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Association of Amount of Fatty Infiltration between Full-Thickness Tear & No Tear of Supraspinatus Tendon According to Goutallier Grading System: A Magnetic Resonance Imaging-Based Study in a Tertiary Care Hospital In Central Kerala

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HIGHLIGHTS

- Tears increase fatty infiltration
- Higher Goutallier grades
- Significant muscle atrophy
- Retraction correlates positively
- MRI guides treatment decisions

Key Words:
Supraspinatus tear
Fatty infiltration
Goutallier grading
MRI shoulder
Rotator cuff
Tendon retraction

ABSTRACT

Introduction: Fatty infiltration of rotator cuff muscles is a key prognostic factor affecting surgical outcomes in supraspinatus tendon tears. Its severity, commonly assessed using the Goutallier grading system, plays an important role in determining tendon healing potential and functional recovery. **Aim & Objective:** This study aimed to evaluate the association between fatty infiltration and full-thickness supraspinatus tendon tears, assess tendon retraction using the Patte classification, and examine the relationship between retraction severity and fatty infiltration. **Materials & Methods:** A cross-sectional study was conducted on 60 patients undergoing shoulder MRI at a tertiary care center in Kerala. The study population included 30 patients with full-thickness supraspinatus tears and 30 without tears. Fatty infiltration was graded from 0 to 4 using the Goutallier classification, while tendon retraction was categorized into Patte grades I–III. Statistical analysis was performed using SPSS version 25. **Results:** Patients with full-thickness tears were significantly older compared to those without tears (mean age 60.83 vs. 52.53 years, $p<0.001$). Higher grades of fatty infiltration (Goutallier grades 3 and 4) were observed exclusively in the tear group ($p<0.001$). A significant difference in muscle atrophy severity was also noted between the two groups ($p<0.001$). Tendon retraction showed a strong positive correlation with Patte grading ($\rho=0.71$, $p<0.001$). However, no significant correlation was found between fatty infiltration grade and retraction distance ($\rho=0.22$, $p=0.241$). **Conclusion:** Full-thickness supraspinatus tears are strongly associated with increased fatty infiltration and muscle atrophy. Preoperative MRI evaluation using Goutallier and Patte classifications is crucial for surgical planning and outcome prediction.

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INTRODUCTION

The supraspinatus tendon is essential for normal rotator cuff function, contributing to humeral head stabilization and shoulder motion, particularly during abduction and external rotation. Pathological involvement of the tendon, whether due to tendinopathy, partial-thickness tears, or full-thickness disruption, impairs its ability to transmit force and maintain glenohumeral stability, leading to pain, altered biomechanics, & functional decline [1]. Supraspinatus tendinopathy is common, especially with advancing age, and results from a combination of intrinsic degeneration, extrinsic impingement, altered vascular-ity, and muscular imbalance [1,2].

Progression to full-thickness tears results in secondary degenerative changes within the muscle tendon unit, including tendon retraction, muscle atrophy, and fatty infiltration. These changes begin early after tendon detachment, with moderate fatty infiltration typically developing within three years and severe infiltration by approximately five years [3]. Fatty infiltration is a critical prognostic indicator, strongly associated with increased re-tear rates, poor functional outcomes, and reduced healing potential following rotator cuff repair [4,5]. Early recognition of these degenerative changes is clinically important, as timely surgical intervention prior to advanced fatty degeneration has been associated with improved anatomical and functional outcomes [3,4]. Fatty infiltration has emerged as a key parameter in the preoperative evaluation of rotator cuff disease. The Goutallier grading system, originally developed using computed tomography & later adapted for magnetic resonance imaging (MRI), provides a standardized method for quantifying intramuscular fat from Grade 0 to Grade 4 [6,16]. Higher grades, particularly Grades 3 and 4, are strongly associated with poor healing and higher re-tear rates [8]. As fatty degeneration is largely irreversible and accelerates after tendon detachment, early imaging assessment is crucial for optimal management [6,9].

