5-year Changes in 3D Supraspinatus Muscle Volume and Fat Fraction Following Rotator Cuff Repair: Comparison of Successful and Failed Repairs

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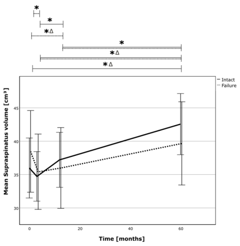
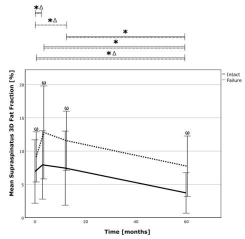
INTRODUCTION:
The outcomes of rotator cuff repair surgery can be affected by muscle atrophy and fatty infiltration. Most studies on this topic have used qualitative measurements such as the Thomazeau and Zanetti classifications for muscle volume and the Goutallier classification for fatty infiltration to assess muscle characteristics. Additionally, many researchers have analyzed only a single slice of computed tomography or magnetic resonance imaging (e.g., the scapula-Y view), which may not accurately represent the entire muscle. Consequently, the reported results on muscle volume and fatty infiltration have been inconsistent. This study aimed to analyze the muscle volume and fatty infiltration of the entire supraspinatus muscle in 3D at a midterm follow-up of 5 years. The hypothesis was that muscle volume would increase and fatty infiltration decrease following successful rotator cuff repair, and to a lesser extent, even after failed rotator cuff repair.

METHODS:
A total of 115 patients (mean age 59±8 years, 33% female) who underwent rotator cuff repair for full-thickness supraspinatus tendon tears were prospectively recruited and evaluated at 3 and 12 months follow-up. Of these, 18 patients with unsuccessful rotator cuff repair at 12 months were matched for basic demographics and tear configuration to 21 successful repairs and were re-evaluated at a minimum follow-up of 60 months. All patients underwent quantitative 2-point Dixon magnetic resonance imaging preoperatively, at 3 months, 12 months, and a minimum of 60 months postoperatively to evaluate full 3D muscle volume and 3D fatty infiltration. All muscles were manually segmented by two independent readers, and the intraclass correlation coefficient was calculated. The clinical examination included the full Constant-Murley Score.
RESULTS:
The failed repair group was successfully matched to a comparable group based on basic demographic data and initial tear configuration (Table 1). The mean age was 61 ± 6 years for successful repairs and 63 ± 6 years for failed repairs, with 24% and 17% females, respectively (Table 1).
The relative changes in supraspinatus 3D muscle volume differed significantly between the two groups over time ($p<0.01$). Successful repairs showed a mean volume increase of 18%, whereas failed repairs exhibited an increase of 3%. However, comparisons between the groups at all time points did not reveal any significant differences preoperatively (successful vs. failed: 36.0 cm^3 vs. 38.5 cm^3, $p = 0.666$), at 3 months (34.7 cm^3 vs. 35.4 cm^3, $p = 0.919$), at 12 months (37.2 cm^3 vs. 36.0 cm^3, $p = 0.587$), and at 60 months (42.6 cm^3 vs. 39.7 cm^3, $p = 0.494$) (Figure 1).
Analysis of full muscle 3D fatty infiltration revealed significantly lower fat content following successful rotator cuff repair at all time points: preoperatively (6.9% vs. 9.1%, $p = 0.007$), at 3 months (7.9% vs. 12.8%, $p = 0.003$), at 12 months (7.5% vs. 11.6%, $p < 0.001$), and at 60 months postoperatively (3.7% vs. 7.7%, $p < 0.001$). Fatty infiltration decreased by 46% following successful repair and by 15% following failed repair between preoperative and the minimum follow-up of 60 months (Figure 2). Inter-rater reliability was very good, with an intraclass correlation coefficient of 0.893 for consistency.
The clinical outcome was slightly better following successful rotator cuff repair, with an absolute Constant score of 81 ± 6 vs. 72 ± 15 ($p = 0.069$) and a relative Constant score of 94% ± 7% vs. 85% ± 17% ($p = 0.078$) (Figure 3).

DISCUSSION AND CONCLUSION:
Successful rotator cuff repair was associated with relevant improvement of supraspinatus muscle volume and reduction of fatty infiltration at mid-term follow-up of 5 years. A comparable effect was seen in the failed rotator cuff repair group but less pronounced. Those findings are novel and might be interesting for the treating surgeon to counsel the patient and as a basis for further studies. The most interesting aspect of this study was that the muscle volume and fatty infiltration improved significantly after 12 months postoperatively, also in failed repairs which is quite remarkable. To some extent, it might challenge the theory that the extend of fatty infiltration is irreversible. This study highlights how recent technological advances were utilized to analyze development of muscle volume and fatty infiltration in a prospectively conducted study. However, it is important to acknowledge the limited cohort size, which precluded any analysis of potential outcome predictors.





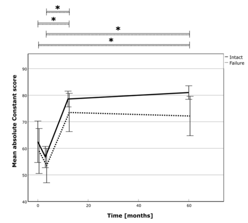


TABLE 1

Intergroup Comparison of Patients' Demographics, Clinical Data, and Rotator Cuff Tear Patterns (Cofield and Patte Classification) and Muscle Degeneration According to Goutallier[1]

			Intact		Failure		
			n[2]	%	n[2]	%	P Value
Patients		39	21		18		
Gender							0.70[5]
	Female	8	5	24%	3	17%	
	Male	31	16	76%	15	83%	
Side							0.40[6]
	Right	18	11	48%	7	61%	
	Left	21	10	52%	11	39%	
Dominance							1.00[5]
	Right	37	20	95%	17	94%	
	Left	2	1	5%	1	6%	
Age[3], y		62 ±6	61 ±6		63 ±6		0.28[4]
BMI[3]		27 ±4	27 ±4		27 ±4		0.63[4]
Cofield							0.17[6]
	Medium		15	72%	8	44%	
	Large		3	14%	7	39%	
	Massive		3	14%	3	17%	
Goutallier SSP							0.07[6]
	Grade 0		10	26%	3	8%	
	Grade 1		10	26%	11	28%	
	Grade 2		1	2%	4	10%	
Goutallier ISP							0.39[6]
	Grade 0		13	33%	8	21%	
	Grade 1		6	15%	9	23%	
	Grade 2		2	5%	1	3%	
Goutallier SSC							0.04[6]
	Grade 0		19	49%	10	26%	
	Grade 1		2	5%	6	15%	
	Grade 2		0	0%	2	5%	
Patte SSP							0.47[6]
	Grade 1		7	33%	5	28%	
	Grade 2		13	62%	10	55%	
	Grade 3		1	5%	3	17%	
Occurence							1.00[5]
	Acute		4	19%	4	22%	
	Chronic		17	81%	14	78%	
Tear pattern							
Involving ISP			11	28%	12	31%	0.37[6]
Involving SSC			15	40%	13	34%	0.85[6]
Involving both			6	29%	9	50%	0.17[6]

[1]BMI, body mass index; ISP, infraspinatus; SSC, subscapularis; SSP, supraspinatus.
[2]Absolute number
[3]Mean ± SD
[4]Independet Samples T-Test
[5]Fischer's Exact Test
[6]Pearson Chi-Square Test