

# Poor Prognostic Factors in Patients With Rotator Cuff Retear

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**Background:** The treatment for retears after arthroscopic rotator cuff repair (ARCR) has long been a challenge.

**Purpose:** This study aimed to (1) summarize the characteristics of patients with a retear after primary ARCR and (2) determine the risk factors for poor clinical outcomes after a retear.

**Study Design:** Case-control study; Level of evidence, 3.

**Methods:** We collected the data of patients with a retear after primary ARCR between January 2011 and December 2016. There were 45 patients with retears included (19 men [42.2%] and 26 women [57.8%]; mean  $\pm$  SD age, 63.11  $\pm$  8.87 years). Initially, the demographic and outcome data of patients with a retear were analyzed. Patients were classified into good and poor outcome groups according to their overall satisfaction at final follow-up. Univariable and multivariable logistic regression analyses were performed to determine the factors for poor clinical outcomes after a retear.

**Results:** A total of 31 patients were classified into the good outcome group, and 14 patients were classified into the poor outcome group. Both the good and the poor outcome groups showed that clinical scores significantly improved at the time of the retear diagnosis, but the final scores were maintained or worse compared with scores at the time of the retear diagnosis. Final range of motion (ROM), except external rotation in the good outcome group, was worse or had no significant change compared with ROM at the time of the retear diagnosis. On multivariable logistic regression analysis, current smoking (odds ratio [OR], 45.580 [95% CI, 3.014-689.274];  $P = .006$ ), female sex (OR, 32.774 [95% CI, 2.433-441.575];  $P = .009$ ), and retears of the same or larger size than the initial tear (OR, 10.261 [95% CI, 1.544-68.202];  $P = .016$ ) showed a higher OR for poor clinical outcomes after a retear.

**Conclusion:** Smoking, female sex, and retears of the same or larger size than the initial tear were independent risk factors for poor clinical outcomes after a rotator cuff retear. Final clinical scores and ROM were similar or worse compared with the scores and ROM at the time of the retear diagnosis. Therefore, revision surgery should be actively considered in female patients or those who smoke with poor clinical outcomes and a larger retear size than the preoperative tear size at the time of the retear diagnosis.

**Keywords:** rotator cuff injuries; retear; American Shoulder and Elbow Surgeons score; Single Assessment Numeric Evaluation; visual analog scale; risk factor; clinical outcome

Various studies have been conducted to improve rotator cuff healing at the bone-to-tendon junction.<sup>9,18,22,36</sup> Nevertheless, the incidence of retears has been reported to be 11% to 94%, indicating a high incidence rate.<sup>4,7,10,24,33</sup> Even in cases in which a retear occurs during follow-up, satisfactory results in pain and function are often seen.<sup>2,8,17,21,35</sup> On the other hand, despite successful healing of the rotator cuff tendon, there are often cases in which a clinical improvement of symptoms is not achieved or the patient's satisfaction is low. Therefore, a retear does not affect clinical improvement or patient satisfaction alone.

Some studies have reported that revision surgery improved outcomes when a retear occurred.<sup>20</sup> However, some studies have reported that patients who had developed a retear are more likely to have a retear, even with revision surgery.<sup>29,32</sup> Moreover, there are also studies showing good results of nonoperative treatment for retears.<sup>12,13,28</sup> Because of several studies with contrasting views on retears, it is difficult to determine whether revision surgery or nonoperative management should be performed if a retear occurs after arthroscopic rotator cuff repair (ARCR). If the clinical course and prognosis after a retear can be predicted, better treatment will be provided to patients with retears. Therefore, this study aimed to classify patients with retears into good and poor outcome groups to evaluate the characteristics of the total cohort

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and each group and determine which factors influence poor outcomes. Our null hypothesis was that no factor would have a significant effect on the outcomes of patients with rotator cuff retears.

## METHODS

We obtained institutional review board approval at the planning stage of this study. The current study complied with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all patients.

### Patients and Follow-up

A total of 646 patients who underwent ARCR in a tertiary hospital between January 2011 and December 2016 were retrospectively investigated. All surgical procedures were performed by a single shoulder surgeon (I.-H.J.), and follow-up was conducted at 2 weeks, 4 weeks, 3 months, 6 months, 1 year, and 2 years postoperatively. Magnetic resonance imaging (MRI) was routinely performed at 1 year postoperatively. However, if the patients continued to have pain or weakness after 1-year follow-up, additional MRI was performed to look for the presence of a retear. Patients with retears confirmed via MRI were closely monitored and evaluated annually. Revision surgery was recommended to the patients who had pain and discomfort at 1-year follow-up. If the patients agreed to undergo revision surgery, revision ARCR was performed.

