RESEARCH ARTICLE

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Correlations Between Different Types of Posterior Superior Rotator Cuff Tears and Myoarchitecture: Insights from Magnetic Resonance Imaging

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Abstract

Objectives: Posterior rotator cuff (RC) tears (RCTs) are common and cause adverse structural and functional changes within the associated musculature. Despite our existing knowledge of the architectural features of normal RC muscles, their specific characteristics remain insufficiently understood in the context of RCTs. The aim of the study is to investigate the association between muscle and tendon architectural alterations in posterior superior RCTs and their correlation with the Goutallier grade of the supraspinatus and infraspinatus muscles.

Methods: The study cohort comprised 150 patients with distinct subtypes of posterior superior RCTs, specifically L-shaped, C/U-shaped, and complete tears. Two experienced musculoskeletal radiologists conducted a blinded analysis of the magnetic resonance imaging (MRI) images obtained using a 3.0 Tesla MRI machine to quantify the Goutallier grade for both the supraspinatus and infraspinatus muscles. Furthermore, the authors assessed the muscle architectural parameters of the supraspinatus, including the central tendon angle (CTA), anterior pennation angle (PA), and posterior PA, for each individual in the cohort.

Results: The Goutallier grade was significantly higher in the infraspinatus muscle than in the supraspinatus muscle ($p<0.001$). CTA demonstrated a moderate positive correlation with the Goutallier grade in L-shaped ($p=0.002$) and C/U-shaped tears ($p=0.004$), but no significant correlation was observed in complete tears ($p=0.183$). Specifically, the anterior PA showed a moderate positive correlation with the Goutallier grade in L-shaped tears only ($p=0.02$), whereas the posterior PA exhibited a strong positive correlation across all tear types ($p<0.05$).

Conclusion: In cases of posterior superior RCTs, changes in the posterior PA exhibit a robust correlation with the Goutallier grade of the supraspinatus and infraspinatus muscles. Consequently, the posterior PA can serve as a surrogate marker for evaluating early, irreversible morphological alterations in the RC muscles, thereby prompting timely consideration of surgical interventions.

Keywords: Rotator cuff, muscle atrophy, tendon, MRI, shoulder

Introduction

The supraspinatus muscle and tendon exhibit a complex architecture. The muscle is anatomically divided into two primary regions: anterior and posterior, each exhibiting distinct functional characteristics. The anterior region comprises 75-86% of the muscle volume, with its pennate fiber bundles inserted laterally into the anterior tendon, thereby generating the predominant force output of the muscle. Conversely, the posterior region is considerably smaller in volume and partially situated deep into the anterior region, with parallel fiber bundles inserted laterally into the posterior tendon.[1-5] The functional capacity of a muscle is intrinsically linked to its architectural configuration. Among the architectural parameters, fiber bundle length (FBL) is of paramount importance because it is directly proportional to muscle excursion and contraction velocity.[6,7] A direct linear relationship exists between muscle length and the force of isometric contraction.[8] Consequently, variations in FBL can significantly influence the optimal range and velocity of muscle contraction.[9] In the pennate muscles, only a component of the force of the muscle fibers is aligned with the line of action; thus, alterations in the pennation angle (PA) will also impact the muscle's force-generating capacity.[10] Given that FBL and PA are critical determinants of skeletal muscle function,[11] quantifying these parameters in the pathological supraspinatus is imperative. Existing literature has examined the myoarchitecture of anterior and posterior rotator cuff (RC) tears (RCTs) and related them to one another. However, no previous studies have specifically investigated the subtypes of posterior superior RCT.

The pattern of posterior superior RCT affects the development of surgical planning. C-shaped tears are typically repaired with direct

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tendons at the greater nodules of the humerus, whereas U-shaped and smaller L-shaped tears require tendon edge convergence and side-to-side tendon repair before the broken tendon can be directly anchored to the bone insertion.[12] Therefore, studying the myoarchitecture of each tear pattern and specifying the tear pattern in radiology reports will help orthopedists in their per-operative planning and guide the management options.