MRI has become the imaging modality of choice for evaluating supraspinatus pathology due to its superior soft tissue contrast and ability to assess tendon morphology, tear characteristics, muscle atrophy, and fatty infiltration [11]. It demonstrates high diagnostic accuracy for full-thickness tears, with sensitivity and specificity reported around 0.91 and 0.88, respectively [9,13]. Additionally, MRI findings correlate well with arthroscopic observations and provide valuable prognostic information, although postoperative signal changes must be interpreted cautiously [9,12]. Importantly, while tendon integrity may improve after repair, muscle atrophy and fatty infiltration typically show minimal reversibility [15].

Tendon retraction is another critical factor influencing prognosis and surgical outcomes. Patte's classification categorizes retraction into three stages based on the degree of medial displacement: Stage I (minimal retraction), Stage II (retraction to the glenoid level), and Stage III (retraction beyond the glenoid) [18,19]. Increasing retraction is associated with muscle atrophy, fatty infiltration, and reduced tendon elasticity, all of which negatively impact repairability and functional outcomes. Studies have demonstrated a strong correlation between higher Patte stages and advanced Goutallier grades, indicating parallel progression of tendon retraction and muscle degeneration [6,9].

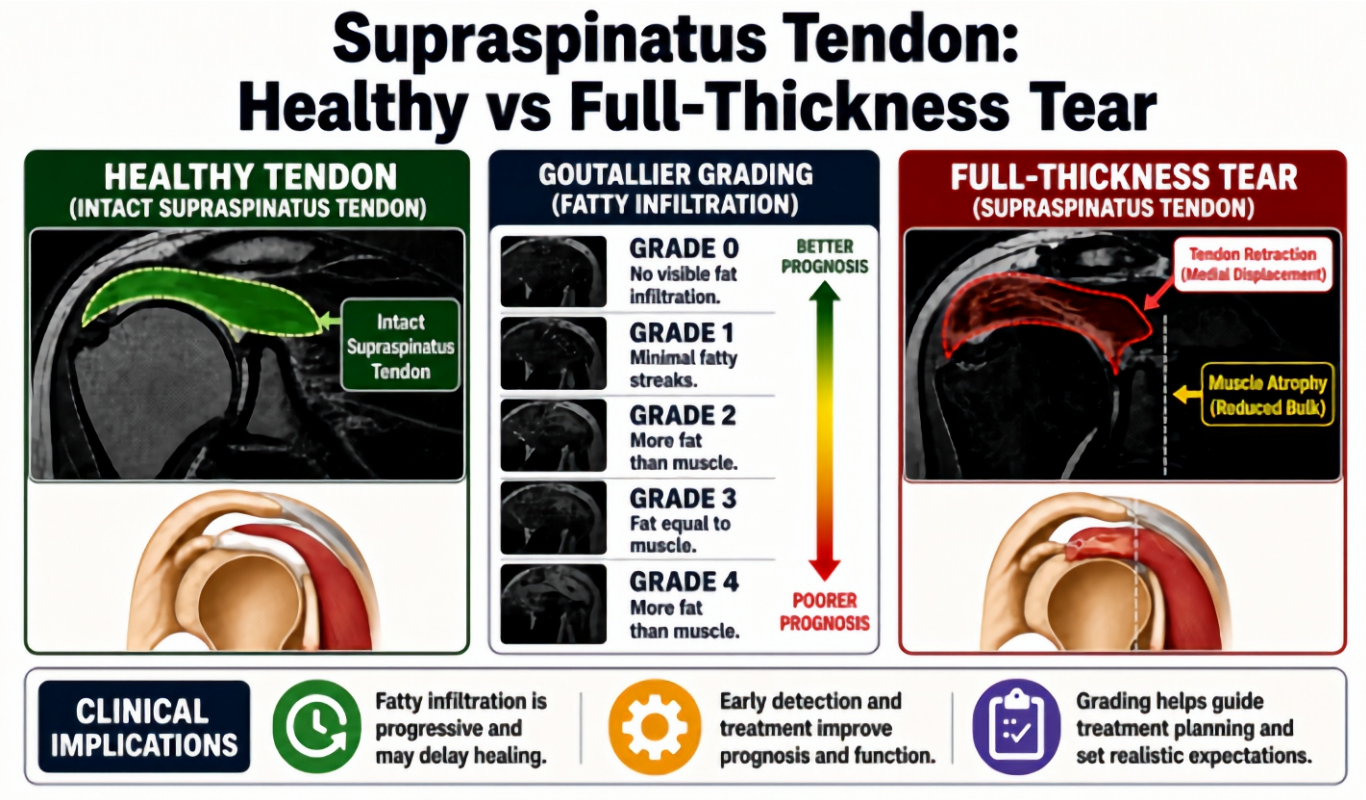

Figure 1: Comparison of supraspinatus tendon integrity and Goutallier fatty infiltration grades, showing progression from healthy tissue to chronic atrophy and its prognostic relevance.

Severe retraction is also linked to increased surgical difficulty, higher re-tear rates, and poorer postoperative recovery [11,20].

Comparative studies between intact tendons and full-thickness tears further highlight the clinical significance of fatty infiltration. While intact tendons typically demonstrate minimal, age-related fatty changes, full-thickness tears exhibit rapid and progressive muscle degeneration due to disruption of the musculotendinous unit [6,7]. This distinction is critical, as higher degrees of fatty infiltration in torn tendons are strongly associated with increased tear size, tendon retraction, and reduced likelihood of successful repair [8,9].

