

## Research Article

# Magnetic Resonance Imaging Classifications of Rotator Cuff Tear Are Associated with Different Shoulder Outcome Scores

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**Objective.** Rotator cuff tear (RCT) accounts for 50% of shoulder injuries, leading to chronic pain and disability in the upper extremity. The study is conducted to investigate the association between resonance imaging (MRI) classifications of patients with RCT and different shoulder outcome scores. **Methods.** From September 2018 to October 2019, 112 patients underwent shoulder MRI at our institution and selected as eligible study subjects according to inclusion and exclusion criteria. Among these 112 patients, 69 cases had confirmed history of shoulder trauma and 43 cases were due to chronic shoulder joint pain. The shoulder function of patients was evaluated by University of California Los Angeles Shoulder (UCLA) score, Constant-Murley score, Shoulder Pain and Disability Index (SPADI), and simple shoulder test (SST). **Results.** Among the 112 patients, there were 34 cases, 58 cases, and 20 cases with MRI classifications at grades I, II, and III, respectively. There was no significant difference in the injured tendons in patients with different MRI classifications ( $P > 0.05$ ). The injury at the supraspinatus was more common. The scores of UCLA, Constant-Murley, and SST in patients with MRI grading at grade I were significantly higher than those at grades II and III ( $P < 0.05$ ), which were significantly higher in patients at grade II than those at grade III ( $P < 0.05$ ). SPADI score in patients with MRI grading at grade I was significantly lower than that at grades II and III ( $P < 0.05$ ), while there was no significant difference in SPADI score between patients at grades II and III ( $P > 0.05$ ). MRI classifications were negatively correlated with scores of UCLA, Constant-Murley, and SST ( $P > 0.05$ ). There was no significant correlation between MRI grade and SPADI scores ( $P > 0.05$ ). **Conclusion.** The supraspinatus tendon injury is more common in patients with RCT. MRI classifications were negatively correlated with scores of UCLA, Constant-Murley, and SST.

## 1. Introduction

Rotator cuff tear (RCT) accounts for 50% of shoulder injuries, leading to chronic pain and disability in the upper extremity [1]. The prevalence of RCT increases with advanced age, and more than 50% individuals in their 80s suffer from RCT [2]. The initial treatment for most RCT cases is conservative, with physical therapy, analgesics, and possibly corticosteroid or plasma-rich protein injections. There are a wide variety of surgical options, such as rotator cuff repair, superior capsule reconstruction, subacromial decompression, as well as reverse shoulder arthroplasty [3, 4]. However, reinjury rates of RCT range from 11% to 94% after surgical intervention [5]. Failed rotator cuff repair may be attributed to some nonmodifiable and modifiable patient

factors, such as age, tendon quality, rotator cuff tear characteristics, acute or chronic rotator cuff tear, bone quality, tobacco use, and medications, and surgical variables, such as the technique, timing, tension on the repair, the biomechanical construct, and fixation, as well as the postoperative rehabilitation strategy [6].

Many surgeons rely on magnetic resonance imaging (MRI) to assist in decision-making and presurgical planning for patients with RCT [7]. MRI provides more comprehensive evaluation of the glenohumeral joint, including more accurate evaluation of articular cartilage and labroligamentous structures, factors that dictate conservative treatment, guide surgical management, and help set patient expectations [8]. However, MRI interpretation following rotator cuff repair can be challenging and requires familiarity with

different types of RCT, their surgical treatments, normal postoperative MRI appearance, and complications [9]. In this study, we evaluated the severity of RCT according to MRI and analyzed the association between MRI evaluations and different shoulder outcome scores including University of California Los Angeles (UCLA) shoulder score, Constant-Murley scale, Shoulder Pain and Dysfunction Index (SPADI), and simplified shoulder functional testing (SST), in a bid to provide reference for diagnosis and management of RCT.