All scores and range of motion (ROM) data at each follow-up visit were collected by a clinical nurse specialist (CNS; J.H.P.) with >10 years of experience. Final follow-up was conducted between January and June 2019. Patients who could not visit the outpatient clinic were followed up using a telephone survey by the same CNS (Figure 1).

### Inclusion and Exclusion Criteria

Among the patients who underwent primary ARCR between January 2011 and December 2016, we included the patients who showed retears on MRI scans (Sugaya grade 4 or 5) at 1-year follow-up. In contrast, we excluded the patients who underwent concomitant superior capsular reconstruction or augmentation procedures, refused to undergo MRI, or did not come to the outpatient clinic at 2-year follow-up. Of 646 patients, 253 patients were observed for >2 years and evaluated using MRI. Ultimately, 45 patients were included in the current study

based on the inclusion criteria. The mean follow-up duration was  $49.36 \pm 20.25$  months. No patient had a workers' compensation claim.

### Preoperative Data Extraction

Initially, descriptive data including age, sex, right or left side, dominant side affected, height, weight, body mass index, duration of symptoms, smoking status, and medical history (Charlson Comorbidity Index) were collected. Subsequently, the ROM as well as pain visual analog scale (pVAS), Single Assessment Numeric Evaluation (SANE), and American Shoulder and Elbow Surgeons (ASES) scores measured a day before ARCR were recorded. All patients currently smoking were considered smokers, regardless of the amount. Preoperative shoulder MRI was used to evaluate tear size, retraction length, fatty infiltration (Goutallier classification), and supraspinatus muscle atrophy (occupation ratio). The occupation ratio of the supraspinatus in the supraspinatus fossa was calculated on the T1-weighted scapular Y-view image.<sup>34,41</sup> All MRI measurements were performed by a fellowship-trained musculoskeletal radiologist independent of the current study. Internal rotation was defined as the highest spinal segment that the thumb of the patient could reach, and each segment was converted into numerical data for statistical analysis. For example, spinal segments T1 through T12 were designated 1 to 12, respectively, and spinal segments L1 through L5 were designated 13 to 17, respectively. The sacral level was set to 18.<sup>23</sup>

### Surgical Technique and Operative Data Extraction

All surgical procedures were performed with patients in the beach-chair position under general anesthesia. An intra-articular examination was performed using the posterior portal to assess the biceps tendon and subscapularis, and appropriate debridement was performed. Age, extent of the biceps tear, and subluxation were analyzed to determine the biceps procedure, such as biceps tenodesis or tenotomy. If the subscapularis showed mild fraying or small-sized partial-thickness tears, only simple debridement was performed. If the subscapularis showed more than high-grade partial-thickness tears, repair was performed. Subsequently, surgical instruments penetrated the subacromial space. Bursectomy, acromioplasty in case of acromial spurs, and rotator cuff mobilization with peripheral release were performed. Afterward, the fixation and suture method was decided to form the optimal repair configuration. Single-row repair was performed in cases of severe retraction, sufficient