Understanding the relationship between fatty infiltration, tendon retraction, and tear morphology is essential for accurate diagnosis, prognostication, and treatment planning. Larger and more retracted tears are associated with higher Goutallier grades, reflecting advanced disease chronicity and reduced healing potential [6,7]. These structural and functional changes significantly influence clinical decision-making, including the feasibility of repair and the need for alternative surgical strategies. Supraspinatus tendon integrity and Goutallier fatty infiltration showing progression from normal to atrophic changes **(Figure 1)**.

Therefore, the present study aims to evaluate the association between fatty infiltration, supraspinatus tear status, and tendon retraction patterns. By integrating Goutallier grading, tear morphology, and Patte classification, this study seeks to provide a comprehensive understanding of rotator cuff degeneration and its implications for prognosis, surgical planning, and individualized patient management [8,10].

MATERIALS & METHODS

This hospital-based cross-sectional analytical study was conducted over eighteen months at the Department of Radiodiagnosis, Pushpagiri Institute of Medical Sciences and Research Centre, Kerala, after ethical approval. A total of 60 adult patients undergoing MRI shoulder for suspected rotator cuff pathology were included and divided into two groups: intact supraspinatus tendon (no-tear) and full-thickness tear groups, with 30 patients each. Consecutive sampling was used, and patients with prior surgery, MRI contraindications, poor image quality, partial tears, or associated pathologies were excluded. MRI was performed using a 1.5 Tesla scanner with a standard shoulder protocol. Images were analyzed by experienced radiologists blinded to clinical data. Full-thickness tears were defined by complete tendon discontinuity. Fatty infiltration was graded using the Goutallier system (Grades 0–4), tendon retraction was measured and classified using Patte stages (I–III), and muscle atrophy was graded qualitatively. Data was recorded systematically, and a subset was reviewed for observer reliability. Statistical analysis was performed using SPSS version 25, with appropriate tests applied and $p<0.05$ considered significant.