The aim of this study is to investigate the association between muscle and tendon architectural alterations in posterior superior RCTs and their correlation with the Goutallier grade of the supraspinatus and infraspinatus muscles.

Methods

Study Design and Grouping

The study population of this retrospective study comprised adult men and women aged less than 60 years who underwent shoulder magnetic resonance imaging (MRI) between January 2019 and December 2023 at our hospital. All cases meeting the inclusion and exclusion criteria were included in this study, and data were collected by searching the Picture Archiving and Communication System (PACS) of the medical institution. We divided the study population into three groups: 1) those involving L-shaped tears, i.e., tear involving the anterior part of the supraspinatus tendon with a tear gap wider in oblique coronal images and shorter in sagittal oblique images (n=50); 2) those with crescent/U-shaped tears, i.e., a tear that did not affect the anterior part of the supraspinatus or the posterior part of the infraspinatus tendon with a tear gap wider in the oblique-sagittal plane than in the oblique coronal images (n=50); 3) those with a complete tear of the supraspinatus and infraspinatus tendons (n=50).

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: 1) Adult men and women aged less than 60 years old 2) radiological final report with a diagnosis of full-thickness posterior superior RCT. 3) MRI report was reviewed twice by two senior musculoskeletal imaging radiologists, and the diagnosis was confirmed as a full-thickness posterior superior RCT. 3) full-thickness posterior superior RCT presenting as L-shaped, U/crescent-shaped, or a complete tear of the supraspinatus and infraspinatus tendons.

The exclusion criteria were as follows: 1) full-thickness not conforming to L-shaped, U-shaped, crescent-shaped, or complete tear of the supraspinatus and infraspinatus tendons. 2) Concurrent abnormal disease process of the supraspinatus or infraspinatus muscle. 3) Tears to the RC muscles other than the supraspinatus and infraspinatus. 4) Other pathological shoulder processes such as metastatic lesions, Bankart, Hill-Sachs deformity, osteoarthritis or osteonecrosis. 5) Prior RC repair surgery or joint replacement. 6) Absent or poor quality oblique sagittal T1-weighted MRI sequence.

Magnetic Resonance Imaging and Image Analysis

In this study, shoulder MRI examinations were conducted using a 3.0 Tesla MRI machine equipped with a specialized shoulder coil. The imaging protocol included several sequences: 1) an oblique sagittal and oblique coronal T1-weighted fat-sensitive sequence with repetition time (TR) of 600 milliseconds (ms) and time to echo (TE) measuring 15 ms; 2) an oblique sagittal, oblique coronal, and axial proton density fat suppression sequence (TE=40 ms, TR=3000 ms), and 3) an axial T2* gradient inversion recovery sequence (TE=16 ms, TR=1039). The slice thickness for all sequences was 3 mm.

Two senior musculoskeletal imaging radiologists performed a blind analysis of the MRI images. These images were taken from the PACS. They measured the medial-lateral and anterior-posterior tear range data for full-thickness posterior upper RCTs. These tears were recorded based on the RCT shape defined by Davidson and Burkhart[13], which included L-shaped or U-shaped/crescent-shaped tears. A complete tear was defined as a full-thickness tear involving the entire supraspinatus and infraspinatus tendons.

Additionally, diagnostic radiologists retrospectively analyzed the MRI images of each shoulder in the study population and measured the central tendon angle (CTA) and anterior and posterior PA of the supraspinatus muscle (Figures 1, 2). The degree of intramuscular fat infiltration (FI) in the supraspinatus and infraspinatus muscles was independently evaluated using the blind Goutallier grading method utilizing imaging sequences corresponding to a Y-shaped view of each study object. The Goutallier grades used in this study were as follows: grade 0 (no fat), grade 1 (fat stripe), grade 2 (muscle > fat), grade 3 (muscle = fat), and grade 4 (muscle < fat).