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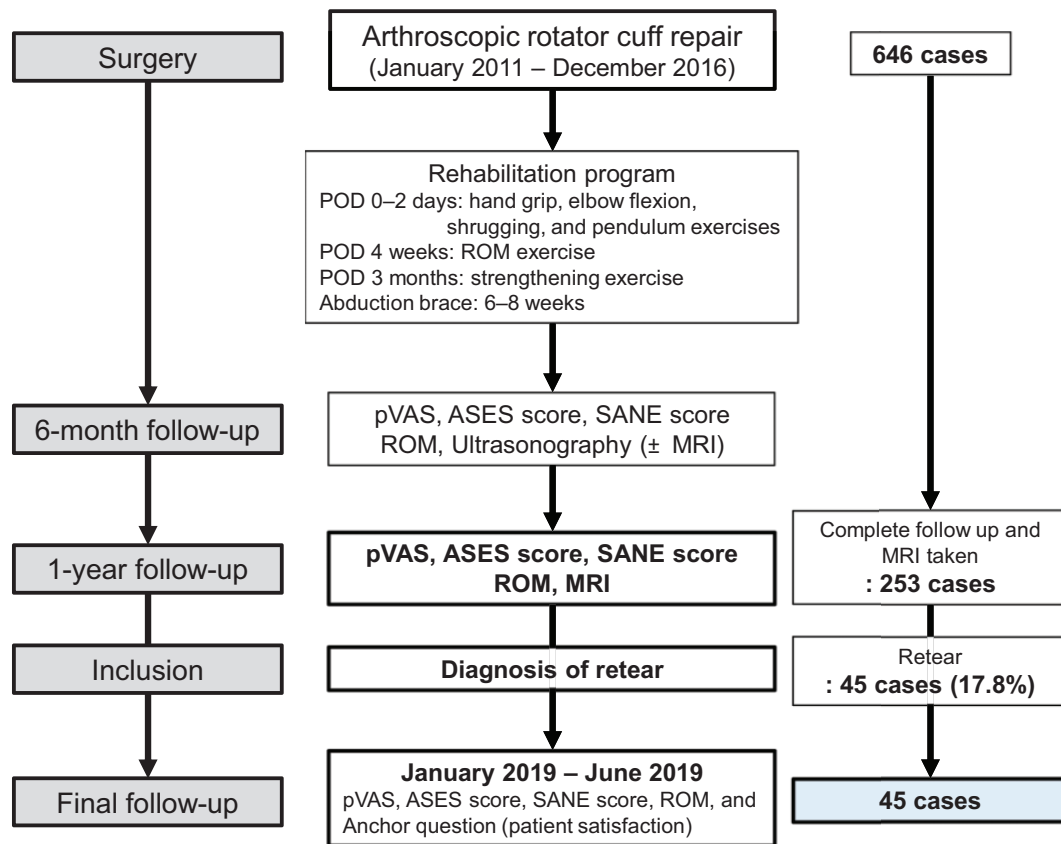
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Ethical approval for this study was obtained from Asan Medical Center (No. AMC 2019-0159).



**Figure 1.** Flow diagram showing the overall progress of this study. ASES, American Shoulder and Elbow Surgeons; MRI, magnetic resonance imaging; POD, postoperative day; pVAS, pain visual analog scale; ROM, range of motion; SANE, Single Assessment Numeric Evaluation.

remnant tissue of the greater tuberosity, or small-sized tears. Double-row repair was performed when a large contact area was required for bone-to-tendon healing. Most double-row repair procedures used the suture bridge technique, and knotless anchors were used as the lateral anchors.

Operative data were extracted from operative records and arthroscopic images. Data such as tear size (partial, small, medium, large, or massive), repair configuration (single or double row), presence of subscapularis tears, subscapularis repair, biceps procedure (tenotomy, tenodesis, or repair), and acromioplasty were summarized and recorded. Tear size was determined by combining operative records and arthroscopic images.

### Postoperative Data Extraction

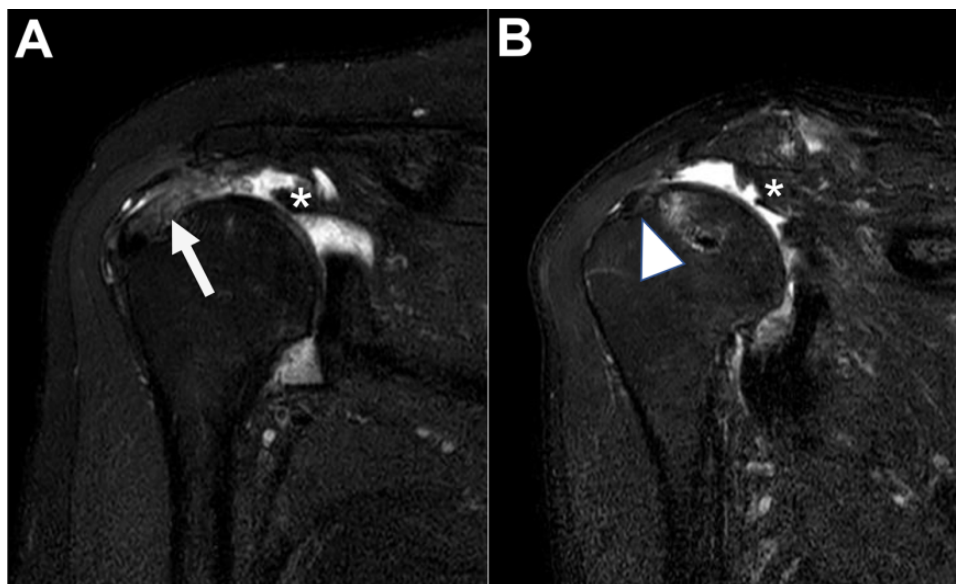
Postoperative data were based on clinical outcomes at the time of the retear diagnosis on MRI scans (mostly 1 year, some <1 year) and at final follow-up. Initially, the ROM, pVAS score, ASES score, and SANE score at the time of the retear diagnosis were recorded. Then, MRI findings were analyzed to evaluate the retear size in the coronal and sagittal planes (whether the retear size was smaller than, the same as, or larger than the size preoperatively), the Sugaya classification, and the loss of force couple. The loss of force couple

was considered when the anteroposterior force couple was not likely to be maintained because of anterior or posterior rotator cuff tears. Additionally, the location of the retear was evaluated. A lateral retear was defined as the occurrence of a retear near the initial tear location or insertion site without a remnant. In contrast, a medial retear was defined as the occurrence of a retear with remnant tissue in the greater tuberosity (Figure 2).