RESULTS

The No Tear group was younger (M = 52.53, SD = 5.81) than the Full Thickness Tear group (M = 60.83, SD = 8.78). Levene's test indicated unequal variances ($p = 0.048$), so Welch's t-test was used, showing a significant age difference, $t(50.29) = -4.32$, $p < 0.001$, mean difference = −8.30 years (95% CI: −12.16 to −4.44), with a large effect size (Cohen's d = 1.12) **(Table 1)**. **Table 2** shows sex distribution by tear status. The No Tear group had equal males and females (50% each), while the Full Thickness Tear group had more females (60%). Overall, 45% were male and 55% female. Chi-square and Fisher's exact tests showed no significant association between sex and tear status ($\chi^2(1) = 0.61$, $p = 0.436$; Fisher's $p = 0.604$, Cramér's V = 0.10). Distribution by tear status. In the No Tear group, right and left sides were equal (50% each), while in the Full Thickness Tear group, right-sided involvement was more common (66.7%). Overall, 58.3% were right-sided and 41.7% left-sided. Chi-square and Fisher's exact tests showed no significant association between side and tear status ($\chi^2(1) = 1.71$, $p = 0.19$; Fisher's $p = 0.295$, Cramér's V = 0.17) (**Figure 2**). Goutallier grade distribution by tear status. In the No Tear group, grades 0–2 predominated, with no grade 3 or 4. In the Full Thickness Tear group, higher grades were observed (grade 3 and 4: 13.3% each). Overall, grade 1 was most common (41.7%). Despite some expected cell frequencies <5, both Chi-square ($\chi^2(4) = 15.04$, $p = 0.005$, Cramér's V = 0.5) and Fisher's exact tests ($p < 0.001$) showed a significant association between Goutallier grade and tear status (**Figure 3**). Goutallier grade distribution differed between patients with intact and full-thickness supraspinatus tears. In the Intact group, grades 0–2 predominated, with no grade 3 or 4. In the Full Thickness Tear group, grades 3 and 4 were present (13.3% each), while grades 1–2 remained most common. Overall, grade 1 was most frequent (41.7%). Mann–Whitney U analysis showed a significant difference between groups ($U = 248$, $p = 0.003$, $r = 0.41$), with higher fatty infiltration in the Full Thickness Tear group (**Figure 4**). Supraspinatus tendon retraction increased with higher Goutallier grades: grade 0 (0.0 cm), grade 1 (0.99 cm), grade 2 (1.24 cm), grade 3 (2.70 cm), and grade 4 (2.48 cm). ANOVA showed significant differences across grades ($F = 4.86$, $p = 0.002$, $\eta^2 = 0.26$), with post hoc Bonferroni tests indicating differences between grade 0 vs 3 and 0 vs 4. Spearman correlation revealed a weak, non-significant positive relationship ($\rho = 0.22$, $p = 0.241$) (**Figure 5**). Muscle atrophy was absent in most No Tear patients (66.7%) and mild in 33.3%, whereas Full Thickness Tear patients showed mostly mild atrophy (73.3%) with some moderate and severe cases (13.3% each). Mann–Whitney U test indicated a significant difference between groups ($U = 110$, $p < 0.001$, $r = 0.72$), with greater atrophy in the Full Thickness Tear group (**Figure 6**). Among full-thickness tear patients, mild atrophy was most common across Patte grades: grade I (100%), grade II (68.2 %), & grade III (66.7%), with moderate and severe atrophy mainly in grades II & III. Fisher's exact test showed a significant

association between Patte grade and atrophy severity ($p < 0.05$) (**Figure 7**). Supraspinatus tendon retraction increased with higher Patte grades: grade I (1.08 cm), grade II (2.50 cm), and grade III (3.27 cm).

ANOVA showed significant differences across grades ($F = 17.51$, $p < 0.001$, $\eta^2 = 0.56$), with post hoc differences between grades I–II and I–III. Spearman correlation confirmed a strong positive association ($\rho = 0.71$, $p < 0.001$) **(Figure 8)**.

Table 1: Age distribution of study participants according to supraspinatus tendon tear status

Tear Status	n	Mean Age (years)	Median	Std. Deviation	Minimum	Maximum
No Tear	30	52.53	52.5	5.81	42	62
Full Thickness Tear	30	60.83	60.0	8.78	47	83
T test, p < 0.001						

Table 2: Sex distribution of study participants according to supraspinatus tendon tear status

Group	Male n (%)	Female n (%)	Total n (%)
No Tear	15 (50.0)	15 (50.0)	30 (100)
Full Thickness Tear	12 (40.0)	18 (60.0)	30 (100)
Total	27 (45.0)	33 (55.0)	60 (100)

