The Egyptian Orthopedic Journal

Vol. 60, No. 1, 2025
ISSN: 1110-1148 (print)
ISSN: 2090-9926 (online)
DOI: 10.21608/EOJ.2025.419268

# ORIGINAL ARTICLE

## Evaluation of MRI Fat Signal of Rotator Cuff Tears Before and After Repair

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**Objective** This work was to evaluate the MRI fat signal of rotator cuff tears before and after repair.

**Background** Following rotator cuff tearing, fatty degeneration, a degenerative disorder of the tendon-muscle unit of the rotator cuff muscles occurs. It is characterized by fatty deposition within and around the muscles as well as atrophy of the muscle fibers. It is commonly linked to a decline in the rotator cuff tendons' capacity for regeneration brought on by aging.

**Subjects and Methods** A prospective cohort study included 20 patients diagnosed with rotator cuff injury on MRI and was followed-up for 3 months, during a period time from July 2020 to February 2023.

**Results** According to Goutilier classification there were grade 0, 1, 2 and 3. In preoperative they were 25, 45, 25 and 5%, respectively, where as in postoperative were 20, 35, 30, and 15%, respectively. A significant differences According to the improvement of goutilier classification worsen in (30.0%) of patient and same in (70.0%) of patients with mean (0.30±0.47).

**Conclusions** According to improvement of goutilier classification we found no fatty infiltration progression in 70% of cases while 30% was Worsen.

**Keywords** Fatty infiltration, Goutallier classification, Rotator cuff injury.

### INTRODUCTION

Shoulder pain, which ranks third in frequency of musculoskeletal pain behind low back and knee pain, can result in severe morbidity and a lower quality of life [1]. Up to 86% of patients with shoulder pain have rotator cuff issues as their primary cause [2]. Fatty degeneration (FD) of the rotator cuff muscles is observed after tendon rupture or rotator cuff nerve damage. This disorder has a major impact on the anatomical and clinical results after surgery.

Tendon rupture results in changes to the physiology, structure, and function of the muscle due to atrophy and fatty infiltration of the muscle when the tensile stresses decrease. This process is referred to as fatty muscle degeneration [3,4].

FD is an irreversible process that does not seem to lead to the regeneration of muscle tissue, even after successful rotator cuff surgery [5]. Therefore, surgery should be performed before serious FD manifests. It has been shown that FD is partially reversible in a sheep model [6]. Predicting the degree of FD before surgery is a critical step in establishing the timing and expected clinical success of rotator cuff repair and should be done using a systematic classification. The FD was first proposed for computer tomography (CT) based grading in axial images by Goutallier *et al*., [7] and it was revised for magnetic resonance imaging (MRI) in 1999 by Fuchs *et al*., The currently approved method for evaluating FD from oblique-sagittal T1-weighted MR images is the semi-quantitative, five-grade modified Goutallier classification. Since FD has a major impact on the postoperative result, numerous attempts have been undertaken to increase the validity and reliability of the Goutallier Classification [8].

MRI has become the standard study for rotator cuff illnesses in preoperative and postoperative evaluation, as well as healing following treatment, due to its outstanding soft tissue resolution and multiplanar imaging capabilities [9]. It has been controversial to discuss whether fatty infiltration and muscle atrophy progress or regress after cuff repair. While some researchers argue that there is no improvement in muscle status following a successful rotator cuff repair, others counter that a good repair does not lead to an increase in muscle status. To address this issue in the clinical setting, prior studies have compared preoperative CT or MRI scans with postoperative images obtained months or years after repair [10]. This study aimed to evaluate the MRI fat signal of rotator cuff tears before and after repair.

## SUBJECTS AND METHODS

A prospective cohort study included 20 patients with rotator cuff injuries during a period time from July 2020 to February 2023. The individual was informed of the study's objectives in detail and was then asked to sign an informed consent form. The study proposal (IRP 8/2020 O RTH22) was approved by the Menoufia Faculty of Medicine's local ethical scientific committee in Menoufia, Egypt.

The patients with repairable rotator cuff tears and both sexes were included while patients with associated cervical pathology as cervical spondylosis, associated with glenohumeral arthritis, (rheumatoid patients, OA), co morbidity as uncontrolled diabetes mellitus, previous operations of the shoulder, patients with associated GH pathology (glenohumeral instability, frozen shoulder requiring arthroscopic release, calcific tendinitis, or biceps tendon lesion) and fracture were excluded.

