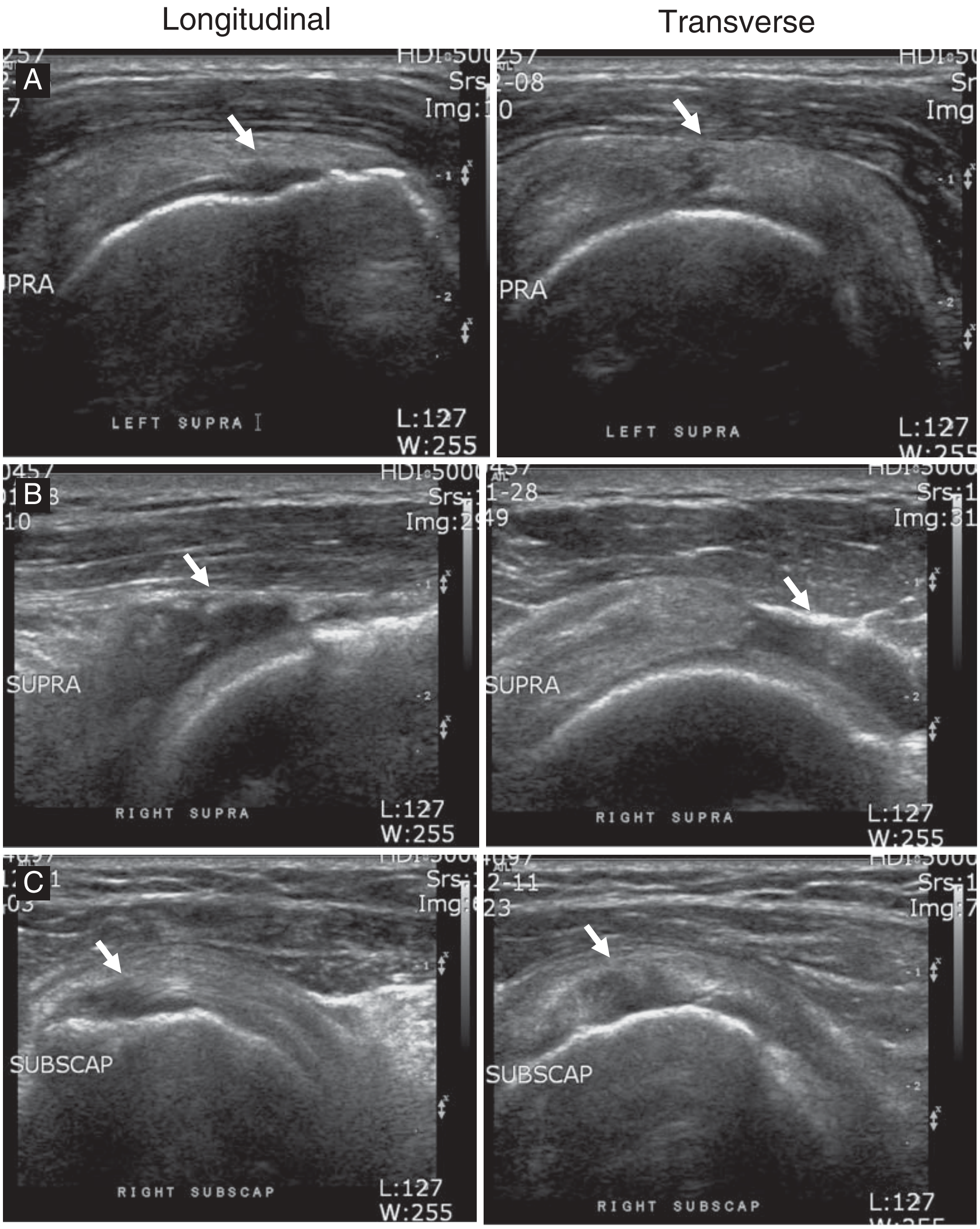

Fig. 1. Examples of ultrasonography (US) abnormalities detected in the study patients. **a** Partial-thickness tear of the supraspinatus. **b** Full-thickness tear of the supraspinatus. **c** Partial thickness tear of the subscapularis