Patient satisfaction was assessed at final follow-up using an anchor-based approach, similar to that used to derive the minimal clinically important difference and substantial clinical benefit (Table 1).<sup>38</sup> Patients who answered “C” and “D” were classified into the good outcome group, and patients who answered “A” or “B” or who underwent a reoperation were classified into the poor outcome group.

### Statistical Analysis

We consulted with a medical statistician during the entire course of the study. All preoperative, operative, and postoperative factors that may affect the prognosis of a retear were assigned as variables. Initially, descriptive, preoperative, operative, and postoperative data were summarized for the entire patient cohort, good outcome group, and poor outcome group. Repeated-measures analysis of variance was used to analyze changes in clinical scores and ROM



**Figure 2.** Classification of retears according to the re-tear location: (A) medial and (B) lateral. Asterisk, supraspinatus tendon; arrow, remnant tissue; arrowhead, tear site.

**TABLE 1**  
Patient Satisfaction

Response	Description	Outcome Group
A (no change)	No improvement in pain and discomfort	Poor
B (improved but dissatisfied)	Slight improvement; pain and discomfort remain	Poor
C (improved)	Improvement in pain and discomfort compared with preoperative status; intermittent discomfort	Good
D (excellent)	Sufficient and satisfactory improvement in pain and discomfort	Good

at each time point. Then, univariable analysis was performed between the good and poor outcome groups using the Student *t* test, Fisher exact test, and crosstab analysis. Variables with a *P* value  $\leq .2$  and variables with a potential clinical effect even if the *P* value was  $> .2$  were added to multivariable logistic regression analysis. Finally, variables with a *P* value  $< .05$  were determined as independent factors affecting poor outcomes after a re-tear. All statistical analyses were performed using SPSS for Windows (Version 24.0.0.0; IBM).

## RESULTS

### Clinical Outcomes of Patients With Retear

Table 2 shows the descriptive data and preoperative characteristics of patients with a re-tear. There were 19 men (42.2%) and 26 women (57.8%) with a mean age of  $63.11 \pm$

8.87 years. There were 28 cases (62.2%) on the right side, and 28 cases (62.2%) were on the dominant side.

At final follow-up, 3, 11, 15, and 16 patients answered “A,” “B,” “C,” and “D,” respectively, to the question regarding satisfaction. Thus, 31 patients were classified into the good outcome group, and 14 patients were classified into the poor outcome group. There were 3 patients who underwent revision surgery, which was performed after 1-year follow-up. Although 1 of 3 patients underwent revision ARCR, the repaired rotator cuff re-ruptured and was finally repaired using an open manner. Another patient was diagnosed with a dislocation and re-tear, and reduction and open subscapularis repair were performed. The other patient was diagnosed with a massive re-tear, and conversion to superior capsular reconstruction was performed. All 3 patients showed satisfactory clinical results at final follow-up.

Table 3 presents the operative and postoperative characteristics. Double-row repair was performed in 25 patients (55.6%), and a lateral re-tear was observed in 10 patients (22.2%). There were 28 patients (62.2%) with a Sugaya grade 5 re-tear. Moreover, 23 patients (51.1%) had the same or larger re-tear size than the initial tear size.

### Changes in Clinical Scores and ROM After a Retear

Figure 3 shows the changes in pVAS, ASES, and SANE scores over time for each group. In the total cohort and good outcome group, the scores at the time of the re-tear diagnosis were significantly greater than were the preoperative scores. However, the final scores did not differ compared with the scores at the time of the re-tear diagnosis. Although the scores at the time of the re-tear diagnosis in the poor outcome group were significantly higher than were the preoperative scores, the poor

