Journal of Clinical and Nursing Research, 2026, Volume 10, Issue 2
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

Diagnostic Efficacy of Musculoskeletal Ultrasound in Rotator Cuff Injuries and Analysis of the Extent of Damage

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Abstract: *Objective*: To analyze the effectiveness of musculoskeletal ultrasound in diagnosing rotator cuff injuries. *Methods*: A total of 80 patients with suspected rotator cuff injuries who were admitted and diagnosed between January 1, 2020, and December 31, 2024, were selected. Musculoskeletal ultrasound was performed on these patients, and the diagnostic efficacy of musculoskeletal ultrasound was evaluated by comparing the results with those of MRI. *Results*: The detection rates of musculoskeletal ultrasound for the location and extent of injury were similar to those of MRI ($p > 0.05$). Based on the MRI diagnosis results, the diagnostic accuracy rate of musculoskeletal ultrasound was 92.50%, with a sensitivity of 93.06% and a specificity of 87.50%. The morphological and signal characteristics, as well as ultrasound indicators, of patients with positive musculoskeletal ultrasound results differed significantly from those of patients with negative results ($p < 0.05$). *Conclusion*: Musculoskeletal ultrasound can effectively detect the location and extent of rotator cuff injuries, comprehensively assess the damage, and demonstrate high diagnostic efficacy. Furthermore, the morphological and signal characteristics, as well as ultrasound indicators, of musculoskeletal ultrasound can serve as diagnostic criteria for rotator cuff injuries, improving disease detection efficiency.

Keywords: Musculoskeletal ultrasound; Rotator cuff injury; Diagnostic effectiveness; Damage assessment

Online publication: Mar 11, 2026

1. Introduction

Common symptoms of rotator cuff injuries include shoulder dysfunction, swelling, and pain in the shoulder joint, among others. The causes are typically excessive exercise or trauma to the shoulder joint, which can have a long-term impact on patients' basic daily lives, necessitating early diagnosis and treatment [1,2]. At present, imaging techniques are commonly used for diagnosing this condition, with musculoskeletal ultrasound being the primary method. It can assess the location and extent of the injury, thereby providing reasonable guidance for subsequent treatment plans and improving disease prognosis. Musculoskeletal ultrasound is simple to operate, non-invasive, and convenient. It can evaluate rotator cuff injuries by utilizing typical ultrasonic manifestations or morphological information, making it widely applicable to patients with this condition and demonstrating relatively good diagnostic effectiveness [3]. Based on this, this study selected 80 patients with suspected rotator cuff injuries to evaluate the diagnostic performance of musculoskeletal ultrasound for this disease.

2. Materials and methods

2.1. General information

Eighty patients with suspected rotator cuff injuries admitted to the hospital from January 1, 2020, to December 31, 2024, were selected. Among them, there were 48 male patients and 32 female patients; the age range was 42–71 years, with a mean age of (55.18 ± 4.19) years; the body mass index ranged from 19–26 kg/m^2, with a mean of (22.49 ± 3.18) kg/m^2.

2.1.1. Inclusion criteria

Adult patients; complete basic information; highly informed about the study.

2.1.2. Exclusion criteria

Patients with cardiovascular and cerebrovascular diseases; a history of shoulder joint surgery; abnormal liver and kidney function; tumors around the shoulder joint; mental illnesses; immune system or blood diseases; those who withdrew from the study midway.

2.2. Methods

For musculoskeletal ultrasound, an ultrasound imaging device was selected, and the probe frequency was set between 6 and 15 MHz. The patient was seated on a rotating chair, with the shoulder fully exposed and kept in a neutral position. The operator stood in front of the patient for a face-to-face examination, using the rotating chair to scan the posterior and lateral aspects of the shoulder. The probe frequency was adjusted flexibly according to the patient's body type and the target detection depth. For superficial areas, the probe frequency was 10 MHz. For obese patients or those with deep tissues or well-developed muscles, the probe frequency was 5–7 MHz. Meanwhile, the long head tendon of the biceps brachii was located.

