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Research Article

Factors associated with the development of re-tear following arthroscopic rotator cuff repair: A retrospective comparative study

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ABSTRACT

Objective: The aim of this study was to analyze the risk factors for the development of re-tear following Arthroscopic Rotator Cuff Repair (aRCR).

Methods: This retrospective clinical study included 196 consecutive aRCRs with a minimum 3-year follow-up. Pre- and postoperative clinical and functional outcomes were measured using the Visual Analog Scale (VAS), the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES), the University of California at Los Angeles Shoulder Rating Scale (UCLA), the Constant–Murley Score (CMS), and the Douleur Neuropathique (DN4) questzionnaire. The Goutallier staging of fatty infiltration, Occupational Ratio (OR), the Acromiohumeral Interval (AHI), Acromioclavicular Joint (ACJ) arthritis, acromion type, Critical Shoulder Angle (CSA), and tangent sign (tan- sign) were evaluated as radiological parameters. Different subgroup parameters were evaluated after dividing the patients into re-tear (–) and re-tear (+) groups, according to clinical and radiological outcomes as well as patient and intraoperative characteristics.

Results: The mean follow-up period was 72.0 ± 15.8 months. The mean age at the time of surgery was 58.4 ± 8.9 years. A significant improvement was found in clinical and functional scores in the re-tear (–) group ($P < 0.001$ for all). However, the re-tear (+) group had poorer outcome scores than the re-tear (–) group. Twenty patients (10.2%) had re-tear at the last follow-up. There was a significant difference between groups regarding pre-and postoperative clinical scores, with worse scores in the re-tear (+) group ($P < 0.001$ for all). Also, pre-and postoperative pseudoparalysis ($P = 0.001$ for both), acromioclavicular joint arthritis (ACJ) ($P = 0.001$), intraoperative rotator cuff wear ($P = 0.007$) or stiffness ($P = 0.025$), a longer time period between symptom onset and surgery ($P = 0.031$), larger tear size ($P = 0.010$), preoperative shoulder stiffness ($P = 0.001$), higher duration of postoperative analgesia use ($P < 0.001$), higher degrees of preoperative Occupational Ratio (OR) ($P < 0.001$), and higher degrees of fatty degeneration ($P < 0.001$) were found to be associated with re- tear development.

Conclusion: Surgeons should consider the preoperative degree of fatty degeneration, clinical and functional scores, presence of ACJ arthritis, intraoperative tendon quality, tear size and chronicity as well as postoperative prolong analgesic requirement, and development of pseudoparalysis as factors regarding re-tear development risk following aRCR.

Level of Evidence: Level IV, Therapeutic Study

Introduction

Rotator Cuff Tear (RCT) are among the most typical shoulder pathologies, increasing in incidence with age and requiring surgical intervention.[1] Arthroscopic Rotator Cuff Repair (aRCR) procedures have greatly improved with the use of suture anchors with several advantages over open surgery.[2] However, re-tear are well-known problems following this procedure. Several studies have evaluated the possible risk factors affecting rotator cuff healing or re-tear.[1,3–17] Investigation of the associations with re-tear or failure has included patient characteristics and comorbidities such as sex, smoking habits, age, diabetes, obesity, hypercholesterolemia, hypertension, and heart disease.[1,3,4,6,7] Fatty degeneration, Goutallier index, Occupational Ratio (OR), Critical Shoulder Angle (CSA), Acromiohumeral Interval (AHI), and Tangent Sign (tan-sign) were investigated as radiological potential risk factors for rotator cuff re-tear.[3,7–11] The relationship between surgical technique, tear characteristics, rotator cuff integrity, and the re-tear rate was also evaluated in many studies.[3,7,10,12–17] Although several authors evaluated the preoperative functional and pain scores on postoperative outcomes after aRCR,[18–20] to our knowledge, no studies evaluated the effect of clinical scores on re-tear development. Therefore, the present study aimed to evaluate the effect of clinical scores and pre- and intraoperative factors on the re-tear rate following aRCR. We hypothesized that clinical status, patient characteristics and preoperative radiological factors were associated with re-tear status.