TABLE 2  
Descriptive Data and Preoperative Characteristics<sup>a</sup>

	Total (N = 45)	Good Outcome Group (n = 31)	Poor Outcome Group (n = 14)
Age, y	63.1 ± 8.9	64.4 ± 8.4	60.4 ± 9.6
Age group, 40-49/50-59/60-69/≥70 y, n	3/9/23/10	1/7/15/8	2/2/8/2
Sex, n (%)			
Male	19 (42.2)	11 (35.5)	8 (57.1)
Female	26 (57.8)	20 (64.5)	6 (42.9)
Follow-up duration, mo	49.4 ± 20.3	49.2 ± 18.9	49.7 ± 23.8
Dominant side, n (%)			
Right	28 (62.2)	20 (64.5)	8 (57.1)
Left	17 (37.8)	11 (35.5)	6 (42.9)
Dominant side affected, n (%)			
Yes	28 (62.2)	21 (67.7)	7 (50.0)
No	17 (37.8)	10 (32.3)	7 (50.0)
Symptom duration, mo	23.0 ± 45.6	25.6 ± 54.3	17.4 ± 13.2
Body mass index	25.4 ± 2.8	25.3 ± 2.6	25.6 ± 3.4
Time of retear diagnosis, mo	10.6 ± 3.3	10.6 ± 3.8	10.6 ± 1.9
CCI score, 0/1/2/3/4, n	32/5/2/4/2	21/5/0/3/2	11/0/2/1/0
Age-adjusted CCI score	2.6 ± 1.7	2.7 ± 1.7	2.2 ± 1.6
Current smoking, n (%)			
No	36 (80.0)	27 (87.1)	9 (64.3)
Yes	9 (20.0)	4 (12.9)	5 (35.7)
Patient satisfaction response, n (%)			
A (no change)	3 (6.7)	NA	NA
B (improved but dissatisfied)	11 (24.4)	NA	NA
C (improved)	15 (33.3)	NA	NA
D (excellent)	16 (35.6)	NA	NA
Revision surgery, n (%)			
Yes	3 (6.7)	NA	NA
No	42 (93.3)	NA	NA
Clinical outcome, n (%)			
Good	31 (68.9)	NA	NA
Poor	14 (31.1)	NA	NA
Full-thickness tear, n (%)			
Yes	42 (93.3)	29 (93.5)	13 (92.9)
No	3 (6.7)	2 (6.5)	1 (7.1)
Tear size, partial/small/medium/large/massive, n	3/4/17/12/9	2/4/10/8/7	1/0/7/4/2
Tear retraction, mm	26.3 ± 10.1	27.0 ± 10.5	24.6 ± 9.4
Goutallier classification, 0/1/2/3/4, n	6/14/14/8/3	4/10/9/6/2	2/4/5/2/1
Occupation ratio (supraspinatus muscle atrophy)	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1

<sup>a</sup>Data are reported as mean ± SD unless otherwise indicated. CCI, Charlson comorbidity index; NA, not applicable.

outcome group showed worse pVAS ( $P < .01$ ), ASES ( $P = .044$ ), and SANE ( $P = .089$ ) scores than did the good outcome group at the time of the retear diagnosis. The final scores then deteriorated compared with those at the time of the retear diagnosis: the pVAS ( $P = .029$ ) and SANE ( $P = .028$ ) scores decreased to a statistically significant level, and the ASES score ( $P = .058$ ) showed a nearly significant decrease.

Figure 4 shows the changes in forward elevation, external rotation (ER), and internal rotation over time for each group. Forward elevation in the total cohort and good outcome group significantly increased at the time of the retear diagnosis and then decreased again at final follow-up. The poor outcome group showed no statistically significant change. The final ER in the total cohort and good outcome group was significantly greater compared with preoperative ER, and the poor outcome group showed no significant

change in ER. Internal rotation in all groups did not change significantly.

#### Univariable and Multivariable Logistic Regression Analyses

We performed a comparison between 2 groups for all possible variables (Table 4). Among them, the variables with a  $P$  value  $\leq .2$  were sex ( $P = .173$ ), age ( $P = .164$ ), Charlson Comorbidity Index ( $P = .118$ ), current smoking ( $P = .111$ ), and same or larger retear size than the preoperative tear size ( $P = .067$ ). In addition to these 5 variables, potential clinical risk factors were selected (large to massive tear, repair configuration, Sugaya classification, and retear location) and included in multivariable analysis. Finally, independent risk factors affecting poor outcomes after a retear were current smoking (odds ratio [OR], 45.580 [95% CI,

3.014-689.274];  $P = .006$ ), female sex (OR, 32.774 [95% CI, 2.433-441.575];  $P = .009$ ), and same or larger retear size (OR, 10.261 [95% CI, 1.544-68.202];  $P = .016$ ). Age showed an OR of 0.894 (95% CI, 0.791-1.012), suggesting poor outcomes at a younger age, but it was not statistically significant ( $P = .077$ ).