The scanning method for the subscapularis tendon was as follows: The elbow joint was flexed at 90°, reducing the distance between the chest wall and the elbow joint, with the forearm in a supinated position. The probe was placed on the medial side of the lesser tuberosity to directly visualize the long axis of the subscapularis tendon. Scanning started from the medial side and proceeded laterally to the lesser tuberosity. In passive movement, the shoulder joint was placed in the maximum external rotation position to assess the tendon's mobility. The height of the short axis was equal to that of the long axis. The probe was placed on the medial side of the lesser tuberosity for longitudinal scanning to assess the longitudinal tear of the tendon's short axis.

The scanning method for the supraspinatus tendon was as follows: The patient's upper limb was placed behind the back, with the fingers naturally positioned and the back of the hand placed on the iliac crests on both sides. The operator stood on the patient's side and scanned the junction between the tendon and the muscle, moving the probe laterally to display the short-axis section. The long-axis section of the supraspinatus was consistent with the short axis. The probe was placed at the greater and lesser tuberosities and moved posteriorly and laterally. The patient was asked to abduct and adduct the shoulder joint to assess the damage to the supraspinatus.

The scanning method for the teres minor tendon and the subscapularis tendon was as follows: The operator stood on the patient's lateral side, with the affected arm placed on the opposite shoulder. The long head tendon and the supraspinatus tendon were scanned, and the probe was moved posteriorly and laterally. If the two tendons overlapped, the probe was placed on the infraspinatus tendon and moved posteriorly and laterally until the teres minor tendon was observed. During long-axis scanning, the infraspinatus and teres minor tendons were scanned to observe their distribution and running characteristics. The probe was rotated 90° for transverse scanning of the infraspinatus and teres minor tendons, observing the tendons from the lateral side until they disappeared from the screen.

MRI examination was performed using a magnetic resonance diagnostic device. T1WI and PD-FS sequences were used for oblique coronal scanning, T1WI and T2-FS sequences for oblique sagittal scanning, and PD-FS and T2-FS sequences for axial scanning to obtain diagnostic images, which were used as the gold standard.

2.3. Observation indicators

2.3.1. Location of damage

Assess the probability of injury at locations such as the subscapularis tendon, supraspinatus tendon, infraspinatus tendon, and teres minor tendon.

2.3.2. Degree of damage

(1) Normal rotator cuff

The echo within the rotator cuff is uniform and slightly higher than that of the deltoid tissue. The supraspinatus tendon has a "beak-like" distribution with low internal echoes. The tendon insertion attaches to the fibrocartilage, which has low internal echoes.

(2) Partial tear

The tendon thickness is thinner than that of a healthy tendon, with low or no echoes, accompanied by signs such as a large amount of bursal effusion from the deltoid to the shoulder suture, joint exudation, or changes in fat shape.

(3) Full-thickness tear

There is a lack of rotator cuff tissue, with local low or no echoes. The rotator cuff fibers are discontinuously distributed, with fractures or retractions. It is difficult to clearly display the rotator cuff tissue. The subdeltoid bursa is in contact with the humeral head, and the bursal effusion under the acromion and the effusion of the long head tendon sheath are mixed.

2.3.3. Diagnostic efficacy

Using MRI diagnostic results as the gold standard, accuracy = (number of true positives + number of true negatives) / number of cases in this group; sensitivity = number of true positives / (number of true positives + number of false negatives); specificity = number of true negatives / (number of true negatives + number of false positives).

2.3.4. Morphological and signal characteristics

Assess the differences in morphological and signal characteristics between positive and negative patients after musculoskeletal ultrasound examination. Grade 0 indicates no tendon rupture, normal rotator cuff tissue, and no changes in morphology or signal distribution. Grade I indicates morphology similar to that of a healthy rotator cuff, with low-signal images or local increased signal in the tendon tissue. Grade II indicates visible thinning of the tissue edges in morphology, with signal characteristics similar to those of Grade I. Grade III indicates visible tissue interruption in morphology, with increased signal at the interrupted site and significant changes.

2.3.5. Ultrasound indicators

Assess the manifestations of calcification within the tendon, synovial bursa indentation of the tendon body, positive elastic imaging (green or red linear echoes at the site of tendon injury), and low echoes within the tendon in positive and negative patients. Meanwhile, measure the specific depths of the subacromial bursa effusion, long head tendon sheath effusion, and glenohumeral joint effusion.