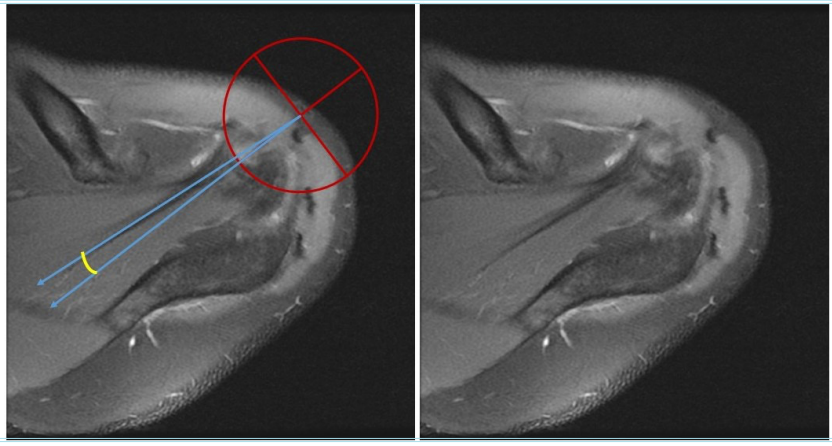

Figure 1. Magnetic resonance imaging axial proton density fat saturation sequence. The red circle demonstrates the humeral head with its transaxial axis. The central tendon angle (yellow arc) was measured between the supraspinatus tendon and the line paralleling the transverse humeral head axis

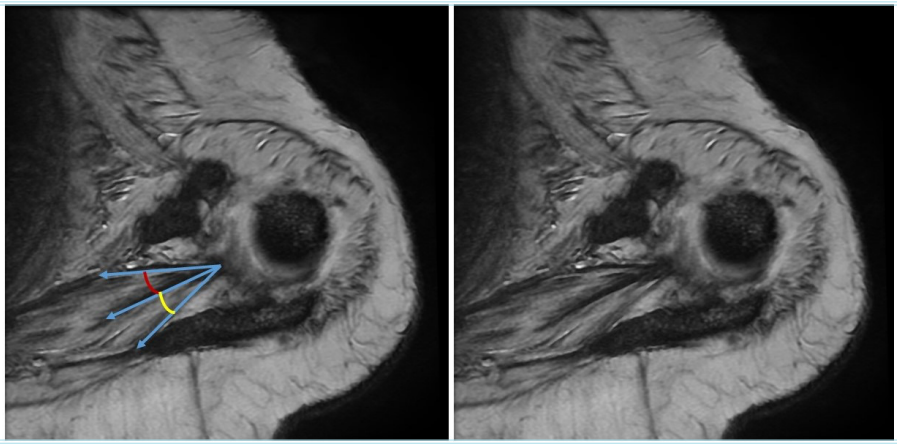

Figure 2. Magnetic resonance imaging axial gradient inversion recovery sequence of the left shoulder joint showing the anterior pennation angle (red arc) and posterior pennation angle (yellow arc)

Statistical Analysis

The data were analyzed using Stata 15.0 statistical software. The chi-square test was used to compare age, male-to-female ratio, tear range, trauma history, and symptom duration (below or above 4 weeks). Additionally, the mean Goutallier grades of the supraspinatus and infraspinatus muscles were compared between the groups using an unpaired t-test after examining the data using the Kolmogorov-Smirnov test. Associations among age, male percentage, tear range, trauma history, and Goutallier grade were evaluated using Spearman's rank correlation coefficient within each group. Additionally, the correlation between CTA, anterior and posterior PA, tear range and subtype, and Goutallier grade was examined using the same statistical method. The reliability between the two assessors was determined by calculating the kappa value, with a significance level of $p<0.05$.