TABLE 3  
Operative and Postoperative Characteristics<sup>a</sup>

	Total (N = 45)	Good Outcome Group (n = 31)	Poor Outcome Group (n = 14)
Subscapularis tear			
Present	28 (62.2)	19 (61.3)	9 (64.3)
Absent	17 (37.8)	12 (38.7)	5 (35.7)
Subscapularis repair			
Yes	13 (28.9)	9 (29.0)	4 (28.6)
No	32 (71.1)	22 (71.0)	10 (71.4)
Repair configuration			
Single row	20 (44.4)	15 (48.4)	5 (35.7)
Double row	25 (55.6)	16 (51.6)	9 (64.3)
Biceps procedure, none/ torn state/tenotomy/ tenodesis, n	24/3/4/14	16/3/3/9	8/0/1/5
Sugaya classification			
Grade 4	17 (37.8)	12 (38.7)	5 (35.7)
Grade 5	28 (62.2)	19 (61.3)	9 (64.3)
Retear location			
Medial	35 (77.8)	25 (80.6)	10 (71.4)
Lateral	10 (22.2)	6 (19.4)	4 (28.6)
Retear size, mean ± SD, mm			
Coronal	15.22 ± 10.10	14.13 ± 9.76	17.64 ± 10.78
Sagittal	13.02 ± 9.70	12.13 ± 9.41	15.00 ± 10.38
Change in size from preoperatively			
Same or larger	23 (51.1)	13 (41.9)	10 (71.4)
Smaller	22 (48.9)	18 (58.1)	4 (28.6)
Loss of force couple			
Yes	12 (26.7)	9 (29.0)	3 (21.4)
No	33 (73.3)	22 (71.0)	11 (78.6)

<sup>a</sup>Data are reported as n (%) unless otherwise indicated.

## DISCUSSION

Compared with previous studies in which the factors affecting a retear were the main themes, our study aimed to determine the factors that influence the prognosis of a retear and found 3 independent factors: current smoking, female sex, and retears of the same or larger size than the initial tear. Considering that all the current smokers were male, female sex was a more prominent risk factor among nonsmokers. Applying this to clinical practice, women and men who currently smoke should be followed with more caution at the time of the retear diagnosis. If these patients have a retear with a size similar to or larger than that of the preoperative tear, it is likely that they will continue on a worsening course. However, it does not mean that they will benefit from additional surgery, such as superior capsular reconstruction or augmentation. Encouraging the cessation of smoking before initial rotator cuff surgery is likely to improve the prognosis after a retear.

We also found impressive findings in our analysis of changes in clinical scores and ROM. Although both the good and poor outcome groups showed that clinical scores significantly improved at the time of the retear diagnosis, the final scores did not improve compared with those at the time of the retear diagnosis and sometimes worsened. Similarly, most ROM values, except ER in the good outcome group, were worse or had no significant change at final follow-up compared with those at the time of the retear diagnosis. These findings suggest that the clinical course of patients who are dissatisfied with the surgical outcome at the time of the retear diagnosis is unlikely to improve with longer follow-up. In fact, all 3 patients who underwent revision surgery had prominent pain and discomfort at the time of the retear diagnosis, and their progress was not improved during the follow-up period. There were no other pain sources on physical examination and MRI scans. All 3 patients who underwent revision surgery showed satisfactory clinical results at final follow-up.

Namdari et al,<sup>26</sup> who studied a similar topic, suggested labor-intensive occupation as a factor influencing outcomes after a retear. Although they used the ASES score threshold (80 points) as the basis for classifying a successful or unsuccessful group,<sup>26</sup> the importance of patient-based

