Anteroposterior and Lateral Coverage of the Acromion: Prediction of the Rotator Cuff Tear and Tear Size

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Background: The aim of this study was to assess whether the anteroposterior coverage of the acromion reflecting acromial morphology affects the rotator cuff tear (RCT) and tear size, in addition to the lateral coverage.

Methods: Medical records of 356 patients with RCTs, concentric osteoarthritis, and calcific tendinitis identified using three-dimensional computed tomography between January 2016 and December 2017 were retrospectively analyzed. The patients were divided into group A (those with RCTs) and group B (those with concentric osteoarthritis or calcific tendinitis). Subsequently, group A was subdivided into three categories according to the size of RCTs: small-to-medium, large, and massive. The lateral coverage was measured through the lateral acromial angle (LAA) and critical shoulder angle (CSA), whereas the anteroposterior coverage was measured via the acromial tilt (AT), acromiohumeral interval (AHI) in the sagittal view, and anteroposterior coverage index (APCI) as a new radiologic parameter.

Results: Between groups A and B, CSA (34.5° ± 3.4° and 30.8° ± 3.4°, respectively), APCI (0.83 ± 0.10 and 0.75 ± 0.08, respectively), and AHI (6.3 ± 2.0 mm and 7.8 ± 1.8 mm, respectively) were significantly different (all p < 0.001), whereas LAA and AT did not show a significant difference between the groups (p = 0.089 and p = 0.665, respectively). The independent predictive radiologic parameters of the RCT were the CSA, APCI, and AHI. The parameters associated with the size of RCTs were CSA (p = 0.022) and AHI, of which AHI, in particular, had the most significant effect on both small-to-medium and large tears (all p < 0.001).

Conclusions: Large CSA, high APCI, and low AHI were predictors of RCTs, with the APCI showing the strongest correlation. In addition to the large CSA, low AHI also correlated with the size of RCTs and affected the entire size groups. We suggest that both the lateral coverage and anteroposterior coverage of the acromion should be considered essential factors for predicting the presence of RCTs and tear size.

Keywords: Acromial morphology, Lateral coverage, Anteroposterior coverage, Rotator cuff tear, Rotator cuff tear size

Rotator cuff tears (RCTs) can be caused by aging and degenerative changes due to repeated overuse.1 However, these can also occur as a consequence of extrinsic factors influencing acromial morphology.1,21 Since Neer3 first reported impingement due to an acromial spur as a cause of RCTs, various studies have been conducted on the acromial morphology.4-6

In particular, among the morphology of the acromion, many previous studies have reported the relation-
ship of RCTs with the lateral coverage of the acromion, such as the acromial index (AI) and the critical shoulder angle (CSA). Nyffeler and Meyer examined the AI using shoulder true anteroposterior (AP) radiographs and reported that the lateral extension of the acromion was larger in patients with RCTs. Moor et al. suggested that CSA was significantly higher in patients with RCTs. As shown in the above studies, the relationship between the lateral coverage of the acromion and RCTs has been continuously reported, but studies investigating the influence of the AP coverage of the acromion on RCTs are scarce. Moreover, a small number of studies that have already reported the AP coverage of the acromion show different results. Beeler et al. used multiplanar computed tomography (CT) to examine the three-dimensional (3D) shape of the acromion and reported that the axial (more externally rotated acromion) and coronal tilt of the acromion was larger and the posterior glenoid coverage was wider in patients with RCTs than in those with osteoarthritis (OA). In patients without RCTs, the anterior coverage was reported to have been significantly wider. Sakoma et al. reported in their cadaver study, albeit not based on a direct CT examination, that the anterior projection of the acromion correlated with RCTs. In addition, there is a question as to whether plain radiography is an accurate tool to measure the morphology of the acromion. Fujisawa et al. argued that although the acromial shape had been traditionally assessed using radiographs, a poor interobserver agreement led to unclear results. Thus, the authors studied the correlation between scapular morphology and RCTs using a 3D-CT model.

The current study aimed to (1) investigate whether the acromial morphology correlated with the RCT and tear size by analyzing the 3D-CT data of patients and (2) analyze the correlation between the AP acromial coverage and RCTs using a new radiologic evaluation approach involving 3D-CT. The authors hypothesized that the lateral coverage of the acromion and the AP coverage assessed using a new method would be associated with RCTs and that the AP coverage of the acromion would be correlated with the tear size.