In line with previous reports,[6,18] our results show that the clinical examination of the painful shoulder is not accurate. Norwood et al.[18] tried to define the clinical signs and symptoms that indicate the presence of a rotator cuff tear and predict its severity. They found that the characteristics of the pain and the site of tenderness were not helpful, nor was the weakness to resisted abduction. The low sensitivity and specificity of physical examination may be owing to the fact that most patients with chronic shoulder pain have multiple periarticular lesions, usually involving different tendons, the subacromial–subdeltoid bursa, and impingement syndrome. Clinical examination may be supplemented by plain radiography; however, except for the delineation of degenerative changes and calcifications, the findings are usually nonspecific. In a study involving 206 patients visiting the emergency room for shoulder pain, 88% of the simple shoulder radiographs were found to be therapeutically uninformative.[19] In our results, however, the presence of abnormalities in simple X-ray was associated with rotator cuff tendon tear.

At present, MRI has been widely used to evaluate painful shoulders. In a study comparing ultrasonography with MRI in 31 painful shoulders of the 30 patients,[20] the former visualized biceps tendon ruptures equally well as the latter. MRI was better able to reveal full-thickness tear of the supraspinatus tendon and joint inflammation, whereas ultrasonography showed other changes of the supraspinatus tendon (degeneration or partial-thickness tear) better. In a more recent report, however, there were no significant differences between MRI and ultrasonography with regard to the correct identification of a full-thickness tear or its size, reflecting the improvement in the quality of the US equip-