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Materials and Methods

Between 2009 and 2015, two surgeons (HS, AG), with at least 5 years' experience in arthroscopic shoulder surgery, performed 336 aRCRs. Of these, we retrospectively reviewed 196 aRCRs with a minimum 3-year follow-up. We included patients with partial or total aRCRs who did not respond to conservative treatment and attended regular follow-ups. In the case of bilateral rotator cuff repair, data were collected only from the first operated shoulder. Patients were excluded if they had not attended regular follow-ups (86 patients), had undergone previous surgery for the affected shoulder (subacromial pathologies: 20 patients; trauma: 3 patients; glenohumeral pathologies: 12 patients), had an isolated tear of the subscapularis tendon (4 patients), or had not attended a postoperative rehabilitation program regularly (15 patients).

All surgical procedures were performed under combined interscalene block and general anesthesia in the beach-chair position. A single- or double-row repair technique was used according to tear size and configuration. Torn tendon properties were evaluated by assessing whether the suture passer was pushing forward easily and/or by checking with the probe. Repairs were performed using a suture anchor (Twinfix® or Footprint PK®, Smith & Nephew, London, UK). Subacromial decompression and release of the anterior aspect of the coracoacromial ligament were performed following aRCR.

Postoperative in-hospital analgesics included 50 mg of tramadol and 500 mg of acetaminophen every 6 to 8 hours a day. After discharge, 50 mg tramadol and 500 mg acetaminophen, one or two pills every 12 hours, combined with 750 mg naproxen once a day were prescribed. An immobilizer was used postoperatively for 6 weeks. Pendulum exercises were started immediately postoperatively. Twice a day, 10-min pendulum exercises with active elbow, wrist, and hand exercises were allowed for the first 6 weeks. Passive range of motion was allowed in weeks 6–8, active-assisted range of motion between weeks 8 and 10, and active range of motion between weeks 10 and 12. A strengthening program was started on the 12th week.

Patient characteristics and demographic data were recorded. Operative reports were evaluated, and pre- and postoperative clinical and preoperative radiological examinations were performed. While preoperative Magnetic Resonance Imaging (MRI) was used routinely, postoperative MRI was evaluated only in patients with ongoing or new-onset symptoms. One of the criteria of passive forward flexion at less than 120°, external rotation at less than 30°, or internal rotation at the back lower than L3 was considered shoulder stiffness. Pre- and postoperative functional outcome scores were obtained preoperatively and at the last follow-up visit using the Visual Analog Scale (VAS; ranging from 0 to 10; 0 = no pain, 10 = worst pain ever), the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES),[21] the University of California at Los Angeles Shoulder Rating Scale (UCLA),[22] the Constant–Murley Score (CMS),[23] and the Douleur Neuropathique (DN4) questionnaire.[24] Pre- and postoperative Occupation Ratio (OR) (Grade 1: severe – <33%; Grade 2: moderate – 33–66%; Grade 3: mild – >66%) of the affected tendons were evaluated by MRI. Fatty infiltration and muscular atrophy were investigated using the technique identified by Fuchs et al.[25] The Goutallier fatty degeneration grade and the presence of tan-sign were evaluated using MRI, as previously reported.[26,27] Postoperative rotator cuff re-tear was evaluated by physical examination (persistent pain, loss of strength, pseudoparalysis) correlating with MRI (assessing the structural integrity of the repaired rotator cuff).[28]

The acromial type was determined by lateral X-ray using the Bigliani classification.[29] CSA and AHI were measured from true Anteroposterior (AP) X-rays. The AHI was measured by calculating the distance from the acromion's undersurface to the greater tuberosity perpendicular to the acromial body's long axis. All measurements were performed by two examiners who were blinded to the study protocol. Informed consent was obtained from all participants. The study was approved by the Local Ethics Committee of the Erciyes University (protocol no: 2015/330)

Statistical analysis

Mean, standard deviation, median, lowest and highest values, and frequency ratio were used in descriptive statistics of the data. The distribution of the variables was measured with the Kolmogorov–Smirnov test. The Independent Samples *t*-test and Mann–Whitney *U*-tests were used for the analysis of independent quantitative data. The Wilcoxon test was used for the analysis of dependent quantitative data. The Chi-square test was used to analyze independent qualitative data, and Fischer's exact test was used when the Chi-square test requirements were not met. An intraclass correlation coefficient was used in the evaluation of agreement between individual measurements. A P value of <0.05 was considered significant. All statistical analyses were performed using SPSS v22.0 for Windows (SPSS Inc., IL, USA).