Results

Assessment of the Goutallier Grade of the Supraspinatus and Infraspinatus Muscles

The intraclass correlation coefficients (ICC) for the Goutallier grade measurements provide important insights into the reliability of these assessments. For the supraspinatus muscle, the ICC was 0.500, indicating moderate inter- and intraobserver agreement. Similarly, the infraspinatus muscle had an ICC of 0.480, which also reflects moderate inter- and intraobserver agreement. These results suggest that although there is a reasonable level of consistency between different observers and across repeated measurements, room remains for improvement in the reliability of these measurements.

Analysis and Summary of the Clinical Data of All Subjects in Each Group

The analysis of various factors related to different tear types (Table 1) revealed that the mean ages of the L-shaped, C/U-shaped, and complete tear groups were approximately 51.58, 52.44, and 56.72 years, respectively. The P-value for age differences across these groups is $p<0.001$, indicating a statistically significant difference in age distribution, with the complete tear group being older on average. The percentage of males was fairly consistent across the groups, with 50% in the L-shaped group, 54% in the C/U-shaped group, and 48% in the complete tear group ($p=0.830$). The distribution of right and left side involvement was similar across the groups, with approximately 60-62% of tears occurring on the right side ($p=0.972$). There was significant variation in tear size distribution among the groups, particularly in the complete tear group, which had a higher proportion of larger tears [32% falling within the 3-5 cm range ($p<0.001$)]. Trauma history was relatively uncommon across all groups, with the complete tear group reporting no history of trauma history ($p=0.143$). Most patients in the L-shaped and C/U-shaped tear groups experienced symptoms lasting more than four weeks (86%), whereas all patients in the complete tear group experienced symptoms lasting over four weeks ($p=0.021$).

The analysis suggests that there were statistically significant differences in age, tear size distribution, and symptom duration among the different tear types, whereas gender, side involvement, and trauma history did not show significant differences.

Analysis of Myoarchitecture in Each Group

Analysis of muscle and tendon architecture (Table 2) revealed significant differences among tear types. The comparison of L-shaped and C/U-shaped tears yielded a p value of 0.233 for CTA, indicating no statistically significant difference. However, significant differences were observed between L-shaped and complete tears ($p<0.001$) and C/U-shaped tears ($p<0.001$). Similarly, the anterior PA showed significant differences between the complete tear group and both L-shaped ($p<0.001$) and C/U-shaped tears ($p<0.001$). The posterior PA exhibited statistically significant differences across all comparisons, with particularly pronounced differences between L-shaped and complete tears ($p<0.001$) and a p value of 0.002 when comparing C/U-shaped to complete tears. The findings underscore that the posterior PA is significantly altered in C/U-shaped tears compared with L-shaped tears.

Comparison of Goutallier Grades of the Supraspinatus and Infraspinatus Muscles

The analysis of Goutallier grades for the supraspinatus and infraspinatus muscles (Table 3) revealed that the complete tear group exhibits significantly higher grades. The p values between both groups were extremely low, demonstrating statistically significant differences in Goutallier grade severity among the various types of RCTs. Within each group, the differences between the supraspinatus and infraspinatus muscles were generally not statistically significant; however, the Goutallier grade was notably higher in the infraspinatus muscle than in the supraspinatus muscle for all types of RCT. These findings suggest

Table 1. Analysis and summary of the clinical data of all subjects in each group were performed using the chi-square test

Items	L-shaped tear (n=50)	C/U-shaped tear (n=50)	Complete tear (n=50)	p value
Age (years)	51.58±5.87	52.44±5.00	56.72±2.48	<0.001
Male %	50%	54%	48%	0.830
Side, n (%)				0.972
Right	31 (62%)	30 (60%)	31 (62%)	
Left	19 (38%)	20 (40%)	19 (38%)	
Tear range, n (%)				<0.001
<1 cm	14 (28%)	14 (28%)	0	
1-3 cm	36 (72%)	36 (72%)	34 (68%)	
3-5 cm	0	0	16 (32%)	
>5 cm	0	0	0	
Trauma history, n (%)				0.143
Yes	4 (8%)	3 (6%)	0	
No	46 (92%)	47 (94%)	50 (100%)	
Duration of symptoms >4 weeks, n (%)				0.021
Yes	43 (14%)	43 (14%)	100%	
No	7 (86%)	7 (86%)	0	