Detailed history was taken including age, sex, BMI, dominant side, occupation, Smoking, cause (trauma or degenerative) and comorbidities (diabetes mellitus or thyroid or RH), then laboratory investigations was done as complete blood count, serum urea and creatinine, C-reactive protein, random blood sugar, HBA1c, and Rheumatoid factor (RF), then imaging studies (MRI) were done for each patient pre and 3 months after surgery. The 5-stage assessment system approved by Goutallier *et al*., [11] was used to assess tendon repair (Figures 1 and 2).

### Statistical analysis:

The computer was fed data, and IBM SPSS software package version 20.0 was used for analysis. (IBM Corp., Armonk, NY) Numbers and percentages were used to describe the qualitative data. The tests that were employed were $\chi^2$ test used to compare several groups based on categorical variables. When more than 20% of the cells have an expected count of less than 5, the $\chi^2$ needs to be corrected using Fisher's Exact or Monte Carlo method. Independent t test used to compare two groups under study for quantitative variables that are regularly distributed. $p$ value less than 0.05 is considered a significant level.


**Figure 1:** NMR in T1 in a weighted oblique sagittal series. Full line arrows denote supraspinatus muscle grade 1 goutilier, whereas dotted arrows denote infraspinatus muscle grade 2 goutilier [12].

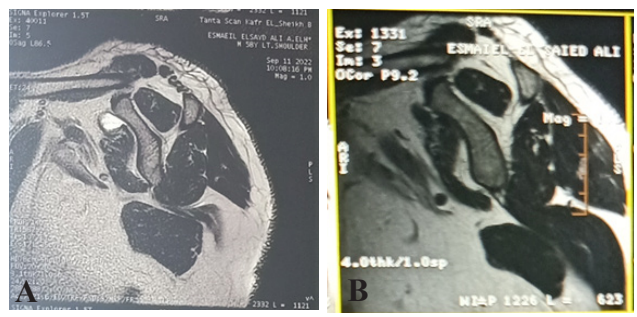


**Figure 2:** Oblique sagittal magnetic resonance imaging of SS tear of left sholder in male patients, 58 years old, worker, with BMI 29.1, smoker; A: Pe opreative with grade 1 goutilier; B: Postopreative with grade 1 goutilier.

## RESULTS

Demographic characteristics of our patients are shown in (Table 1).

According to Goutilier classification grade 0 was found in (25.0%) of preoperative and in postoperative found in (20.0%). While, grade 1 was found in (45.0%) preoperative and in postoperative found in (35.0%). Additionally, grade 2 was found in (25.0%) of preoperatie and (30.0%) postoperative. Grade 3 was found in (5.0%) preoperative and (15.0%) postoperative. With a significant differences ($p$=0.014) (Table 2).

According to the improvement of goutilier classification worsen in (30.0%) of patients and the same in (70.0%) of patients with mean (0.30±0.47) (Table 3).

No relation was found between the changes and age ($p$=0.354), side ($p$=0.642), impingement ($p$=0.642), and anchor ($p$=0.500). While a significant association between the changes and occupation. Where, most of the worsn cases were not workers while, 9 same patients was worker ($p$=0.014). As well as, a significant association between the chnages and trauma. Where most of worsen patients was not have trauma and 8 of same patients have a trauma ($p$=0.042) (Table 4).

**Table 1:** Demographic data among the studied cases ($n$=20)

| Variables | Cases *No.* (%) |
|---|---|
| Age | |
| <50 years | 6 (30) |
| ≥50 years | 14 (70) |
| Sex | |
| Male | 5 (25) |
| Female | 15 (75) |
| Dominant side | |
| Right | 11 (55) |
| Left | 9 (45) |
| Works | |
| Worker | 8 (40) |
| Non worker | 12 (60) |
| Causes | |
| Trauma | 9 (45) |
| Degenerative | 11 (55) |
| Comorbidity | |
| Diabetes mellitus | 5 (25) |
| Smoking | |
| Yes | 4 (20) |
| No | 16 (80) |
| Goutilier classification | |
| Grade 0 | 5 (25) |
| Grade 1 | 9 (45) |
| Grade 2 | 5 (25) |
| Grade 3 | 1 (5) |

**Table 2:** Comparison between pre and postoperative goutilier classification ($n$=20)

| Goutilier classification | Preoperative *No.* (%) | Postoperative *No.* (%) |
|---|---|---|
| Grade 0 | 5 (25.0) | 4 (20.0) |
| Grade 1 | 9 (45.0) | 7 (35.0) |
| Grade 2 | 5 (25.0) | 6 (30.0) |
| Grade 3 | 1 (5.0) | 3 (15.0) |
| MH (p) | 2.449* (0.014*) | |

MH: Marginal Homogeneity Test.