Results

The mean age of the 196 patients was 58.4 ± 8.9 years. There were 156 right-sided and 40 left-sided tears. The mean follow-up duration was 72.0 ± 15.8 months (range: 46 to 121 months). A significantly strong intra- and interobserver agreement was detected in all measurement parameters ($P < 0.001$ and $r > 0.885$ for all measurement parameters). We found no effect of patient characteristics and demographic data on re-tear development (Table 1).

Good to excellent outcomes with significant improvements in clinical and functional scores were obtained at the last follow-up. Pre- and postoperative VAS, ASES, UCLA, CMS, and DN4 scores were significantly improved compared to the baseline ($P < 0.001$ for all). However, preoperative and postoperative VAS, ASES, UCLA, CMS, and DN4 scores were significantly different between the groups with better outcomes in the re-tear (−) group ($P < 0.05$) (Table 2).

A radiological assessment revealed significant differences between groups regarding preoperative measurements of OR and the Goutallier grade ($P < 0.001$ and $P < 0.001$, respectively). The re-tear (+) group

HIGHLIGHTS

- Lower pre- and postoperative clinical scores and various pre- and intraoperative factors are associated with re-tear after aRCR. The pre- and postoperative clinical situation may also be guiding in aRCR outcome expectations.
- Higher OR and Goutallier fatty degeneration grade and ACJ arthritis were associated with re-tear rates.
- Delayed surgery, larger tear size, analgesic use, shoulder stiffness, pseudoparalysis, tendon wear, and stiffness were associated with re-tear development.
- Good to excellent outcomes with significant improvements in clinical and functional scores could be obtained after aRCR in mid-term, regardless of repair technique.

Table 1. Pre- and Postoperative Patient Characteristics and Demographic Data of All Patients and Two Groups

		Total, *n* (%) = 196 (100)		Re-tear (–), *n* (%) = 176 (89.8)		Re-tear (+), *n* (%) = 20 (10.2)		
		Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min–Max)	*P*
Age		58.4 ± 8.9	58.5 (27–78)	58.3 ± 8.9	59.0 (27–78)	58.9 ± 8.5	60.0 (44–77)	0.881
Follow-up period (month)*		72.0 ± 15.8	72.0 (46–121)	72.0 ± 16.2	72.0 (46–121)	72.0 ± 12.2	72.0 (56–96)	0.877
BMI		26.3 ± 3.0	26.4 (19.2–34.3)	26.2 ± 2.9	26.1 (19.2–34.3)	27.3 ± 3.4	31.0 (20.1–33.6)	0.181
Sex	Female	121 61.7%		112 92.6%		9 7.4%		0.167
	Male	75 38.3%		64 85.3%		11 14.7%		
Side	Right	156 79.6%		140 89.7%		16 10.3%		1.000
	Left	40 20.4%		36 90%		4 10%		
Smoking habit	(–)	160 82.7%		141 88.1%		19 11.9%		0.132
	(+)	36 18.3%		35 97.2%		1 2.8%		
Comorbidity	(–)	110 56.1%		102 92.8%		8 7.2%		0.938
	(+)	86 43.9%		74 77.0%		12 23.0%		
Diabetes	(–)	164 83.7%		148 90.2%		16 9.8%		0.432
	(+)	32 16.3%		28 87.5%		4 12.5%		
Hypercholesterolemia	(–)	159 81.1%		146 91.8%		13 8.2%		0.074
	(+)	37 18.9%		30 81.0%		7 19.0%		
Thyroid disease	(–)	190 97.0%		170 89.4%		20 10.6%		1.000
	(+)	6 3.0%		6 100%		0 0%		
Time period between symptom onset and surgery (months)		8.9 ± 0.1	6.0 (0–48)	8.7 ± 8.2	6.0 (0–48)	10.6 ± 6.9	12.0 (1–28)	
Postoperative analgesic use in hospital (hours)		33.6 ± 11.9	24.0 (24–72)	33.3 ± 11.9	24.0 (24–72)	35.4 ± 11.6	30.0 (24–48)	1.000
Postoperative analgesic use at discharge (day)		13.2 ± 3.8	14.0 (6–79)	10.7 ± 3.5	12.0 (4–21)	25.2 ± 4.0	28.0 (14–79)	
Preoperative shoulder stiffness	(–)	146 74.4%		134 76.1%		12 60%		
	(+)	50 25.6%		42 23.9%		8 40%		
Repair type	single	120 61.2%		113 64.2%		7 35%		0.493
	double	76 39.8%		63 35.8%		13 65%		
Biceps tenotomy	(–)	135 68.8%		118 67.0%		17 85%		0.619
	(+)	61 32.2%		58 33.0%		3 15%		
Preoperative pseudoparalysis	(–)	118 60.2%		118 67.0%		0 0%		
	(+)	78 39.8%		58 33.0%		20 100%		
Postoperative pseudoparalysis	(–)	160 82.7%		159 90.3%		1 5%		
	(+)	36 18.3%		17 9.7%		19 95%		
Preoperative ACJ arthritis	(–)	165 81.3%		154 87.5%		11 55%		
	(+)	31 18.7%		22 12.5%		9 45%		