Table 2. Comparison of myoarchitecture among the groups using the chi-square test

Item	Normal subjects (n=30)	L-shaped tear (n=50)	C/U-shaped tear (n=50)	Complete tear (n=50)	p value
CTA	6.35±0.67	7.02±1.35	7.31±1.07	9.14±1.56	0.233 <0.001 <0.001
Anterior PA	17.83±1.47	18.47±1.84	18.40±1.59	21.16±2.99	0.857 <0.001 <0.001
Posterior PA	17.86±1.54	19.73±2.38	23.56±3.09	25.53±3.06	<0.001 <0.001 0.0012

CTA: Central tendon angle, PA: Pennation angle

Table 3. Comparison of Goutallier grades of the supraspinatus and infraspinatus muscles using the unpaired t-test after examining the data with a Kolmogorov-Smirnov test

Goutallier grade	L-shaped tear (n=50)	C/U-shaped tear (n=50)	Complete tear (n=50)	p value (between groups)
Supraspinatus	1.88±0.92	1.60±1.20	3.50±0.51	<0.001
Infraspinatus	2.44±1.19	2.54±1.20	3.63±0.76	<0.001
p value (within groups)	0.638	0.114	0.022	

that the severity of Goutallier grade varies markedly among patients with different types of RCTs, particularly highlighting the differential involvement of the infraspinatus muscle.

Correlation Analysis Between Goutallier Grade, Myoarchitecture, and Other Clinical Data

1. L-shaped Tear

Both age and tear size were strongly positively correlated with Goutallier grade in the supraspinatus and infraspinatus muscles, suggesting that older age and larger tears were associated with greater fatty infiltration of the muscles. The duration of symptoms showed a moderate positive correlation, indicating that longer symptoms duration is associated with an increased Goutallier grade. In contrast, trauma history displayed a negative correlation, suggesting that patients with a history of trauma tend to have a lower Goutallier grade than those without such a history. This is likely because the majority of patients with a history of trauma have symptoms lasting less than four weeks (Table 4).

All architectural parameters showed moderate positive correlations with Goutallier grades of the supraspinatus and infraspinatus muscles, with the strongest correlation noted in the posterior PA. The CTA and posterior PA showed moderate positive correlations with duration of symptoms, with no significant correlation found with anterior PA. The tear range exhibited weak positive correlations with the anterior and marginal PAs, indicating that larger tears may contribute to increases in these angles. Conversely, age generally did not show significant correlations with cytoarchitectural angles, suggesting that age may not

directly influence the morphological alteration of muscle architecture in the context of L-shaped tears (Table 5).

2. C/U-shaped Tear

Both age and tear range were strongly positively correlated with Goutallier grade in the supraspinatus and infraspinatus muscles, mirroring the findings of the L-shaped tear group. Trauma history consistently displayed a moderate negative correlation in both muscles. Unlike the L-shaped tear, the duration of symptoms showed no significant correlation with the supraspinatus grade and a weak, borderline significant correlation with the infraspinatus grade. These findings underscore the importance of tear size as a significant factor associated with the severity of muscle fatty infiltration regardless of the duration of symptoms (Table 6).

Age demonstrates a strong correlation with posterior PA, indicating that as age increases, there is a significant increase in posterior PA. Additionally, tear size is consistently correlated with all three cytoarchitectural features, suggesting that larger tears are associated with notable changes in tendon and muscle architecture. The duration of symptoms exhibits moderate correlations with the CTA, posterior PA, and posterior PA, implying that longer symptom duration is linked to structural changes in these areas. Furthermore, the supraspinatus and infraspinatus Goutallier grades were significantly correlated with posterior PA, indicating that higher levels of Goutallier grade in the supraspinatus and infraspinatus muscles are associated with alterations in tendon and muscle architecture (Table 7).