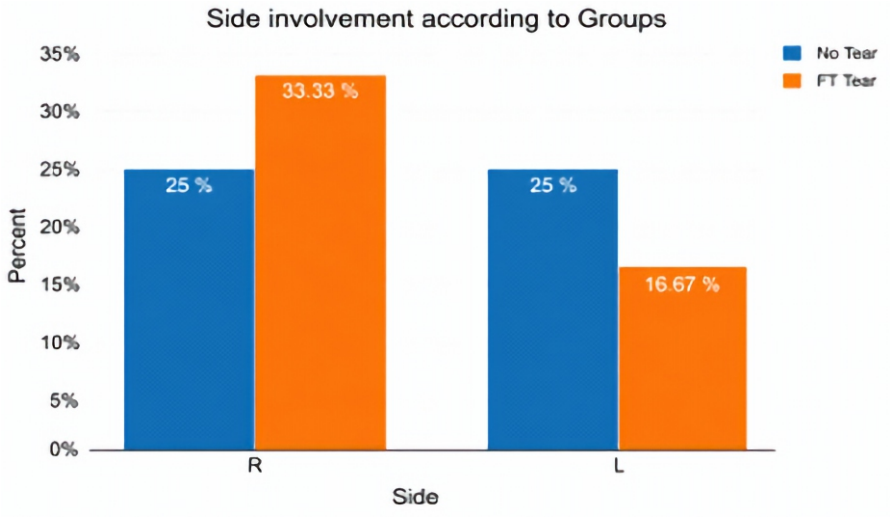

Figure 2: Distribution of side involvement according to supraspinatus tendon tear status

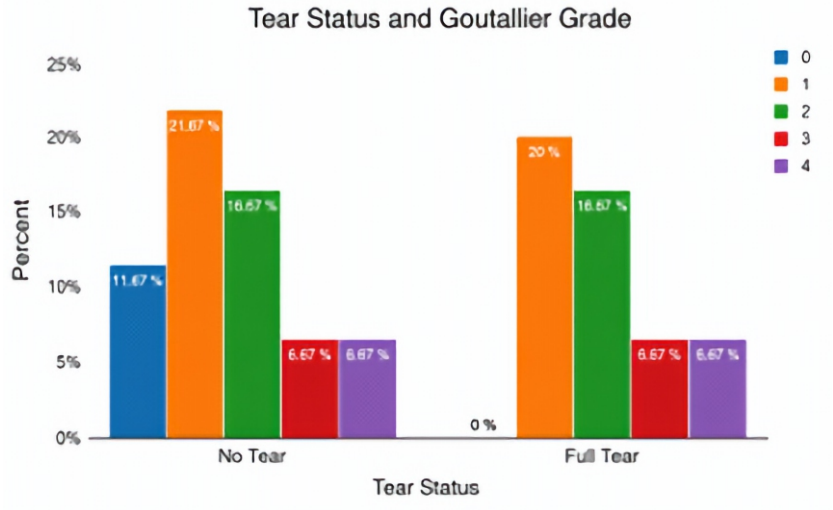

Figure 3: Distribution of Goutallier grades according to supraspinatus tendon tear status