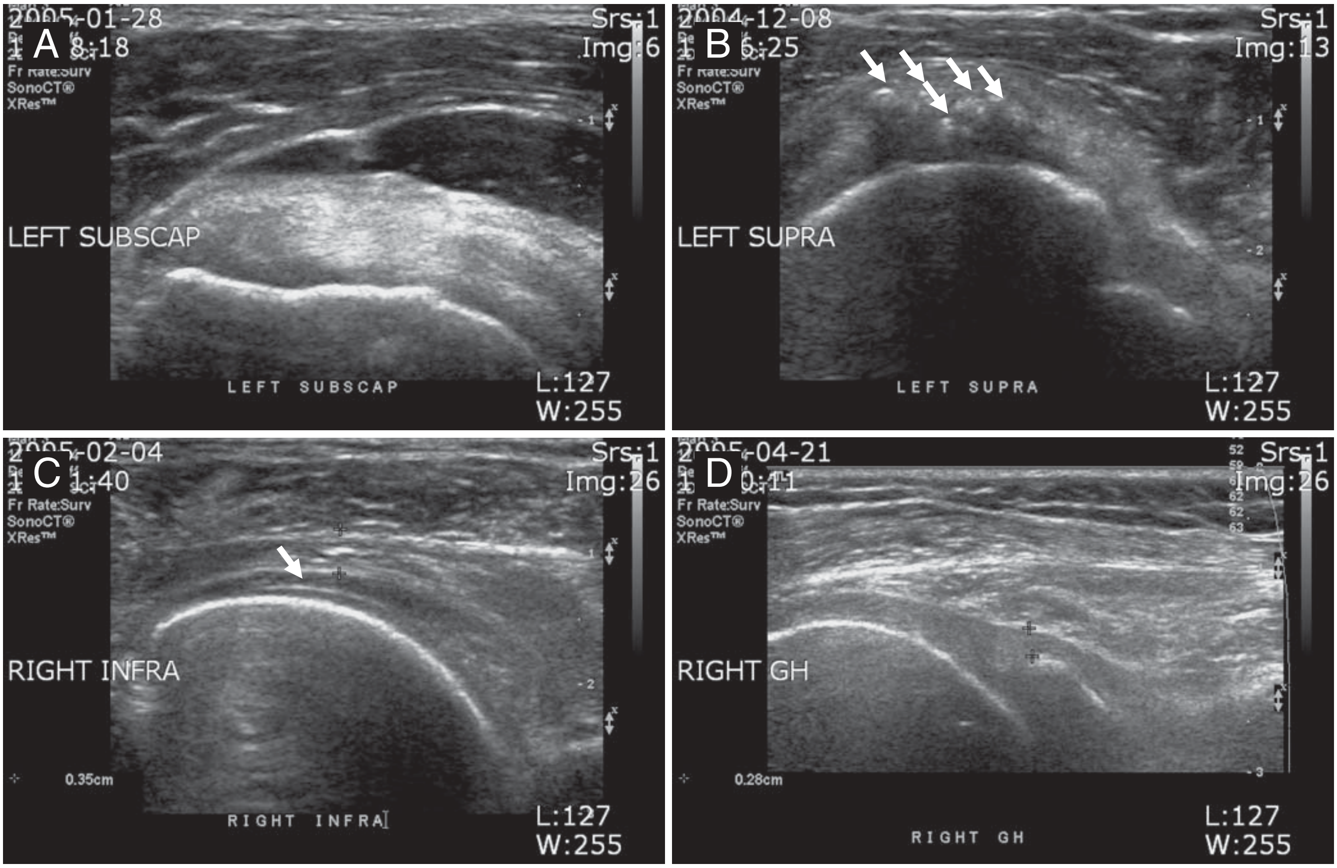

Fig. 2. Examples of US abnormalities detected in the study patients. **a** Subdeltoid effusion detected over left subscapularis tendon. **b** Multiple calcification (*arrows*) in the left supraspinatus tendon. **c** Cartilage sign noted over humeral head (*arrow*) in glenohumeral effusion. **d** Glenohumeral effusion with the gap between glenoid labrum and inferior surface of the infraspinatus measuring 0.23 cm

ment and the protocol for the evaluation of the shoulder.[21] Errors in US diagnosis most often consisted of an inability to distinguish between partial and full-thickness tears that are approximately 1 cm in size, which did not significantly affect the planned surgical approach.[21] Arthrosonography, a standard sonography integrated with the injection of a saline solution into the glenohumeral cavity, was found to considerably increase the diagnostic sensitivity for rotator cuff tears.[22] Although ultrasonography offers considerable benefit for the proper evaluation of shoulder joint problems, limitations such as a lack of visualization of the posterior aspect of the rotator cuff tendons, limited view of the glenohumeral joint, and considerable dependence on the operator exist. In our study, gold standard for the diagnosis of tendon tear, such as arthroscopy or MRI, was not included. Therefore, our US estimation of tendon tear may not be precise. However, in 21 patients who underwent MRI for further evaluation following US examination, the correlation for tendon tear was excellent (data not shown). The primary purpose of this study was to define the differences between clinical examination and US examination of the shoulder, and further study comparing US and MRI for the evaluation and the treatment of patients with shoulder pain is warranted.

Aside from medical treatment, conservative treatments of shoulder problems include physiotherapy and local injections of corticosteroids. Few studies have evaluated the differences in the outcome of the different periarticular lesions with or without diagnosis by an accurate imaging technique.[23] A recent Korean study involving 334 patients with shoulder pain showed that ultrasonography is useful for the prediction of response to corticosteroid injection therapy: patients with normal US findings showed significantly better response when compared with those with mixed capsular and noncapsular US patterns.[24] In another study, evaluating the efficacy of steroid injection into the subacromial bursa and biceps tendon sheath guided by ultrasonography, 94% of the shoulders showed an improvement in pain and range of motion, implicating the role of ultrasonography for therapeutic purpose as well as diagnostic one.[25] There is a need for further trials investigating whether the US examination of the painful shoulder offers the possibility of improving its treatment.

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The authors have no conflicts of interest to disclose.

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