**METHODS**

This is a retrospective case-control study that investigated the correlation between acromial morphology and RCTs in patients who underwent shoulder surgery. Informed consent was obtained from all patients, and Institutional Review Board approval was obtained from Kyung Hee University Hospital (No. KHUH 2019-09-001).

**Patient Selection**

We retrospectively reviewed the data of 1,052 patients who underwent shoulder joint surgery performed by a single senior surgeon (YGR) at our institution between January 2016 and December 2017. In this study, we investigated patients with preoperative magnetic resonance imaging (MRI) and 3D-CT. The exclusion criteria were patients diagnosed with shoulder instability (n = 176) due to tendency to occur at a relatively young age compared to RCTs; patients diagnosed with adhesive capsulitis (n = 23) because there were no previous studies that reported associations between adhesive capsulitis and acromion morphology and 3D-CT was not performed preoperatively in most patients; patients diagnosed with partial-thickness RCTs on preoperative MRI (n = 184); patients with full-thickness RCTs accompanied by arthritic classification stage 3 or above OA in chronic RCTs according to Hamada et al. (n = 13); patients with eccentric OA (Walch classification ≥ B, posterior or anterior subluxation of the humeral head < 45%) that could affect the glenoid morphology (n = 6); patients with rheumatoid arthritis (n = 8), post-infectious sequelae (n = 6) or fracture sequelae (n = 3), and osteonecrosis (n = 11); patients who had undergone revision surgery due to failed rotator cuff repair (RCR) (n = 24); and patients who did not undergo 3D-CT (n = 242). After screening the patients using the inclusion and exclusion criteria, records of 356 patients were analyzed. Patients were divided into two groups: group A contained 239 patients diagnosed with RCTs and group B contained 117 patients diagnosed with concentric OA (the erosion of the anterior and posterior rim of the glenoid was the same) and calcific tendinitis (n = 39 and n = 78, respectively) without an RCT. Group A was subdivided into three subgroups according to the DeOrio and Cofield classification based on preoperative MRI: small- to-medium (n = 126), large (n = 63), and massive (n = 50) size groups. In this study, we included records of patients whose preoperative MRI data and 3D-CT were available. All shoulder 3D-CT scans were performed in the supine position with the shoulder adducted and the arm in a neutral position. The lateral coverage and AP coverage of the acromion were evaluated based on 3D-CT performed 1 day before surgery. All radiologic parameters were measured by two independent orthopedic surgeons blindly (SMR and MSK).

**Lateral Acromial Coverage**

A true AP view was captured using a 3D-CT scan the day before surgery without scapular rotation and overlapping anterior and posterior glenoid edges. Next, the CSA and
lateral acromial angle (LAA) were measured. The CSA was measured as the angle between the line connecting the upper and lower margins of the glenoid fossa and the line drawn from the lower margin of the glenoid to the most inferolateral border of the acromion (Fig. 1A). The LAA was measured as the angle between the line connecting the upper and lower margins of the glenoid fossa and the line extending to the inferior border of the acromion (Fig. 1B). 

**Fig. 1.** Lateral coverage of the acromion. (A) The critical shoulder angle was measured as the angle between the line connecting the upper and lower margins of the glenoid fossa and the line drawn from the lower margin of the glenoid to the most inferolateral point of the acromion. (B) The lateral acromial angle was measured as the angle between the line connecting the upper and lower margins of the glenoid fossa and the line extending to the inferior border of the acromion.