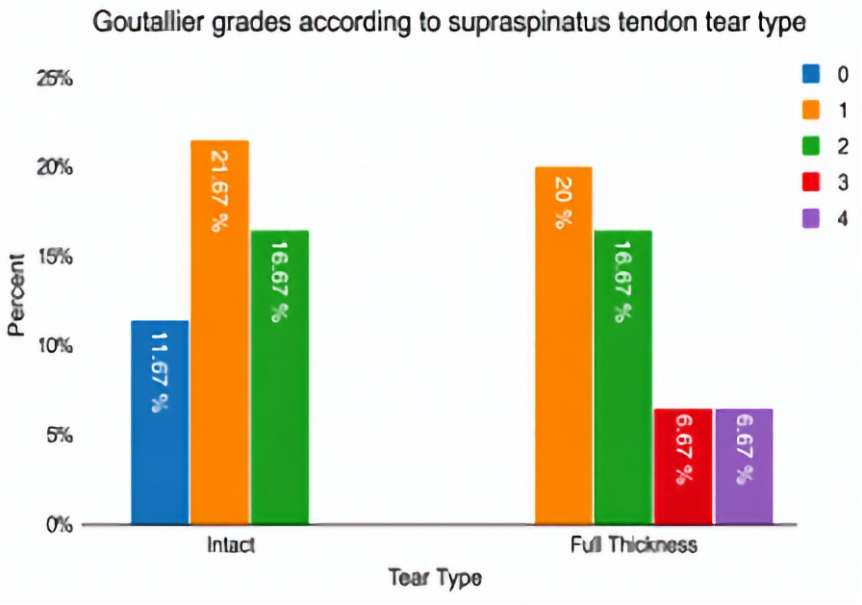

Figure 4: Distribution of Goutallier grades according to supraspinatus tendon tear

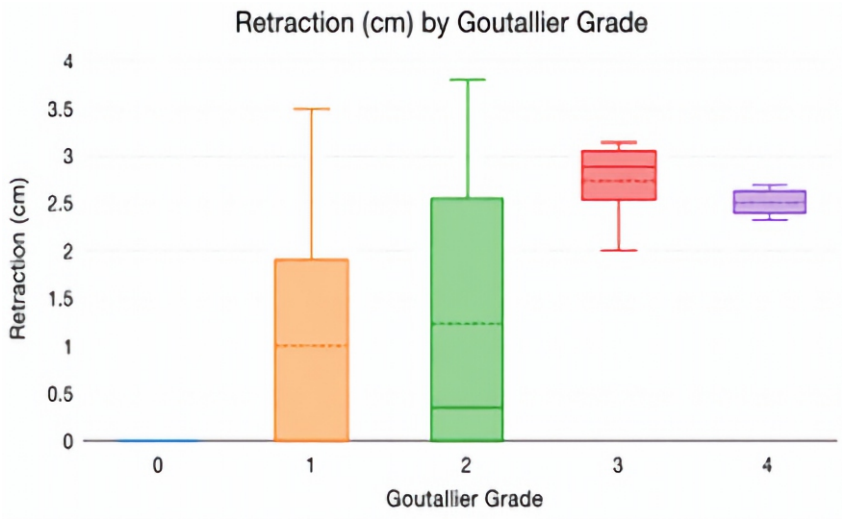

Figure 5: Comparison of supraspinatus tendon retraction across Goutallier grades

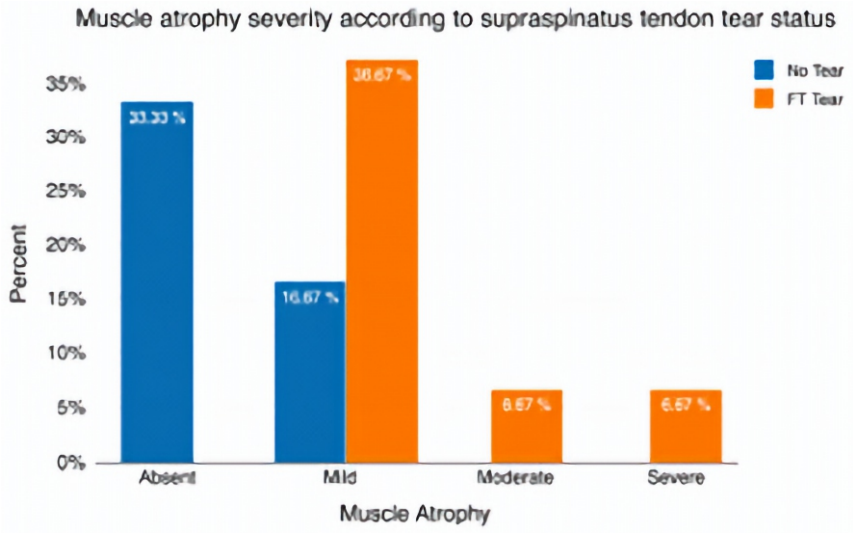

Figure 6: Distribution of muscle atrophy severity according to supraspinatus tendon tear status