Table 4. Correlation analysis of the average Goutallier grade in the L-shaped tear group

	Supraspinatus muscle		Infraspinatus muscle	
	rs	p value	rs	p value
Age (years)	0.611	<0.001	0.624	<0.001
Duration of symptoms	0.408	0.003	0.326	0.021
Trauma history	-0.366	0.01	-0.398	0.004
Tear range	0.631	<0.001	0.605	<0.001

rs: Spearman's rank correlation coefficient

Table 5. Correlation analysis of myoarchitecture in the L-shaped tear group

	CTA		Anterior PA		Posterior PA	
	rs	p value	rs	p value	rs	p value
Age (years)	-0.117	0.418	-0.223	0.12	-0.129	0.372
Tear range	0.066	0.647	0.309	0.029	0.272	0.056
Duration of symptoms	0.380	0.007	0.232	0.105	0.418	0.003
Supraspinatus Goutallier grade	0.413	0.003	0.366	0.024	0.580	0.006
Infraspinatus Goutallier grade	0.335	0.008	0.269	0.022	0.595	0.002

CTA: Central tendon angle, PA: Pennation angle, rs: Spearman's rank correlation coefficient

Table 6. Correlation analysis of average Goutallier grade in the C/U-shaped tear group

	Supraspinatus muscle		Infraspinatus muscle	
	rs	p value	rs	p value
Age (years)	0.539	<0.001	0.607	<0.001
Duration of symptoms	0.045	0.754	0.277	0.052
Trauma history	-0.293	0.039	-0.405	0.004
Tear range	0.538	<0.001	0.582	<0.001

rs: Spearman's rank correlation coefficient

Table 7. Correlation analysis of myoarchitecture in C/U-shaped tear group

	CTA		Anterior PA		Posterior PA	
	rs	p value	rs	p value	rs	p value
Age (years)	0.47	0.013	0.27	0.1683	0.62	<0.001
Tear range	0.47	0.001	0.48	<0.001	0.36	0.011
Duration of symptoms	0.28	0.046	0.37	0.01	0.41	0.003
Supraspinatus Goutallier grade	0.32	0.025	0.23	0.116	0.22	<0.001
Infraspinatus Goutallier grade	0.40	0.004	0.37	0.088	0.47	<0.001

CTA: Central tendon angle, PA: Pennation angle, rs: Spearman's rank correlation coefficient

3. Complete Tear

The analysis indicates that age has weak or no significant correlation with Goutallier grade in both muscles, whereas tendon retraction has a moderate positive correlation with Goutallier grade in both the supraspinatus and infraspinatus muscles. This finding is likely attributed to the exclusion of elderly patients aged >60 years from the study population to eliminate false-positive results secondary to senile fatty infiltration of the muscles. No significant correlations were found between tear range and trauma history, with some variables being incalculable due to a lack of variability in the data. These findings suggest that tendon retraction is a more influential factor in determining Goutallier grade in the complete tear group, whereas age and tear size play a less significant role (Table 8).

The posterior PA demonstrates the most significant correlations with both Goutallier grade and tendon retraction, indicating that changes in muscle architecture are closely linked to the severity of Goutallier grade and tendon retraction. Tear range was moderately correlated with anterior palmar arch, highlighting a relationship between tear size and anterior muscle architecture. Age was significantly correlated only with posterior PA, suggesting that older patients may exhibit more pronounced changes in this particular aspect of muscle architecture (Table 9).

Discussion

This is the first study to investigate and model both the muscle and tendon architecture of the pathologic supraspinatus. The findings revealed substantial architectural alterations associated with RC tendon pathology, with variations observed among different subtypes of posterior superior RCTs.