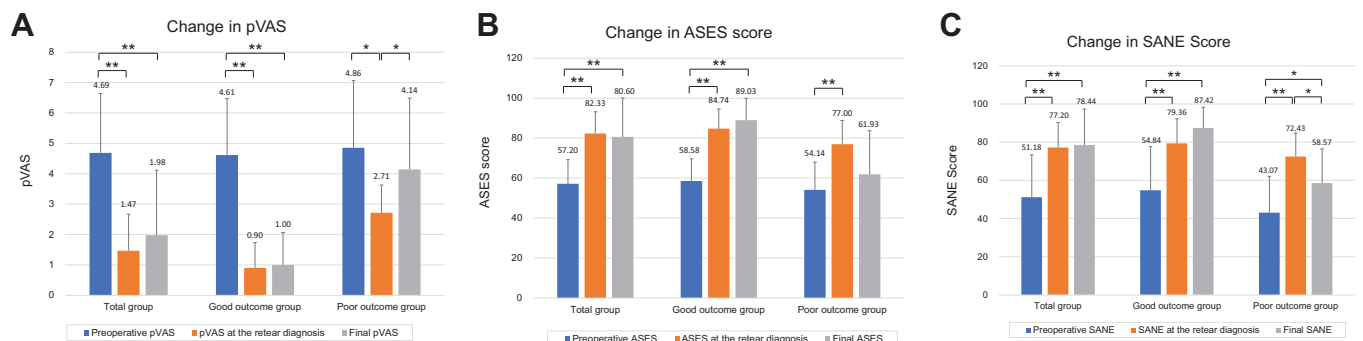
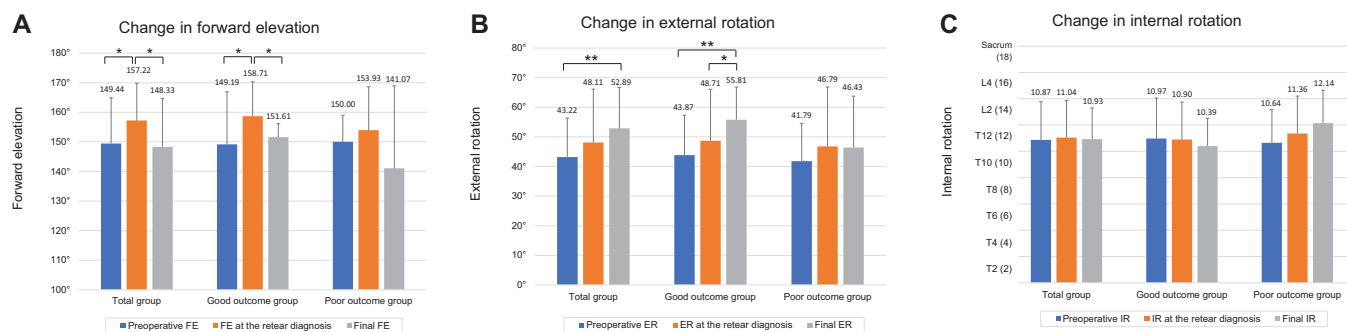


Figure 3. Changes in scores according to each group: (A) pain visual analog scale (pVAS), (B) American Shoulder and Elbow Surgeons (ASES), and (C) Single Assessment Numeric Evaluation (SANE). \* $P < .05$ . \*\* $P < .001$ .



**Figure 4.** Changes in range of motion according to each group: (A) forward elevation (FE), (B) external rotation (EF), and (C) internal rotation (IR). \* $P < .05$ . \*\* $P < .001$ .

**TABLE 4**  
Results of Univariable and Multivariable Logistic Regression Analyses<sup>a</sup>

	P Value		Odds Ratio (95% CI)
	Univariable Analysis	Multivariable Logistic Regression Analysis	
Female sex	.173	.009 <sup>b</sup>	32.774 (2.433-441.575)
Age	.164	.077	0.894 (0.791-1.012)
Dominant side	.744	NA	NA
Dominant side affected	.326	NA	NA
Symptom duration	.580	NA	NA
Body mass index	.355	NA	NA
CCI score	.118	.870	NA
Age-adjusted CCI score	.827	NA	NA
Current smoking	.111	.006 <sup>b</sup>	45.580 (3.014-689.274)
Full-thickness tear	>.999	NA	NA
Tear size	.639	NA	NA
Tear retraction	.457	NA	NA
Large to massive tear size	.731	.908	NA
Goutallier classification	>.999	NA	NA
Occupation ratio	.524	NA	NA
Subscapularis tear	>.999	NA	NA
Subscapularis repair	>.999	NA	NA
Repair configuration	.428	.198	NA
Biceps procedure	.860	NA	NA
Acromioplasty	.932	NA	NA
Sugaya classification	.848	.715	NA
Retear location	.700	.919	NA
Coronal retear size	.285	NA	NA
Sagittal retear size	.364	NA	NA
Same or larger retear size than preoperative tear size	.067	.016 <sup>b</sup>	10.261 (1.544-68.202)
Loss of force couple	.725	NA	NA
Hosmer-Lemeshow test		.804	

<sup>a</sup>CCI, Charlson Comorbidity Index; NA, not applicable.