## 2. Materials and Methods

**2.1. Study Design and Subjects.** From September 2018 to October 2019, 112 patients underwent shoulder MRI at our institution and selected as eligible study subjects according to inclusion and exclusion criteria. Among these 112 patients, 69 cases had confirmed history of shoulder trauma and 43 cases were due to chronic shoulder joint pain. The disease duration ranged from 2 days to 2 years, with an average disease duration of  $1.3 \pm 0.6$  years. There were 41 left shoulders with RCT and 71 right shoulders with RCT. This retrospective study received the approval of the Ethics Committee of our hospital, and the informed consent was obtained from each subject. The inclusion criteria were as follows: (a) meeting the diagnostic criteria of RCT [10]; (b) with complete MR images; and (c) informed of study design and objective. The exclusion criteria were as follows: (a) previous treatment for shoulder joint injury; (b) history of osteoarthritis, ligament fracture, and other bone and joint diseases; (c) complicated with hypertension and diabetes mellitus; and (d) cognitive and communication impairment. All patients complained different degrees of shoulder pain. Most of the patients have intermittent shoulder pain at the beginning, and the symptoms were aggravated after work and sleeping on the side at night. At the same time, the patients had difficulties in forward elevation, abduction, internal rotation, and extension, with local tenderness instead of high skin temperature. The pain arc sign was positive; namely, the pain increased upon elevation and adduction in the range of 60–120°. Neer impingement test shows a positive sign; namely, the big tubercle of the humerus and acromial impact showed pain. Among 112 cases, 16 cases underwent arthroscopic shoulder surgery and 96 received medication and physical therapy. There were 63 males and 49 females, aged ranging from 20 to 70 years and with an average age of  $50.27 \pm 8.69$  years.

**2.2. MRI Protocols.** MRI examination was performed on patient shoulders by using a MR scanner (Siemens MAGNETOM Avanto1.5 T), with GP-FLEX pliable coil. Patients were scanned in the neutral position. The parameters were set as follows: field of view (FOV) was 24 cm  $\times$  24 cm; scanning thickness and gap were 4 mm and 1 mm, respectively; and matrix was 256  $\times$  256 or 512  $\times$  512. Regular scanning sequence was applied, including fast spin echo (TSE) T2-weighted imaging (T2WI) (where the repetitive time (TR)/echo time (TE) was 4000/78 ms), short-term inversion recovery sequence (STIR) (among them, TR/TE

was 4000/28 ms), and spin echo (SE) T1-weighted imaging (T1WI) (where TR/TE was 450/13 ms). The horizontal axis, oblique coronal, and oblique sagittal were chosen.

**2.3. MR Image Analysis.** Each MR study was reviewed by three radiologists experienced in musculoskeletal MR imaging. The examiners were blinded to the patient's name, clinical history, and arthrographic surgical results. A consensus was reached in each case as to whether the patient had a rotator cuff tear, an intact tendon with tendinitis, or a normal cuff. The rotator cuff tendons were assessed and classified into four grades according to previous report [11]. Grade 0 was defined as a tendon that was normal in signal intensity and morphology. Grade I was defined as a tendon with increased signal intensity but normal morphology. Grade II was defined as a tendon with both abnormal signal intensity and morphology. Abnormal morphology was defined as obvious tendon thinning or irregularity. A grade III tendon was defined as one with a definite large area of discontinuity in the normal signal void of the tendon. The area of discontinuity typically showed increased signal intensity on T2WI. A-H distance was measured by MRI as previously reported [12]. A-H distance less than 0.5 cm was defined as an extensive rotator cuff tear, 0.5–1.0 cm as acromion stenosis, and 1.0–1.5 cm as normal acromion. Fatty infiltration of the rotator cuff muscles was graded according to the Goutallier classification with sagittal proton density images [13, 14]. Based on this classification system, grade 0 represents no fat, grade I represents trace fatty streaks, grade II represents less than 50% fat, grade III represents 50% fat, and grade IV represents more than 50% fat. The global fatty degeneration index (GFDI) of each patient was calculated and classified into <1, 1–1.5, and >1.5 [15].

**2.4. Assessment of Shoulder Function by Different Shoulder Outcome Scores.** In this study, the UCLA shoulder score, Constant-Murley scale, SPADI, and SST were performed to evaluate the shoulder function of 112 patients. The UCLA scale was classified into three levels, including 34–35 scores indicating excellent shoulder outcome, 29–33 scores indicating good shoulder outcome, and <29 scores indicating poor shoulder outcome [16]. The Constant-Murley scores are involved with three items, shoulder range of motion (ROM), pain, and activity, with a total score of 75 [17]. The higher scores are indicative of better shoulder function. The SPADI scale encompasses 5 pain and 8 functional issues, with scores ranging from 0 to 100 scores [18]. The higher scores are indicative of poorer shoulder function. The SST scale involves pain symptoms and impacts on rest, life, and work, including 12 issues and with scores ranging from 0 to 12 scores [19]. The higher scores are indicative of better shoulder function.