2.4. Statistical analysis

Data processing was carried out using SPSS 28.0 statistical software. Count data were expressed as [n/%], and the chi-square test was used. Measurement data were tested for normal distribution using the K-S method and, if conforming, were expressed as [$\overline{x} \pm s$]. Comparisons between groups were made using the independent samples *t*-test, and comparisons within groups were made using the paired *t*-test. A *p*-value < 0.05 indicated a statistically significant difference.

3. Results

3.1. Comparison of the detection rates of damaged locations between musculoskeletal ultrasound and MRI diagnosis

The positive rate of rotator cuff injury detected by musculoskeletal ultrasound was 85.00% (68/80), while the probability of rotator cuff injury confirmed by MRI diagnosis was 90.00% (72/80). The detection rates of damaged locations by the two methods were basically consistent, with no significant difference ($p > 0.05$). See **Table 1**.

Table 1. Comparison of the detection rates of damaged locations between musculoskeletal ultrasound and MRI diagnosis [n/%]

Method	Number of cases	Subscapularis tendon	Supraspinatus tendon	Infraspinatus tendon	Teres minor tendon
Musculoskeletal ultrasound	68	17 (25.00)	33 (48.53)	13 (19.12)	5 (7.35)
MRI diagnosis	72	18 (25.00)	34 (47.22)	13 (18.06)	7 (9.72)
χ^2		0.000	0.024	0.026	0.251
p		1.000	0.877	0.872	0.617

3.2. Comparison of the detection rates of the degree of damage between musculoskeletal ultrasound and MRI diagnosis

The detection rates of the degree of damage by the two methods were basically consistent, with no significant difference between them ($p > 0.05$). See **Table 2**.

Table 2. Comparison of the detection rates of the degree of damage between musculoskeletal ultrasound and MRI diagnosis [n/%]

Method	Number of cases	Normal rotator cuff	Partial tear	Full-thickness tear
Musculoskeletal ultrasound	68	3 (4.41)	21 (30.88)	44 (64.71)
MRI diagnosis	72	0	23 (31.94)	49 (68.06)
χ^2		3.246	0.018	0.176
p		0.072	0.892	0.675

3.3. Comparison of diagnostic efficacy of musculoskeletal ultrasound

Using MRI diagnosis as the reference standard, the accuracy rate of musculoskeletal ultrasound was 92.50% (74/80), with a sensitivity of 93.06% (67/72) and a specificity of 87.50% (7/8). See **Table 3**.

Table 3. Analysis of diagnostic results of musculoskeletal ultrasound

Diagnostic method		MRI diagnosis		
Musculoskeletal ultrasound	**Positive**	Positive	Negative	Total
	Negative	67	1	68
	Total	5	7	12
	Positive	72	8	80

3.4. Comparison of morphological and signal characteristics between patients with positive and negative musculoskeletal ultrasound results

The proportion of Grade III cases was higher among patients with positive musculoskeletal ultrasound results than among those with negative results ($p < 0.05$). (**Table 4)**

Table 4. Comparison of morphological and signal characteristics between patients with positive and negative musculoskeletal ultrasound results [n/%]

Result	Number of cases	Grade 0	Grade I	Grade II	Grade III
Positive	68	0	6 (8.82)	22 (32.35)	40 (58.82)
Negative	12	2 (16.67)	5 (41.67)	3 (25.00)	2 (16.67)
χ^2 value		11.624	9.277	0.257	7.269
p value		0.001	0.002	0.612	0.007

3.5. Comparison of ultrasound indicators between patients with positive and negative musculoskeletal ultrasound results

The ultrasound indicators of patients with positive musculoskeletal ultrasound results were all higher than those of patients with negative results ($p < 0.05$). (**Table 5**)

Table 5. Comparison of ultrasound indicators between patients with positive and negative musculoskeletal ultrasound results [n/%, $\bar{x} \pm s$]