**AP Acromial Coverage**

Using the methods described by Li et al., the medial and lateral scapular borders were overlapped on 3D-CT, a perpendicular standard outlet view that was perpendicular to the glenoid plane was obtained, and the acromial tilt (AT), acromiohumeral interval (AHI), and AP coverage index (APCI) were measured. The AT was measured as the angle between the line connecting the posterosuperior and anteroinferior points of the acromion and the line connecting the posterosuperior point of the acromion and the coracoid inferior border (Fig. 2A). The AHI was measured as the shortest distance between the inferior border of the acromion and the highest part of the humeral head (Fig. 2B). Beeler et al. used the line connecting the superior and inferior rims of the glenoid surface as a scapular plane, a standard to measure the sagittal tilt of the acromion. Using this method, the AP tilt of the acromion based on the scapular plane could be measured; however, the AP coverage of the acromion on RCTs could not be measured. In this study, the line drawn from the glenoid center towards the superior rim of the glenoid surface was set as the standard in an attempt to evaluate the effect of the AP acromial coverage on the supraspinatus and infraspinatus. The APCI was calculated as the angle between the lines drawn from the glenoid center to the anterior and posterior ends of the acromion (overall glenoid coverage of Beeler et al.) divided by the angle formed by the line drawn from the center of the glenoid to the inferior border of the acromion and the line drawn to the posterior end of the acromion (Fig. 2C). The anterior and posterior glenoid coverage was measured using the method described by Beeler et al. (Fig. 3).

**Fig. 2.** Anteroposterior coverage of the acromion. (A) The acromial tilt was measured as the angle between the line connecting the posterosuperior and anteroinferior points of the acromion and the line connecting the posterosuperior point of the acromion and the coracoid inferior border. (B) The acromiohumeral interval was measured as the shortest distance between the inferior border of the acromion and the top of the humeral head. (C) The anteroposterior coverage index was calculated by dividing the angle between the line drawn from the center of the glenoid to the anterior and posterior ends of the acromion (overall glenoid coverage of Beeler et al.) by the angle formed by the line drawn from the center of the glenoid to the superior rim of the glenoid.
Statistical Analysis
The independent t-test and analysis of variance were used to analyze the differences in radiologic parameters. According to RCT size, one-way analysis of variance and post hoc analysis were used to analyze the differences in radiologic parameters. Any parameters showing significance in univariate analysis were then subjected to a multivariate analysis to identify independent predictive values for RCTs and tear size. The correlation between the APCI and anterior and posterior glenoid coverage was assessed via Pearson’s correlation test. Ordinal and multinomial logistic regression analysis was used to determine whether the APCI was a useful parameter to predict the RCT and tear size. All statistical analyses were performed using IBM SPSS ver. 21 (IBM Corp., Armonk, NY, USA). Statistical significance was set at an α level of 0.05 with 95% confidence intervals (CI). The interobserver reliability of the radiologic parameters was determined with intraclass correlation coefficients (ICCs). Post hoc power calculation (alpha error: 0.05, 1-beta error: 0.95) was performed using G*Power (version 3.1.9.7).

RESULTS
The demographic characteristics and radiologic parameters of the enrolled 356 patients are summarized in Table 1. There were no significant differences in the demographic characteristics of group A and B (Table 2). The ICCs of radiologic parameters between the independent observers was 0.911 (95% CI, 0.886–0.930; p < 0.001) for LAA, 0.902 (95% CI, 0.875–0.923; p < 0.001) for CSA, 0.782 (95% CI, 0.722–0.829; p < 0.001) for AT, 0.929 (95% CI, 0.910–0.945; p < 0.001) for APCI, 0.956 (95% CI, 0.943–0.965; p < 0.001) for AHI, 0.937 (95% CI, 0.916–0.952; p < 0.001) for anterior glenoid coverage, and 0.855 (95% CI, 0.807–0.891; p < 0.001) for posterior glenoid coverage, showing good to excellent concordance.
Acromial Morphology and RCTs

Lateral acromial coverage
The mean CSA was 34.5° ± 3.4° in group A, which was significantly higher than that in group B (30.8° ± 3.4°) (p < 0.001) (Table 2).

AP acromial coverage
The mean APCI was 0.83 ± 0.10 in group A, which was significantly higher than that in group B (0.75 ± 0.08) (p < 0.001). The authors performed a post hoc power analysis using the APCI, which demonstrated a statistically significant difference and was considered the most important value in this study. The effect size was 0.883, and at alpha = 0.05, the power of this study was calculated as 0.99. The mean AHI was 6.3 ± 2.0 mm in group A, which was significantly lower than that in group B (7.8 ± 1.8 mm) (p < 0.001). The anterior glenoid coverage was −3.4° ± 8.4° in group A, which was significantly higher than that in group B (−7.9° ± 6.3°) (p < 0.001). The posterior glenoid coverage was also statistically significantly large in group A compared with group B (p = 0.014) (Table 2).