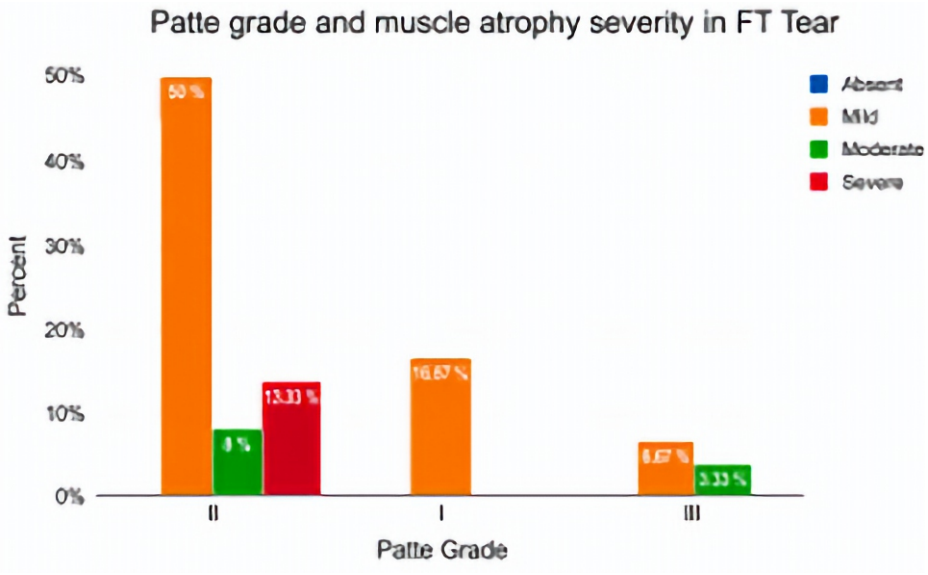

Figure 7: Association between Patte grade and muscle atrophy severity in full-thickness supraspinatus tendon tears

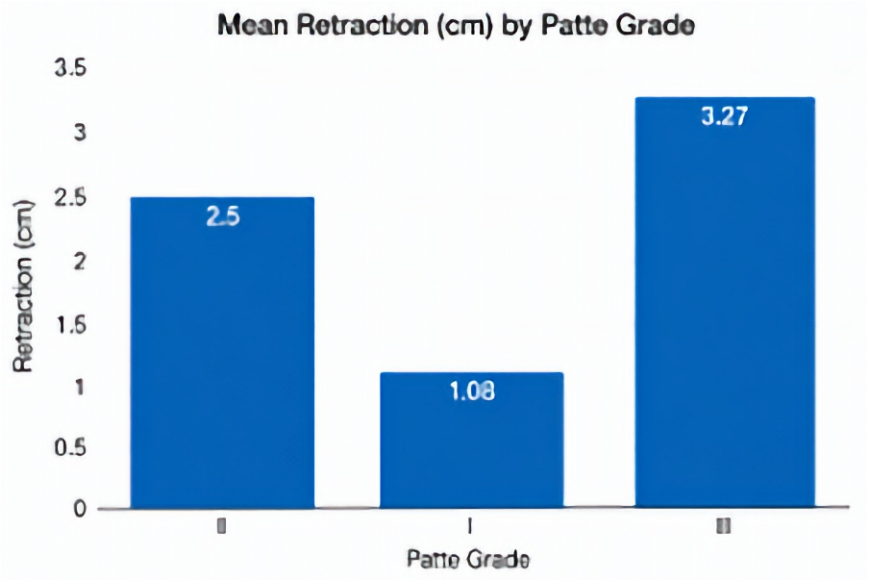

Figure 8: Comparison of supraspinatus tendon retraction across Patte grades in full-thickness tears

DISCUSSION

Rotator cuff disorders are a leading cause of shoulder pain and functional limitation, particularly in older adults, with the supraspinatus tendon most affected due to its anatomical and biomechanical vulnerability [21,22]. The present study highlights that supraspinatus pathology extends beyond tendon disruption to include secondary muscular changes, particularly fatty infiltration and atrophy, which are key indicators of chronicity and disease severity [23].