The RC forms a crucial structural complex with the anterior edge of the supraspinatus tendon, facilitating force transfer from the tendon to the proximal humerus. This complex provides stress-shielding protection to the posterior upper RC crescent region. In comparison with anterior supraspinatus tendon tears, full-thickness tears involving the RC-anterior supraspinatus tendon complex are closely linked to RC dysfunction.[14] Mesiha et al.[15] emphasized that the integrity of this complex ensures normal biomechanical load distribution from the scapula to the proximal humerus. Notably, full-thickness tears involving the anterior supraspinatus tendon result in larger tendon tears, displacement, and mechanical changes in the stress area. These tears may lead to serious clinical symptoms, joint damage, and propensity for RCT progression.

The posterior region, which exhibits a significantly smaller volume than the anterior region in normal muscle, is highly susceptible to even minor atrophy.[3] Chronic tears may lead to atrophy or complete loss, highlighting the critical importance of early tear detection and prompt tendon repair. Delayed detection is associated with surgical complications and suboptimal outcomes, and substantial alterations in the posterior region may contribute to these challenges.[11,12]

The precise origin of the posterior upper RCT remains a subject of ongoing debate. Some theories propose that it initiates at the center of the crescent area, involving the anterior supraspinatus tendon.[3-5] Researchers speculate that age plays a crucial role in the mechanical load transfer from the scapula to the humerus through the RC-anterior supraspinatus tendon complex. Podgórski et al.[14] identified two distinct age-related RCT patterns: 1) Young patients exhibit a robust RC crescent part (the crescent dominant mode), while 2) Elderly patients experience a weakened RC crescent part due to age-related tendon degeneration (the RC dominant mode). Additionally, RC hypertrophy may serve as an adaptation to age-related crescent thinning. Notably, the present study found a positive correlation between age and average Goutallier grade in the L-shaped and C/U-shaped tear groups, supporting the hypothesis.

Previous research indicates that anterior supraspinatus tendon tears are associated with higher fatty infiltration of the supraspinatus than RCTs in other regions. Researchers have speculated that the histology and function of the anterior supraspinatus tendon differ from those of the RC.[5] Additionally, Kim et al.[16] found that full-thickness RCTs, even small-scale tear, result in more severe supraspinatus fatty infiltration when the anterior supraspinatus tendon is involved and less fatty infiltration when it is not. Our investigation revealed a noteworthy association between the degree of fatty infiltration in the supraspinatus muscle and a specific RCT. This phenomenon is particularly pronounced in L-shaped posterior superior RCTs that partially extend into the anterior portion

Table 8. Correlation analysis of the average Goutallier grade in complete tear group

	Supraspinatus muscle		Infraspinatus muscle	
	rs	p value	rs	p value
Age (years)	0.157	0.276	0.297	0.036
Tear range	-0.171	0.234	-0.210	0.143
Tendon retraction	0.435	0.002	0.497	<0.001

rs: Spearman's rank correlation coefficient

Table 9. Correlation analysis of myoarchitecture in complete tear group

	CTA		Anterior PA		Posterior PA	
	rs	p value	rs	p value	rs	p value
Age (years)	-0.248	0.083	-0.135	0.35	0.315	0.026
Tear range	-0.036	0.806	0.413	0.003	0.106	0.466
Supraspinatus Goutallier grade	0.247	0.084	0.039	0.789	0.638	<0.001
Infraspinatus Goutallier grade	0.192	0.183	0.106	0.466	0.648	<0.001
Tendon retraction	-0.022	0.881	0.076	0.602	0.539	<0.001

CTA: Central tendon angle, PA: Pennation angle, rs: Spearman's rank correlation coefficient

of the supraspinatus tendon. In contrast, C/U-shaped tears that do not involve the anterior supraspinatus tendon exhibit lower degrees of fatty infiltration.