Acromial Morphology and RCT Size

Lateral acromial coverage
The CSA was correlated with the size of RCTs in the entire RCT patient group (p < 0.001) and in each size group.

### Table 2. Patient Demographics and Radiologic Parameters of Subgroups

| Variable                     | Group A (n = 239) | Group B (n = 117) | p-value |
|------------------------------|------------------|------------------|---------|
| Age (yr)                     | 62.0 ± 8.4       | 61.6 ± 9.9       | 0.715   |
| Sex (men : women)            | 108 : 131        | 41 : 76          | 0.068   |
| Side (right : left)          | 176 : 63         | 84 : 33          | 0.712   |
| BMI (kg/m²)                  | 24.6 ± 2.3       | 24.2 ± 2.8       | 0.248   |
| Comorbidity                  |                  |                  |         |
| HTN                          | 77 (32.2)        | 33 (28.2)        | 0.442   |
| DM                           | 43 (18.0)        | 25 (21.4)        | 0.447   |
| Hyperlipidemia               | 20 (8.4)         | 7 (6.0)          | 0.425   |
| Smoking                      | 43 (18.0)        | 28 (23.9)        | 0.188   |
| Alcohol                      | 66 (27.6)        | 35 (29.9)        | 0.651   |
| Parameter                    |                  |                  |         |
| Lateral coverage             |                  |                  |         |
| LAA (°)                      | 75.0 ± 7.0       | 76.4 ± 7.0       | 0.089   |
| CSA (°)                      | 34.5 ± 3.4       | 30.8 ± 3.4       | <0.001* |
| Anteroposterior coverage     |                  |                  |         |
| AT (°)                       | 29.2 ± 5.3       | 29.5 ± 4.6       | 0.665   |
| APCI                         | 0.83 ± 0.10      | 0.75 ± 0.08      | <0.001* |
| AHI (mm)                     | 6.3 ± 2.0        | 7.8 ± 1.8        | <0.001* |
| Anterior glenoid coverage†   | −3.4 ± 8.4       | −7.9 ± 6.3       | <0.001* |
| Posterior glenoid coverage†  | 71.2 ± 8.4       | 68.9 ± 7.8       | 0.014*  |

Values are presented as mean ± standard deviation or number (%). Group A: patients diagnosed with rotator cuff tear, Group B: patients diagnosed with concentric osteoarthritis and calcific tendinitis without rotator cuff tear. BMI: body mass index, HTN: hypertension, DM: diabetes mellitus, LAA: lateral acromial angle, CSA: critical shoulder angle, AT: acromial tilt, APCI: anteroposterior coverage index, AHI: acromiohumeral interval.

*Statistically significant. †According to the classification by Beeler et al.5
AP acromial coverage
AT, APCI, AHI, and anterior glenoid coverage showed significant differences according to the RCT size (p = 0.003, p = 0.023, p < 0.001, and p = 0.016, respectively) (Table 3). The mean AT was 30.3° ± 4.7° in small-to-medium RCTs, which was significantly higher than that in massive RCTs (27.9° ± 6.5°) (p = 0.016). The AHI was negatively correlated with the size of RCTs in the entire RCT patient group and in each size group. APCI and posterior glenoid coverage were not correlated with the size of RCTs in each size group. Post hoc analysis of lateral and AP acromial coverage according to the RCT size is presented in Table 4. The AT, AHI, and anterior glenoid coverage showed a statistically significant correlation with the APCI (all p < 0.001) (Table 5).