Note: Bold-italic values indicate statistical significance.
*From index surgery for re-tear (+) group.
BMI, Body Mass Index; ACJ, Acromioclavicular Joint.

had significantly worse scores. However, AHI, CSA, and tan-signs were similar in both groups (Table 3). The longer time between symptom onset and surgery, larger tear size, extended postoperative analgesic use after discharge, preoperative shoulder stiffness, pre- and postoperative pseudoparalysis, Acromioclavicular Joint (ACJ) arthritis, intraoperative cuff wear, and intraoperative tendon stiffness were found to be associated with re-tear development ($P = 0.031$, $P = 0.010$, $P = 0.000$, $P = 0.001$, $P = 0.001$, $P = 0.001$, $P = 0.007$, and $P = 0.025$, respectively) (Tables 1 and 4). Twenty patients had re-tear and underwent revision surgery during the follow-up period. The mean re-tear time was 9.76 ± 5.2 months (range: 3 to 24 months). In the re-tear group, all the patients underwent revision surgery; 3 patients (15%) underwent revision with reverse shoulder arthroplasty, 4 (20%) were treated with latissimus dorsi tendon transfer, and the remainder (13 patients, 65%) underwent revision aRCR. No patients developed a superficial or deep infection. No major complication was observed perioperatively or at the last follow-up.

Discussion

The most important finding of this study was that lower preoperative clinical and functional scores are associated with re-tear development. However, patient characteristics are not associated with re-tear status. Radiologically, higher OR and Goutallier fatty degeneration grade were associated with re-tear rates, whereas AHI, CSA, and tan-sign were not. Furthermore, delayed surgery, larger tear size, prolonged postoperative analgesic use, preoperative shoulder stiffness, pre- and postoperative pseudoparalysis, ACJ arthritis, intraoperative cuff wear, and tendon stiffness were associated with re-tear development. The repair technique (single or double row) did not affect re-tear development.

While several studies have evaluated the impact of preoperative functional and pain scores on postoperative outcomes after aRCR, no studies compared re-tear rates and functional scores.[18–20] Kim et al.[20] found a significant direct correlation between higher initial VAS scores and the onset of acute postoperative pain after aRCR. Castricini et al.[18] reported that lower preoperative CMS negatively affected clinical outcomes after massive RCT repair. Jenssen et al.[19] reported that patients with higher pain scores (ie, less pain, higher CMS) on the contralateral side had better shoulder function at final follow-up. In our study, pre- and postoperative VAS, ASES, UCLA, CMS, and DN4 scores were significantly improved compared to the baseline. Scores were found to be significantly different between the groups with better scores in the re-tear (–) group ($P < 0.05$). According to our findings, lower pre- and postoperative clinical scores were associated with re-tear development.

The effect of comorbidities and patient characteristics on aRCR healing is unclear. Specific comorbidities have been associated with an increased risk of degeneration or re-tear.[3,4] Berglund et al.[4] declared

Table 2. Pre- and Postoperative Clinical Outcome Scores of All Patients and Two Groups