Fatty infiltration, resulting from mechanisms such as tendon detachment, mechanical unloading, and impaired muscle regeneration, plays a critical role in rotator cuff degeneration [24]. Consistent with previous literature, this study demonstrates that full-thickness supraspinatus tears are strongly associated with higher grades of fatty infiltration compared to intact tendons, while minimal fatty changes in the no-tear group likely reflect age-related degeneration [25].

MRI-based Goutallier grading proved to be a reliable tool for assessing these changes, with higher grades correlating with poorer prognosis and reduced healing potential [26,27]. Age was identified as a significant factor associated with full-thickness tears, supporting existing evidence that degenerative tendon changes increase with advancing age, whereas sex and shoulder laterality showed no significant association [28–31]. The balanced grouping in this study enabled robust comparison, minimizing bias and reinforcing findings that fatty infiltration is significantly higher in full-thickness tear cases [32,33]. A strong association between tendon tear status and fatty infiltration severity was observed, with higher Goutallier grades (3 and 4) exclusively present in full-thickness tears, confirming the progressive nature of muscle degeneration [32,34]. Additionally, a graded increase in tendon retraction with increasing fatty infiltration was noted, although the correlation between Goutallier grade and retraction magnitude was weak, suggesting

the influence of other factors such as tear chronicity and muscle atrophy [34,35].

Muscle atrophy was significantly more severe in full-thickness tears, consistent with prior studies linking tendon disruption to progressive muscular degeneration [36,37]. Furthermore, higher Patte retraction grades were associated with greater atrophy severity, indicating coordinated structural deterioration over time [38,39]. The study also demonstrated a strong positive correlation between Patte grade and tendon retraction distance, supporting its validity as a practical indicator of retraction severity [40,41].

Overall, these findings emphasize that fatty infiltration, tendon retraction, and muscle atrophy are interrelated processes reflecting chronic rotator cuff degeneration. MRI-based assessment using Goutallier and Patte classifications provides valuable prognostic information, aiding in clinical decision-making and optimizing management strategies in supraspinatus tendon pathology.

CONCLUSION

This cross-sectional MRI-based study demonstrated a significant association between fatty infiltration of the supraspinatus muscle and full-thickness supraspinatus tendon tears. Higher Goutallier grades were predominantly observed in tear cases, indicating advanced muscle degeneration. Tendon retraction, assessed using Patte classification, showed a positive relationship with fatty infiltration and muscle atrophy, reflecting disease chronicity. MRI proved to be an effective tool for comprehensive evaluation of tendon integrity and muscle changes. Overall, assessment of fatty infiltration, tendon retraction, and muscle atrophy is essential for predicting prognosis and guiding clinical management in rotator cuff pathology.

LIMITATIONS & FUTURE PERSPECTIVES

The study was limited by its single-centre design, relatively small sample size, and short duration, which may restrict generalizability. Future research could focus on multicenter studies with larger cohorts to validate findings, evaluate long-term outcomes, and explore innovative diagnostic and management strategies for appendicular perforation, improving patient prognosis and reducing complications.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare applications. It emphasizes the importance of trans-lating scientific observations into meaningful improvements in patient care, diagnosis, and treatment outcomes. By highlighting realworld relevance, the study contributes to evidence-based medical practice and supports informed clinical decision-making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

ABBREVIATIONS

MRI: Magnetic Resonance Imaging
GG: Goutallier Grade
PG: Patte Grade
RC: Rotator Cuff
FT Tear: Full-Thickness Tear

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

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None

ETHICAL APPROVAL & CONSENT TO PARTICIPATE

All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in the writing or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

AUTHOR'S NOTE

This article serves as an important educational tool for the scientific community, offering insights that may inspire future research directions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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