Regression Analysis of Acromial Morphology for the RCT and Tear Size
The CSA (odds ratio [OR], 1.37; 95% CI, 1.24–1.51; p < 0.001), APCI (OR, 2.82; 95% CI, 1.96–4.07; p < 0.001), and AHI (OR, 0.84; 95% CI, 0.72–0.99; p = 0.043) as predictive values for the RCT were significantly correlated (Table 6). In the multinomial logistic analysis with reference to massive RCTs, the CSA was a parameter that significantly affected large RCTs (OR, 0.84; 95% CI, 0.73–0.98; p = 0.022) and AHI was a parameter that would affect the tear size in both small-to-medium RCTs (OR, 3.37; 95% CI, 2.42–4.69; p < 0.001) and large RCTs (OR, 1.72; 95% CI, 1.32–2.24; p

| Table 3. Patient Demographics and Mean Parameters According to the RCT Size |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Variable                        | Small-to-medium (n = 126) | Large (n = 63) | Massive (n = 50) | p-value         |
| Demographics                    |                 |                 |                 |                 |
| Age (yr)                        | 62.0 ± 8.5      | 61.2 ± 8.7      | 62.2 ± 7.7      | 0.679           |
| Sex (men: women)                | 60:66           | 26:37           | 22:28           | 0.688           |
| Side (right/left)               | 92:34           | 50:13           | 34:16           | 0.385           |
| BMI (kg/m²)                     | 24.6 ± 2.1      | 24.1 ± 2.0      | 25.0 ± 2.9      | 0.112           |
| Comorbidty                      |                 |                 |                 |                 |
| HTN                             | 45 (35.7)       | 19 (30.2)       | 13 (26.0)       | 0.425           |
| DM                              | 26 (20.6)       | 8 (12.7)        | 9 (18.0)        | 0.408           |
| Hyperlipidemia                  | 11 (8.7)        | 5 (7.9)         | 4 (8.0)         | 0.977           |
| Smoking                         | 28 (22.2)       | 10 (15.9)       | 5 (10.0)        | 0.143           |
| Alcohol                         | 39 (31.0)       | 13 (20.6)       | 14 (28.0)       | 0.326           |
| Parameter                       |                 |                 |                 |                 |
| Lateral coverage                |                 |                 |                 |                 |
| LAA (°)                         | 76.4 ± 7.5      | 73.3 ± 5.7      | 73.8 ± 6.7      | 0.006*          |
| CSA (°)                         | 33.8 ± 3.1      | 34.5 ± 3.5      | 36.3 ± 3.1      | <0.001*         |
| Anteroposterior coverage        |                 |                 |                 |                 |
| AT (°)                          | 30.3 ± 4.7      | 28.1 ± 5.1      | 27.9 ± 6.5      | 0.003*          |
| APCI                            | 0.81 ± 0.09     | 0.85 ± 0.10     | 0.84 ± 0.10     | 0.023*          |
| AHI (mm)                        | 7.4 ± 1.3       | 5.8 ± 1.8       | 4.2 ± 1.7       | <0.001*         |
| Anterior glenoid coverage† (°)  | −4.8 ± 7.3      | −1.3 ± 9.2      | −2.5 ± 9.3      | 0.016*          |
| Posterior glenoid coverage† (°) | 71.2 ± 7.7      | 70.6 ± 9.3      | 72.0 ± 8.8      | 0.672           |

Values are presented as mean ± standard deviation or number (%).
RCT: rotator cuff tear, BMI: body mass index, HTN: hypertension, DM: diabetes mellitus, LAA: lateral acromial angle, CSA: critical shoulder angle, AT: acromial tilt, APCI: anteroposterior coverage index, AHI: acromiohumeral interval.
*Statistically significant. According to the classification by Beeler et al.®
< 0.001) (Table 7). In the present study, because the logistic analysis was performed using massive size as a reference, the OR for AHI was greater than 1 for each small-to-medium and large RCT.

### DISCUSSION

This study is significant in that we analyzed whether the AP coverage of the acromion, in addition to the widely known large lateral coverage of the acromion, was a risk factor for RCTs. The CSA is the most widely measured parameter to assess the lateral coverage; in this study, we proposed using AHI and APCI as a novel method for measuring the AP coverage. Along with CSA, AHI and APCI significantly predicted the RCT in the present study, thus demonstrating that the AP coverage can also be a significant risk factor for RCTs.