	Total, *n* (%) = 196 (100)		Re-tear (−), *n* (%) = 176 (89.8)		Re-tear (+), *n* (%) = 20 (10.2)		
	Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min–Max)	*P*
VAS score							
Preoperative	5.1 ± 2.6	4.0 (2–10)	4.8 ± 2.6	4.0 (2–10)	7.3 ± 2.0	8.0 (3–10)	
Postoperative*	2.6 ± 1.8	2.0 (1–9)	2.1 ± 0.9	2.0 (1–7)	7.2 ± 1.1	7.0 (5–9)	
Pre–post difference			−2.7 ± 2.2	−2.0((−8)–1)	−0.4 ± 1.4	−1.0((−2)–4)	
Pre–post difference *P*					0.886		
ASES score							
Preoperative	40.8 ± 17.0	45.0 (10–72)	42.6 ± 16.8	45.0 (10–72)	26.0 ± 10.2	25.0 (13–45)	
Postoperative*	85.3 ± 17.3	90.0 (23–100)	90.4 ± 8.5	90.0 (35–100)	42.6 ± 13.1	42.0 (23–75)	
Pre–post difference			47.8 ± 15.0	45.0 (16–85)	16.3 ± 9.2	14.0 (5–37)	
Pre–post difference *P*							
UCLA score							
Preoperative	17.2 ± 4.4	18.0 (6–26)	17.6 ± 4.3	18.0 (6–26)	13.8 ± 3.0	13.0 (8–19)	
Postoperative*	31.2 ± 4.4	32.0 (14–35)	32.6 ± 2.0	33.0 (23–35)	20.1 ± 2.8	21.0 (14–26)	
Pre–post difference			14.9 ± 3.7	14.0 (5–24)	6.2 ± 4.0	8.0((−2)–11)	
Pre–post difference *P*							
Constant–Murley Score							
Preoperative	41.7 ± 12.1	43.0 (11–70)	42.9 ± 12.1	44.0 (11–70)	32.2 ± 8.0	33.0 (21–49)	
Postoperative*	81.1 ± 14.9	85.0 (32–100)	85.3 ± 9.0	86.0 (48–100)	46.5 ± 8.0	46.0 (32–61)	
Pre–post difference			42.4 ± 11.3	41.0 (17–72)	14.2 ± 11.4	15.0((−5)–40)	
Pre–post difference *P*							
DN4 Score							
Preoperative	5.9 ± 1.9	6.0 (3–10)	5.7 ± 1.9	6.0 (3–10)	7.3 ± 1.5	8.0 (5–10)	
Postoperative*	2.1 ± 1.7	2.0 (0–9)	2.2 ± 0.8	2.0 (0–6)	7.0 ± 0.9	7.0 (6–9)	
Pre–post difference			−3.5 ± 1.7	−3.0((−8)–0)	−0.3 ± 1.1	0.0((−2)–2)	
Pre–post difference *P*					0.196		

Note: Bold-italic values indicate statistical significance.
*From index surgery for re-tear (+) group.
VAS, Visual Analog Scale; ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; UCLA, University at California at Los Angeles Shoulder Rating Scale; CM, Constant–Murley; DN4, Douleur Neuropathique questionnaire.

Table 3. Preoperative Radiological Measurements of All Patients and Two Groups

		Total, *n* (%) = 196 (100)		Re-tear (-), *n* (%) = 176 (89.8)		Re-tear (+), *n* (%) = 20 (10.2)		
		Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min-Max)	*P*
CSA (°)		28.6 ± 2.5	28 (23–36)	28.7 ± 2.5	28 (25–36)	27.7 ± 2.5	27 (23–32)	0.112
AHI (mm)		9.8 ± 1.3	9.8 (6.9–13)	9.8 ± 1.3	9.7 (6.9–13)	9.9 ± 1.3	10 (7.6–13)	0.885
Occupation ratio (%)	I	35 17.8%		21 12%		14 70%		
	II	101 48.2%		95 54%		6 30%		
	III	60 34%		60 34%		0 0%		
Goutallier grade	0	3 1.5%		3 1.8%		0 0%		
	I	32 16.3%		32 18.1%		0 0%		
	II	110 56.2%		108 61.3%		2 10%		
	III	40 20.4%		30 17%		10 50%		
	IV	11 5.6%		3 1.8%		8 40%		
Tangent sign	(−)	142 72.4%		130 73.8%		12 40%		0.297
	(+)	54 26.6%		46 26.2%		8 60%		
Acromion type	1	53 27.0%		51 96.2%		2 3.8%		0.188
	2	100 51.0%		87 87%		13 13%		
	3	43 22.0%		38 88.4%		5 11.6%		

Note: Bold-italic values indicate statistical significance.
CSA, Critical Shoulder Angle; AHI, Acromiohumeral Interval.

that diabetes and obesity negatively affected overall functional scores. However, age, smoking, and hypercholesterolemia did not. Chung et al.[3] reported that sex, smoking habits, and comorbidities (diabetes, hypertension, or heart disease) had no effect on healing rates, but age had. On the contrary, Nicholson et al.[1] reported that age did not affect re-tear development. We found no effect of patient characteristics on re-tear development.