Infraspinatus fatty infiltration is not proportionally correlated with the extent of full-thickness tears observed on MRI. Mochizuki et al.[17] conducted an autopsy study and revealed that the footprint of the infraspinatus tendon insertion was larger than previously assumed. Furthermore, the insertion extended further forward into the articular surface of the upper part of the greater tuberosity of the humerus. Consequently, the insertion range of the greater tuberosity of the humerus in the supraspinatus tendon was much smaller than previously believed. This information highlights the importance of considering anatomical variations when assessing RCT and its impact on muscle function. In our investigation, we observed that the Goutallier grade for fatty infiltration was consistently higher in the infraspinatus muscle than in the supraspinatus muscle across all subtypes of superior posterior RCTs. Notably, the most pronounced difference was observed in complete tear cases.

In the evaluation of tendon architecture, previous research has demonstrated notable changes in the posterior PA in cases of tears affecting the posterior superior RC. Conversely, alterations in the anterior PA are minimal and do not significantly differ.[18,19] Our study corroborates these findings, as we observed significant deviations from the mean normal posterior PA in healthy subjects, particularly in C/U-shaped and complete tears, while the anterior PA exhibited minor deviations with less significant statistical relevance.

In their study, Thompson et al.[4] investigated the CTA of the supraspinatus muscle in both normal subjects and individuals with full-thickness RCTs. The researchers found a statistically significant reduction in supraspinatus CTA among those with full-thickness tears compared with the normal group (17.7 degrees vs. 7.3 degrees; $p<0.001$). Interestingly, our study showed that the mean CTA in normal subjects was much lower than that observed in the literature, and across all tear subtypes, there was a consistent positive trend in CTA. Notably, the most pronounced difference in CTA was observed in complete tears. Furthermore, the study revealed a moderate correlation between CTA and Goutallier grade L-shaped and C/U-shaped tears. These findings highlight the clinical relevance of CTA measurements in assessing the pathology of RC.

Study Limitations

This study has several limitations that warrant consideration. First, its retrospective nature restricted data collection to relevant clinical information available within our institution's PACS. Consequently, only data from this specific source were retrieved. Second, certain factors remained unclear due to the study design. Specifically, information regarding the dominant hand and the range and intensity of daily shoulder activities were not available for the study participants. Third, caution should be exercised when generalizing the findings. The conclusions may not apply to RCTs that were not included in this specific investigation. Additionally, the lack of surgical confirmation in RCTs introduces an element of uncertainty. Although our study demonstrated moderate inter- and intraobserver agreement for the Goutallier grade measurements, this level of consistency highlights the need for further standardization and training to enhance the reliability of this observational assessment. Furthermore, the study sample size was relatively small, which could have affected the statistical power and generalizability of the results. Moving forward, large-scale studies are essential to validate the current findings and explore potential differences among various full-thickness RCTs. Additionally, leveraging big data research projects could shed light on the clinical correlations between different RCT patterns, CTA, anterior and posterior PA, FI, and postoperative outcomes.

Conclusion

In summary, our study revealed a strong association between alterations in muscle architecture and Goutallier grade of the supraspinatus and infraspinatus muscles in posterior superior RCT cases. Notably, the posterior PA is a valuable surrogate marker for detecting early, irreversible morphological changes in the RC muscles, prompting timely consideration of surgical intervention. These findings underscore the clinical significance of assessing the posterior PA in managing patients with RC pathology.

Ethics

Ethics Committee Approval: The study was approved by the Research and Ethics Committee of Dammam Medical Complex under the Trainee Research Category (EXT0409) on March 4, 2024.

Informed Consent: Since the study was a retrospective study, informed consent was not required by the ethics committee.

Footnotes

Authorship Contributions

Concept: Z.S.M.H., S.M.A.S., A.S.A.D., Design: Z.S.M.H., Data Collection or Processing: S.M.A.S., A.S.A.D., Analysis or Interpretation: Z.S.M.H., S.M.A.S., A.S.A.D., Literature Search: Z.S.M.H., Writing: Z.S.M.H.

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