**2.5. Data Processing.** SPSS 20.0 software (IBM Corp, Armonk, NY) was used to process the data. The counting data was described by “*n* and (%)” and tested by the chi-square test; the measurement data were described by (mean  $\pm$  standard deviation), the comparison between two groups was tested by *t*-test, and comparison over two groups

were tested by *F* test; Pearson coefficient was applied for correlation analysis. The level of significant difference represented as *P* value < 0.05.

### 3. Results

**3.1. MRI Classification.** There were 34 cases defined as grade I. A T1WI coronal oblique image demonstrates increased signal intensity in the distal supraspinatus tendon, with no evidence of thinning irregularity or discontinuity, while a normal subdeltoid fat plane was visible (Figure 1). There were 58 cases defined as grade II. A T1WI coronal oblique image demonstrates diffuse increased signal intensity in the supraspinatus tendon, and it was irregular in appearance and thinned. A T2WI coronal oblique image demonstrates high signal intensity consistent with fluid in the subacromial-subdeltoid bursa (Figure 2). There were 20 cases defined as grade III. A T1WI coronal oblique image demonstrates complete disruption of the supraspinatus tendon, and the tendon has retracted to the level of the acromioclavicular joint with irregular and frayed edges. The subacromial-subdeltoid fat plane is lost. It was observed considerable atrophy of the supraspinatus muscle and degenerative changes in the acromioclavicular joint. A T2WI coronal oblique image at the level of the acromioclavicular joint demonstrates the disruption of the supraspinatus tendon as it is outlined by high-signal-intensity fluid. A large amount of fluid is visible in the subacromial and subdeltoid bursae. Increased signal intensity of T2WI was noted in the proximal retracted tendon edges (Figure 3). MRI classifications of 112 patients were listed in Table 1.

**3.2. Association between MRI Classifications and Injured Tendons.** MRI classifications of 112 patients were subclassified according to the injured tendons of muscles (supraspinatus, infraspinatus, subscapularis, and teres minor ones). There were 97 cases with abnormal morphology of supraspinatus tendons and high signal intensity, including 29 grade I, 51 grade II, and 17 grade III. There were 6 cases with abnormal morphology of subscapularis tendons and high signal intensity, including 2 grade I, 3 grade II, and 1 grade III. There were 2 cases with abnormal morphology of teres minor tendons and high signal intensity, including 1 grade I and 1 grade II. There were 7 cases with abnormal morphology of infraspinatus tendons and high signal intensity, including 2 grade I, 3 grade II, and 2 grade III. As shown in Table 2, MRI classifications were not significantly correlated with injured tendons among 112 patients with RCTs.

**3.3. Association between MRI Classifications and Different Shoulder Outcome Scores.** The UCLA, Constant-Murley, and SST scores of patients defined as MRI grade I were significantly higher than those of grades II and III ( $P < 0.05$ ), and those of grade II were significantly higher than those of grade III ( $P < 0.05$ ). The SPADI scores of MRI grade I were significantly lower than those of grade II and grade III ( $P < 0.05$ ), and there was no significant difference between grade II and grade III ( $P > 0.05$ ). Results are revealed in Table 3. The results of Pearson correlation analysis (Table 4) showed



FIGURE 1: MRI grade 1 (pointed by the downward arrow in the figure): the supraspinatus tendon was continuous, and the T2WI hyperintense signal shadow (revealed as a strip) was found near the attachment end of the humerus, and the boundary was still clear; MRI grade 2 (pointed by the upward arrow in the figure): the subscapularis tendon was revealed continuous, and the shape near the attachment of the humerus was distorted and irregular, and T2WI hyperintense signal shadow (revealed as a patch) was found.



FIGURE 2: MRI grade 2 (the arrow pointed in the figure): the supraspinatus tendon was continuous, but the boundary was irregular, T2WI hyperintense signal shadow (revealed as strips) was found, and long T2WI fluidity signal shadow was found in the axillary fossa, joint cavity, and deep deltoid fascia.