Result	No of cases	Intratendinous calcification	Synovial recess depression	Positive elastography	Intratendinous hypoechoic area	Subacromial bursa effusion depth (mm)	Long head of biceps tendon sheath effusion depth (mm)	Glenohumeral joint effusion depth (mm)
Positive	68	18 (26.47)	27 (39.71)	26 (38.24)	35 (51.47)	1.69 ± 0.11	1.63 ± 0.44	1.89 ± 0.18
Negative	12	0	0	1 (8.33)	1 (8.33)	1.41 ± 0.19	1.28 ± 0.27	1.61 ± 0.12
χ^2/t		4.099	7.192	4.079	7.669	7.071	2.652	5.156
p		0.043	0.007	0.043	0.006	0.000	0.010	0.000

4. Discussion

The rotator cuff is composed of tendons such as the supraspinatus, infraspinatus, and teres minor muscles, which maintain the stability of the shoulder joint. Under various factors such as indirect violence and chronic strain, the rotator cuff is prone to injury, leading to persistent pain around the shoulder joint in patients and affecting the range of motion of the upper limbs, which is detrimental to their daily lives [4]. The manifestations of rotator cuff injury are similar to those of diseases such as acromioclavicular joint pathology or periarthritis of the shoulder, necessitating differential diagnosis to fully assess the extent of the injury and scientifically guide the treatment plan.

At present, MRI diagnosis is considered the gold standard for this condition. It allows for the observation of injuries to soft tissues such as the rotator cuff and bursa during surgery, accurately assessing the location and severity of the injury. MRI is characterized by its visual clarity and high diagnostic accuracy [5]. However, MRI diagnosis is invasive and costly, thus limiting its applicability. In comparison, musculoskeletal ultrasound offers the advantages of repeatability, non-invasiveness, reasonable cost, and high diagnostic efficiency. It enables bedside ultrasound examinations, providing great convenience. Musculoskeletal ultrasound allows for real-time diagnosis, dynamically observing the movement of muscles and tendons, and quickly detecting rotator cuff injuries [6]. Additionally, musculoskeletal ultrasound has high resolution and can simultaneously scan multiple muscle and tendon tissues without causing pain or discomfort during the scanning process, resulting in high patient tolerance.

The results show that the detection rates of musculoskeletal ultrasound for the location and extent of rotator cuff injury are close to those of MRI diagnosis ($p > 0.05$). The accuracy rate of musculoskeletal ultrasound is 92.50%, with a sensitivity of 93.06% and a specificity of 87.50%. The reasons for this are as follows: Ultrasound waves have strong penetrability into soft tissues, allowing for the acquisition of clear reflected signals and effective observation of injuries to superficial and deep tendon tissues [7]. Moreover, the probe of musculoskeletal ultrasound is highly flexible and can be reasonably adjusted in frequency and angle according to the anatomical characteristics of the scanning location, enabling rapid identification of rotator cuff injuries. The high-frequency probe used in this study can accurately assess the interruption of rotator cuff tissue and observe abnormal echo characteristics. As a dynamic visualization technique, musculoskeletal ultrasound can evaluate the injury manifestations of rotator cuff structures in real time, demonstrating good diagnostic efficacy [8,9]. The proportion of Grade III morphological and signal characteristics in patients with positive musculoskeletal ultrasound results is higher than that in patients with negative results, and the ultrasound indicators are greater in positive patients ($p < 0.05$). The reasons for this are as follows: Rotator cuff injuries are often accompanied by tendon tears, leading to changes such as hyaline degeneration in tendon cells, resulting in low echo characteristics on musculoskeletal ultrasound. The slow infiltration of fat into the tendon body also contributes to low echo areas. In the case of bursal-sided rotator cuff injuries, the bursal effusion below the acromion contains a large number of inflammatory factors, causing continuous damage to the bursal-sided tendon and subsequently leading to tendon depression [10]. Additionally, rotator cuff injuries can trigger an inflammatory response, resulting in effusion in the surrounding bursa and tendon sheath. Therefore, the depth of the effusion can reflect the degree of inflammation and thus help judge the extent of rotator cuff injury.

5. Conclusion

In conclusion, musculoskeletal ultrasound demonstrates excellent diagnostic efficacy for rotator cuff injuries, enabling the assessment of the extent of the injury. It also exhibits typical ultrasound manifestations, facilitating differential diagnosis of the condition.

Disclosure statement

The author declares no conflict of interest.

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