<sup>b</sup>Statistically significant ( $P < .05$ ).

evaluations has recently emerged, and studies are actively being conducted on the minimal clinically important difference and substantial clinical benefit.<sup>5,30,39</sup> Therefore, we used an anchor-based approach to assess patient satisfaction, and patients were divided into good and poor outcome groups according to the satisfaction grade. Although our criteria have the advantage of focusing on patient

satisfaction, they also have a limitation in that they are not validated outcome measures such as the ASES score.

Analyses of the risk factors affecting structural integrity (retear) have been conducted in several studies, and the reported risk factors are as follows: hyperlipidemia, diabetes, smoking status, duration of symptoms preoperatively, rotator cuff retraction, occupation ratio, preoperative tear

size, and tendon involvement.<sup>6,15,16,19,31</sup> On the other hand, we focused on the factors for a poor prognosis after a retear. In our analysis, most factors, except smoking status, had no significant effect on the outcome after a retear. Our analysis has shown that current smoking worsened the clinical outcome after a retear. Because tobacco contains toxins, such as nicotine and carbon monoxide, which cause blood flow to decrease through vasoconstriction,<sup>25</sup> it has been suggested that tobacco weakens the rotator cuff and interferes with bone-to-tendon healing. Nicotine has been found to worsen the mechanical properties of the rotator cuff in a rat study,<sup>11</sup> and clinical studies have also shown that tobacco affects rotator cuff tears and retears.<sup>1,3,27</sup> The reason that smoking affects clinical outcomes may be related to the metabolic mechanism of these components of tobacco. According to Yamamoto et al,<sup>40</sup> the risk factors for tear progression in symptomatic rotator cuff tears were medium-sized tears, full-thickness tears, and smoking. If smoking affects tear progression after a retear, the reason for considering smoking as a risk factor for poor clinical outcomes may be explained.

Few studies have reported the association between sex and rotator cuff tears. Sex has been included as a variable in most studies on the risk factors for a rotator cuff tear or retear. However, sex was not a definite risk factor. According to Tanaka et al,<sup>37</sup> ovariectomized rats showed decreased biomechanical properties and poor development of chondroid tissue that influenced the repair of the tendon insertion postoperatively. Kim et al<sup>14</sup> reported that the combination treatment of raloxifene and vitamin D prevented a decrease in local bone mineral density and enhanced tendon-to-bone healing of the rotator cuff in a rat model.

We assume that female hormone deficiency may also affect the outcomes after a retear, but further basic science and clinical studies are needed to clarify this. The absolute retear size was not related to the outcomes of a retear in our study. However, the same or larger retear size compared with the preoperative tear size was a significant risk factor. Therefore, when treating a patient with a retear in the outpatient clinic, it is important to compare the preoperative tear size with the retear size in predicting the patient's prognosis.

This study has a few strengths. First, there are few studies on the factors that influence the outcome after a retear. In particular, we applied patient-based evaluations and outcome measures to factor analyses through an anchor-based approach. Second, all score and ROM assessments between 2011 and 2019 were conducted by the same CNS. Therefore, consistent data collection was possible, and interobserver bias was minimized. Last, we also focused on the clinical outcomes at the time of the retear diagnosis and then analyzed how the final outcomes changed. Our results may help predict the prognosis of patients with retear and develop a treatment plan.

However, this study also has several limitations. First, some patients did not undergo follow-up for >2 years. This resulted in the potential for selection bias and transfer bias. Second, the retear diagnosis using MRI was mostly conducted at 1-year follow-up. Routine MRI was not performed

at or after 2-year follow-up if there was no apparent retear on MRI scans at 1-year follow-up. It is possible that an undetected retear occurred during follow-up in these patients. Indeed, it was too difficult to routinely perform MRI at 2-year follow-up in a patient without a definite retear at 1-year follow-up. Third, the number of patients with retear included in the analysis was relatively small. Therefore, we consulted with a medical statistician during the entire course of the study. We finally found 3 significant risk factors. There was the possibility of a type II error for not finding other significant factors. Larger studies in the future may establish other risk factors that affect the outcome after a retear and may suggest a useful assessment criterion or scoring system for actual clinical practice. In addition, there might have been a bias for selecting the additional factors when performing multivariable logistic regression analysis.

## CONCLUSION

Smoking, female sex, and retears of the same or larger size than the initial tear were independent risk factors for poor clinical outcomes after a rotator cuff retear. Final clinical scores and ROM were similar or worse compared with the scores and ROM at the time of the retear diagnosis. Therefore, revision surgery should be actively considered in female patients or those who smoke with poor clinical outcomes and a larger retear size than the preoperative tear size at the time of the retear diagnosis.

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