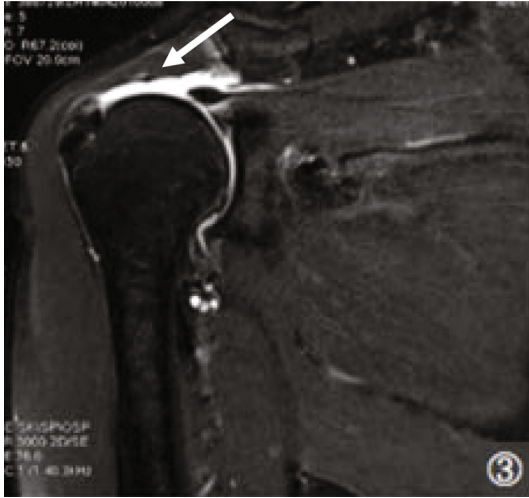


FIGURE 3: MRI grade 3 (the arrow pointed in the figure): the attachment end of the greater tuberosity of the humerus in the supraspinatus tendon indicated emptiness and was filled with liquid signal shadow. It was found that the continuity of the tendon was interrupted and the broken ends were retracted. Effusion in the deltoid bursa below the acromion was found.

TABLE 1: MRI classifications.

MRI grade	Case	Percentage (%)
Grade 1	34	30.36
Grade 2	58	51.79
Grade 3	20	17.86

MRI: magnetic resonance imaging.

that MRI grades were negatively correlated with the UCLA, Constant-Murley, and SST scores ( $P < 0.05$ ). There was no significant correlation between MRI grade and SPADI scores ( $P > 0.05$ ).

**3.4. Association between A-H Distance, Fatty Infiltration of the Rotator Cuff Muscles, and Different Shoulder Outcome Scores.** After MRI examination, among 112 patients with RCTs, there were 19 with A-H distance  $< 0.5$  cm, 32 with A-H distance between 0.5 and 1.0, and 61 with A-H distance between 1.0 and 1.5. No significant difference was observed among patients with A-H distance  $< 0.5$  cm, between 0.5 and 1.0, and between 1.0 and 1.5 ( $P > 0.05$ ). Among 112 patients with RCTs, there were 86 with GFDI  $< 1$ , 11 with GFDI from 1 to 1.5, and 15 with GFDI  $> 1.5$ . No significant difference was observed among patients with GFDI  $< 1$ , GFDI from 1 to 1.5, and GFDI  $> 1.5$  ( $P > 0.05$ ).

## 4. Discussion

Treatment selection and prognosis evaluation largely depend on the dimensions and extent of RCT, tear morphologic features, involvement of the subscapularis and infraspinatus tendons or of contiguous structures, the condition of the involved tendon, and presence of muscle atrophy [20, 21]. MRI can evaluate the extent and configuration of rotator cuff

abnormalities, document abnormalities of the cuff muscles and adjacent structures, and suggest mechanical imbalance within the cuff [22]. In addition to that, MRI can provide information about RCT including tear dimensions, tear depth or thickness, tendon retraction, and tear shape that is required for optimal treatment planning and prognostic accuracy [23]. In this study, we evaluated the severity of RCT according to MRI and then analyzed the association between MRI evaluations and shoulder function scored by UCLA, Constant-Murley, SPADI, and SST scores.

From previous studies, researchers mainly focused on analysis of the correlation between different shoulder outcome scores in patients with RCTs. For example, Assuncao et al. [24] found that the UCLA and American Shoulder and Elbow Surgeons (ASES) scores showed a very high correlation ( $r = 0.91$ ). Allom et al. [25] found a correlation between the Constant-Murley and Oxford scales for open procedures ( $r = 0.77$ ) and for arthroscopic procedures ( $r = 0.89$ ). Cunningham et al. [26] found the correlation between the ASES and Single Assessment Numerical Evaluation scales for primary arthroscopic repair ( $r = 0.75$ ). Gilbert and Gerber [27] found a correlation of 0.80 between the Constant-Murley and Subjective Shoulder Value scales. Romeo et al. [28] compared the results of the UCLA, Constant-Murley, and SST scales applied in patients who underwent open surgery. Skutek et al. [29] found a correlation between the ASES and Constant-Murley scales ( $r = 0.87$ ), the UCLA scale and the Constant-Murley ( $r = 0.66$ ), the Constant-Murley and SST scales ( $r = 0.76$ ), and the Constant-Murley and SST scales ( $r = 0.70$ ) in a study of patients undergoing open repair. However, few literatures reported the correlations between MRI results and different shoulder outcome scores in patients with RCTs. In this study, we evaluated a significant negative correlation between MRI results and the UCLA scores in RCT patients with RCT, indicating that the lower MRI grades and the higher UCLA score correspond to better shoulder function. However, the correlation coefficient is not high ( $r = -0.358$ ), suggesting that UCLA score is not effective in judging the degree of RCT, concurring with other study [30]. The reasons may include the following three points: (a) general classification of patients' functional activities makes it easy to produce errors; (b) assessment of muscle strength and range of motion only through the measurement of shoulder flexion activity generally involving the biceps brachii, deltoid anterior bundle, pectoralis major, and other muscle groups is less representative of the overall shoulder activity; (c) only two items including satisfaction and dissatisfaction make it difficult to reflect the actual condition. In this study, there was a significant negative correlation between the SSR score, Constant-Murley score, and the MRI grades, indicating the higher the SSR and Constant-Murley scores were, the better shoulder function was presented. The Constant-Murley score is composed of shoulder range of motion, pain symptoms, and functional activities, while the evaluation of shoulder range of motion and functional activities is comprehensive and specific, involving internal rotation, external rotation, flexion, and abduction activities [31]. Although the classification of pain score is relatively simple and there are individual differences