Fatty degeneration (Goutallier index >3) was reported as a significant radiological risk factor associated with failure after aRCR.[9,10] Recently, Iijima et al.[8] found significantly higher preoperative fatty infiltration grades in patients with re-tears following aRCR, while Park et al.[7] reported that it was not a major risk factor for re-tear development. Our study found a significant difference between the re-tear (+) and the re-tear (−) groups according to the Goutallier fatty degeneration degree.

Table 4. Pre- and Intraoperative Tear Characteristics of All Patients and Two Groups

		Total, *n* (%) = 196 (100)		Re-tear (−) *n* (%) = 176 (89.8)		Re-tear (+) *n* (%) = 20 (10.2)		
		Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min–Max)	Mean ± SD/*n*-%	Median (Min–Max)	*P*
Tear type	Total	133 67.9%		119 9.5%		14 10.5%		1.000
	Partial	63 32.1%		57 90.5%		6 9.5%		
Tear pattern	Crescent	151 77.0%		136 90.1%		15 9.9%		
	U type	32 16.3%		29 90.6%		3 9.4%		0.812
	L type	13 6.7%		11 84.6%		2 15.4%		
Torn tendon	SS	154 78.5%		138 89.7%		16 10.3%		
	SS + IS	39 19.9%		36 92.4%		3 7.6%		0.443
	SS + IS + SSC	3 1.6%		2 66.6%		1 33.3%		
Number of anchors used		2.3 ± 0.7	2.0 (1–5)	2.3 ± 0.7	2.0 (1–5)	2.2 ± 0.7	2.0 (1–4)	0.734
Tear size (cm)		2.49 ± 1.0	2.05 (1–6)	2.43 ± 1.0	2.0 (1–6)	2.9 ± 1.1	2.5 (1.6–5)	
Retraction amount (mm)		12.8 ± 5.5	13.0 (0–25)	12.5 ± 5.4	12.0 (0–25)	14.4 ± 5.6	15.0 (5–25)	0.234
Intraoperative cuff thickness (mm)		7.4 ± 1.0	7.2 (5–11)	7.3 ± 1.0	7.2 (5–11)	7.7 ± 1.1	7.8 (5–10)	0.568
Repair type	single	120 61.2%		113 64.2%		7 35%		0.493
	double	76 39.8%		63 35.8%		13 65%		
Biceps tenotomy	(−)	135 68.8%		118 67.0%		17 85%		0.619
	(+)	61 32.2%		58 33.0%		3 15%		
Microfracture	(−)	160 82.7%		145 82.3%		15 75%		0.377
	(+)	36 18.3%		31 17.7%		5 25%		
Intraoperative cuff wear	(−)	80 40.8%		78 44.3%		2 10%		
	(+)	116 59.2%		98 65.7%		18 90%		
Intraoperative cuff stiffness	(−)	110 56.2%		104 59.1%		6 30%		
	(+)	86 43.8%		72 40.9%		14 70%		

Note: Bold-italic values indicate statistical significance.
BMI, Body Mass Index; SS, Supraspinatus; IS, Infraspinatus; SSC, Subscapularis.

Kim et al.[10] reported that OR was a significant risk factor for rotator cuff re-tear. In our study, the re-tear rate was significantly higher in patients with a smaller OR, consistent with these findings. Though Kim et al.[10] reported no effect of ACJ arthritis on re-tear after aRCR, we found that the presence of ACJ arthritis significantly increased the re-tear rate. Garcia et al.[11] reported that a higher CSA was associated with an increased re-tear risk and worse postoperative ASES scores and proposed that CSA might help manage expectations in patients with RCTs. We found no significant difference in CSA values between groups with and without re-tear. Chung et al.[3] also found AHI to be a significant risk factor for re-tear. In contrast, we found no difference in AHI between the re-tear (−) and re-tear (+) groups (9.8 mm vs 9.9 mm). A positive tan-sign has been reported as a risk factor for incomplete RCR.[9] In contrast, Jo and Shin reported improvement in the tan-sign after surgery, suggesting that a successful outcome may be possible in some cases where the tan-sign is positive.[30] We found no differences in tan-sign between the re-tear (−) and re-tear (+) groups. We can attribute this to the combined evaluation of partial and total tears in our patient population and their heterogeneity in terms of tear type, morphology, and tear chronicity. With the available data, we suggest that intraoperative tendon quality and tear chronicity may be more valuable rather than the tan-sign. However, the effect of the tan-sign on re-tear development should be investigated in studies including more homogeneous patient groups and larger sample size.