**Table 3:** Distribution of the studied cases according to change of goutilier classification ($n$=20)

| Change of goutilier classification | *No.* (%) |
|---|---|
| Worsen | 6 (30.0) |
| Same | 14 (70.0) |
| Min.–Max. | 0.0–1.0 |
| Mean±SD. | 0.30±0.47 |
| Median (IQR) | 0.0 (0.0–1.0) |

**Table 4:** Relation between the changes with age, occupation, side trauma, impingement, and anchor ($n$=20)

| | Change of goutilier classification | | | |
|---|---|---|---|---|
| Age (years) | Worsen ($n$=6) *No.* (%) | Same ($n$=14) *No.* (%) | Test of significance | *P* |
| <50 | 1 (16.7) | 6 (42.9) | $\chi^2$=1.266 | $^{FE}p$=0.354 |
| ≥50 | 5 (83.3) | 8 (57.1) | | |
| Min–max | 43.0–58.0 | 40.0–58.0 | | |
| Mean±SD | 51.83±5.34 | 49.64±6.11 | $t$=0.760 | 0.457 |
| Median | 52.50 | 50.0 | | |
| Occupation | | | | |
| Nonworker | 6 (100.0) | 5 (35.7) | $\chi^2$=7.013* | 0.014* |
| Worker | 0 | 9 (64.3) | | |
| Side | | | | |
| Right | 3 (50.0) | 9 (64.3) | $\chi^2$=0.357 | 0.642 |
| Left | 3 (50.0) | 5 (35.7) | | |
| Trauma | | | | |
| No | 6 (100.0) | 6 (42.9) | 5.714* | 0.042* |
| Yes | 0 | 8 (57.1) | | |
| Impingement | | | | |
| No | 3 (50.0) | 9 (64.3) | 0.357 | 0.642 |
| Yes | 3 (50.0) | 5 (35.7) | | |
| Anchor | | | | |
| 0 | 0 | 3 (21.4) | $\chi^2$=1.794 | $^{MC}p$=0.500 |
| 1 | 4 (66.7) | 9 (64.3) | | |
| 2 | 2 (33.3) | 2 (14.3) | | |
| Min.–Max. | 1.0–2.0 | 0.0–2.0 | $U$=28.00 | 0.274 |
| Mean±SD. | 1.33±0.52 | 0.93±0.62 | | |
| Median | 1.0 | 1.0 | | |

FE, Fisher Exact; $\chi^2$, Chi square test.

## DISCUSSION

In our study, 9 were left and 11 were right shoulders, 75% were female more affected than male (25%). Our result in accordance with Gruber *et al*., [13] who examined 342 shoulders diagnosed with rotator cuff injury, they found 257 female and 85 male shoulders. Of which 209 had right shoulders and 133 had left shoulders. This seems to be in line with another study that indicates women are

more likely than males to experience cuff tear arthropathy (CTA) [14,15].

According to Goutilier classification, grade 0 was found in (25.0%) preoperative versus in postoperative (20.0%). While, grade1 was found in (45.0%) preoperative versus 35% at postoperative. Then 25% had grade 2 preoperatie versus 30% postoperative. While, Grade 3 found in 5% at preoperative versus 15% at postoperative. In a previous study by Goutallier *et al*., [7]; Goutallier *et al*., [11], reported that a favorable clinical outcome may be predicted by a low preoperative stage of FD of the infraspinatus muscle. Furthermore, it was noted by Goutallier *et al*., [7] and Yao and Mehta [16] that significant anterosuperior rotator cuff injuries may in fact result in FD of the infraspinatus muscle. Although supraspinatus muscle FD has been observed to partially revert in other studies, Goutallier *et al*., [7] discovered that muscle FD virtually never improved following surgery.