TABLE 2: MRI classifications and injured tendons ( $n$  (%)).

MRI grade	n	Supraspinatus	Subscapularis	Teres minor	Infraspinatus
Grade 1	34	29 (85.29)	2 (5.88)	1 (2.94)	2 (5.88)
Grade 2	58	51 (87.93)	3 (5.17)	1 (1.72)	3 (5.17)
Grade 3	20	17 (85.00)	1 (5.00)	0 (0.00)	2 (10.00)
$\chi^2$			1.228		
$P$			0.976		

MRI: magnetic resonance imaging.

TABLE 3: MRI classifications and different shoulder outcome scores (mean  $\pm$  standard deviation).

MRI classification	$n$	UCLA	Constant-Murley	SPADI	SST
Grade I	34	33.05 $\pm$ 5.28* <sup>#</sup>	68.23 $\pm$ 10.25* <sup>#</sup>	60.38 $\pm$ 10.35* <sup>#</sup>	10.15 $\pm$ 1.67* <sup>#</sup>
Grade II	58	30.16 $\pm$ 5.02*	60.14 $\pm$ 8.37*	69.37 $\pm$ 11.84	8.06 $\pm$ 1.35*
Grade III	20	25.27 $\pm$ 4.13	51.49 $\pm$ 7.68	72.54 $\pm$ 12.06	5.24 $\pm$ 0.96
$F$		15.497	23.047	9.249	78.048
$P$		<0.001	<0.001	<0.001	<0.001

MRI: magnetic resonance imaging; UCLA: University of California Los Angeles; SPADI: Shoulder Pain and Disability Index; SST: simple shoulder test.

TABLE 4: Correlation analysis between MRI classifications with scores of UCLA, Constant-Murley, SPADI, and SST.

Shoulder outcome scores	MRI classification	
	$r$	$P$
UCLA	-0.358	<0.001
Constant-Murley	-0.487	<0.001
SPADI	0.038	0.476
SST	-0.702	<0.001

MRI: magnetic resonance imaging; UCLA: University of California Los Angeles; SPADI: Shoulder Pain and Disability Index; SST: simple shoulder test.

in subjective evaluation of patients, the Constant-Murley score can accurately determine the degree of RCT to a large extent due to the small proportion of the pain score. The SST score mainly involves the influence of pain symptoms and diseases on the rest state, life, and work of patients. The evaluation is simple and easy to operate. The range of motion and muscle strength of human shoulder joint in different directions can be effectively considered by using 12 different life problems, which can comprehensively evaluate the joint function of patients with shoulder injury [32]. It was previously reported that the SPADI score exhibited low credibility due to repeated test [33]. As shown in our results, there was no significant correlation between MRI grades and the SPADI score, which was consistent with the above study. It revealed that the SPADI score is insufficient in evaluating shoulder function of patients with RCT.

In conclusion, our results show a negative correlation between UCLA, Constant-Murley, and SST scores. Poorer MRI grades are indicative of higher scores of UCLA, Constant-Murley, and SST. However, there was no significant correlation between SPADI and MRI grades, which provide

reference for decision-making for evaluating shoulder function using different scores in patients with RCTs.

## Data Availability

The data used to support the findings of this study are included within the article.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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