Many studies have evaluated the relationship between surgical technique and tear characteristics, rotator cuff integrity, and re-tear rates with conflicting evidence.[3,7,10,12–17] Larger tear size affected re-tear and postoperative function after aRCRs in some studies.[3,7,12,31] Ishitani et al.[13] recently defined that higher signal intensity on the torn tendon stump (Type 3 vs Type 1 or 2), global fatty degeneration index, and AP tear size were predictive factors on re-tear rate regardless of repair techniques. Chung et al.[3] reported that biceps procedure combined with aRCR and higher retraction amount of cuff tear had a negative effect on healing. We observed 20 re-tears (10.2%) with no impact of repair techniques, tendon thickness, retraction amount between groups (12.5 mm vs 14.4 mm), concomitant biceps procedure, acromioplasty, or microfracture on re-tear development. However, tear size, cuff wear, and stiffness were found to be associated with re-tear development.

While some studies revealed that longer preoperative symptom duration and shoulder stiffness led to poorer functional outcomes after aRCR,[32,33] others reported the opposite findings.[3,34] We found a tendency towards a higher re-tear rate in patients with preoperative stiffness (6.1% vs 4.1%) and >6 months symptom duration.

Oh et al.[35] revealed no significant difference in the outcomes of aRCR between pseudoparalytic and non-pseudoparalytic patients with massive cuff tears. Also, they investigated the tendon healing anatomically using CT arthrography and found no significant difference between groups. However, we found significantly higher pre- and postoperative pseudoparalysis rates in the re-tear (+) group compared to the re-tear (−) group. This might be due to the non-homogeneous distribution of our patients.

NSAIDs and opioids are the most typical forms of postoperative analgesia. Despite advances in analgesics, these may affect tendon-to-bone healing. Recently, Oh et al.[36] recommended that selective cyclo-oxygenase-2 inhibitors should not be used, although they provide comparable postoperative analgesic effects to those of other NSAIDs and opioids. In our study, significantly longer postoperative

analgesic use was observed in the re-tear (+) group. This may be explained by the possible adverse effect of more prolonged analgesic use on tendon-to-bone healing.

The present study's strengths were that all procedures were performed by two surgeons with at least 5 years' experience in arthroscopic shoulder surgery, using the same surgical procedure for both single- and double-row repair and intraoperative measurement techniques. Second, we evaluated several factors: patients' characteristics and demographic data, preoperative scores, physical examination, intraoperative, and radiographic factors.

There are several limitations to the study. First, this study was retrospective in nature, although we used prospectively collected patients' data without loss of follow-up to reach more accurate results. Second, while 3-year follow-up may be sufficient to evaluate re-tear rates, long-term outcomes may differ, and more accurate results may be obtained. Third, intraoperative stiffness and wear of the rotator cuff tendon were subjectively evaluated by the surgeons. Finally, we assessed the partial and total rupture repairs together; more accurate results may be obtained with more homogenous groups. Despite these limitations, the results of the current study might be useful for risk stratification in RCR. However, further prospective randomized controlled studies are needed to evaluate the factors associated with re-tear following aRCR and investigate the relationship between these factors in more homogeneous patient groups and larger sample size.

In conclusion, surgeons should consider the preoperative degree of fatty degeneration, clinical and functional scores, presence of ACJ arthritis, intraoperative tendon quality, tear size and chronicity, postoperative prolong analgesic requirement, and development of pseudoparalysis as factors regarding re-tear development risk following aRCR. Therefore, preoperative planning, postoperative rehabilitation, and follow-up protocols could be revised considering these factors.

Ethics Committee Approval: Ethics committee approval was received for this study from the Local Ethics Committee of the Erciyes University (Approval date and number: 24.07.2015; 2015/330).

Informed Consent: Informed consent was obtained from all participants.

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