In our investigation, 30.0% of patients had changed the goutilier categorization and remained the same in 70.0% of patients with a mean of 0.30±0.47. After severe rotator cuff injuries were surgically repaired, fatty infiltration advanced in all afflicted muscles, according to several studies, however the rate of progression was slowdown [17]. According to Gladstone *et al*.'s study [5], no reversal of muscle atrophy or fatty infiltration was observed during the study period, which is consistent with our findings. At the time of the follow-up, the more progression was observed the larger the preoperative degree of muscle degeneration. 35% of patients had little or minor muscular atrophy advanced (seven patients with grade 1, and one patient with grade 2). Additionally, 67% of the 15 patients with moderate to severe atrophy prior to surgery advanced from grade 2 to 3. The sole instance of noncompliance occurred in a single patient, whose atrophy progressed from a moderate to mild severity (grade 2 to 1) following a successful supraspinatus surgery [5]. Other studies found no changes in the fatty infiltration following the repair [18,19]. However, many authors have previously been conducted to refute this, as noted by Gerber *et al*., [6]. These investigations observed no changes in the degree of fatty infiltration following rotator cuff suture, but rather a higher supraspinatus muscle occupancy rate in the fossa.

Furthermore, Liem *et al*., [20] discovered that from the preoperative to the postoperative exams, there was a substantial increase in fatty infiltration in the supraspinatus and the infraspinatus, regardless of tendon integrity with no discernible increase in fatty infiltration of the subscapularis. The retear group and the intact-tendon group differed in the extent of fatty infiltration of the supraspinatus, infraspinatus, or subscapularis, according to the analysis of 45 preoperative MRI scans that were available. However, these differences did not reach significance with the small number of patients evaluated in this study. On the other hand, regression of fatty infiltration was demonstrated by Goutallier *et al*., [11] in the event of a successful repair. The development of muscle quality may be influenced by tear size, baseline fatty infiltration, and repair integrity, albeit it is yet unclear how these factors relate to one another given the available data.

Additionally, age and progress did not significantly correlate in our study. The study by Cheung *et al*., study [21] showed a noteworthy correlation between advancing age and a rise in supraspinatus fatty infiltration. However, based on the severity of supraspinatus tears, Barry *et al*., study [17] shows a similar link between age and muscle atrophy, indicating an overall trend toward smaller muscles with advancing age that is independent of tear severity. On the other hand, individuals with complete tears had a higher rate of deterioration in the supraspinatus muscle-to-fossa ratio with aging (slope of a linear fit trendline) than patients without tears. Authors added that the prevalence of fatty infiltration and muscular atrophy increases with age in patients without rotator cuff injuries. Other previous studies reported that the aging process can cause a decrease in muscle mass followed by a replacement of fat and connective tissue [22,23] providing support for this observation. The pathologic rotator cuff exhibits both FD and atrophy, but it is still not known exactly how these changes occur, what causes them, and whether these two processes are two different responses to injury or two related processes.

The results of the current investigation indicated a strong correlation between trauma and the changes. Eight of the same patients have trauma, although most worsening patients did not. Hebert-Davies *et al*., [24] provide evidence to support and elucidate a few ideas regarding fatty muscle degeneration in atraumatic rotator cuff tears. The mean rip breadth of 10 to 15 mm, is rather minor, and could be the reason behind the cohort's mild prevalence of muscle degeneration (45%). Another study reported that the development of muscle infiltration and degeneration is dependent upon the size and location of tears [17,25].

According to Nakagaki *et al*., [25], there was a correlation between increased muscle infiltration in cadavers and larger tears. While a comparable association was discovered by Rulewicz *et al*., [26] for the supraspinatus on MRI assessment. Another study conducted by Barry *et al*., [17] discovered a correlation between bigger tears with age and muscle infiltration. Additionally, previous examination of the other cohort study revealed anterior supraspinatus tendon integrity was most highly connected with supraspinatus fatty muscle degeneration, while tear

size was the most significant predictor of infraspinatus fatty muscle degeneration [27].

Limitations of the current study, as this study is a single-center trial with small sample size of patients, conducted during the period of the coronavirus disease 2019 pandemic. Thus, need to carry out more multiple center studies including a large sample size of patients in a large scale.

## CONCLUSION

Our investigation confirms previous findings and contributes to our understanding evaluation of the MRI fat signal of rotator cuff tears pre and postrepair. In our study, according to changes in goutilier classification we found no progression of fatty infiltration in 70% of patients while in 30% was worsened.

## ACKNOWLEDGEMENT

The assistant of Dr. Mohammed Shawky, Professor of Radiology, Faculty of Medicine, Menoufia University.

## CONFLICTS OF INTEREST

There are no conflicts of interest.

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