Previous studies showed the close relationship between acromial morphology and RCTs. Moor et al. reported that the CSA was closely associated with RCTs, whereas several studies have revealed that the risk of RCTs increases with a larger CSA. Further, among vari-

### Table 4. Correlation between the Acromial Morphology and RCT Size

| Variable                  | Small-to-medium (n = 126) | Large (n = 63) | Massive (n = 50) |
|---------------------------|---------------------------|---------------|------------------|
| Lateral coverage          |                           |               |                  |
| LAA (°)                   | 76.4 ± 7.5                | 73.3 ± 5.7    | 73.8 ± 6.7       |
| p-value (vs. massive)     | 0.070                     | 0.918         | -                |
| CSA (°)                   | 33.8 ± 3.1                | 34.5 ± 3.5    | 36.3 ± 3.1       |
| p-value (vs. massive)     | < 0.001*                  | 0.012*        | -                |
| AP coverage               |                           |               |                  |
| AT (°)                    | 30.3 ± 4.7                | 28.1 ± 5.1    | 27.9 ± 6.5       |
| p-value (vs. massive)     | 0.016*                    | 0.974         | -                |
| APCI                      | 0.81 ± 0.09               | 0.85 ± 0.10   | 0.84 ± 0.10      |
| p-value (vs. massive)     | 0.141                     | 0.933         | -                |
| AHI (mm)                  | 7.4 ± 1.3                 | 5.8 ± 1.8     | 4.2 ± 1.7        |
| p-value (vs. massive)     | < 0.001*                  | < 0.001*      | -                |
| Anterior glenoid coverage†(°) | −4.8 ± 7.3              | −1.3 ± 9.2    | −2.5 ± 9.3       |
| p-value (vs. massive)     | 0.215                     | 0.722         | -                |
| Posterior glenoid coverage†(°) | 71.2 ± 7.7              | 70.6 ± 9.3    | 72.0 ± 8.8       |
| p-value (vs. massive)     | 0.815                     | 0.646         |                  |

Values are presented as mean ± standard deviation.
RCT: rotator cuff tear, LAA: lateral acromial angle, CSA: critical shoulder angle, AP: anteroposterior, AT: acromial tilt, APCI: anteroposterior coverage index, AHI: acromiohumeral interval.
*Statistically significant. †According to the classification by Beeler et al.

### Table 5. Pearson’s Correlation Coefficients between the APCI and Radiologic Parameters of Anteroposterior Coverage of the Acromion

| APCI          | AT         | AHI        | Anterior coverage† | Posterior coverage† |
|---------------|------------|------------|--------------------|---------------------|
| Pearson’s correlation coefficient | −0.437     | −0.251     | 0.626              | 0.103               |
| p-value       | < 0.001*   | < 0.001*   | < 0.001*           | 0.054               |

APCI: anteroposterior coverage index, AT: acromial tilt, AHI: acromiohumeral interval.
*Statistically significant. †According to the classification by Beeler et al.
ous RCT-related parameters, the CSA, in particular, was shown to be the most associated risk factor for RCTs. However, studies have rarely examined the relationship between RCTs and the AP coverage of the acromion. In their study analyzing the relationship between RCTs and the scapular shape using CT, Beeler et al. reported that RCTs were associated with the width, axial, and coronal tilt of the acromion, but not with the sagittal tilt. However, the aforementioned study only assessed the degree of AT with reference to the glenoid in the sagittal plane and did not necessarily analyze the AP coverage of the acromion. In the present study, we measured the APCI as a new method for assessing the AP coverage of the acromion. The results indicated that the risk of RCTs would increase with a larger CSA and a higher APCI. Concerning the lateral coverage of the acromion, our results align with the previous findings that the risk of RCTs increased with an increasing lateral coverage and with an increasing AP coverage.

Saupe et al. reported that the RCT was associated with lower AHI. In this study, the authors measured AHI using simple radiography (true AP, supraspinatus outlet view) and magnetic resonance arthrography (coronal and oblique sagittal views). However, the intermethod reliability was low. In the present study, we used 3D-CT to measure the AHI more accurately. A significant difference was observed between the RCT and non-RCT groups, and AHI was identified as an independent parameter affecting RCTs; these findings support previous reports.

In their cadaveric study, Sakoma et al. measured the anterior acromial projection angle by drawing a circle along the undersurface of the coracoacromial arch and calculating the angle between the vertical line from the center of the circle and the line drawn from the anterosuperior edge of the acromion. The authors reported that increased anterior acromial projection angles were associated with the occurrence or progression of RCTs. However, the RCT cadaver group in that study comprised seven cadavers and was therefore deficient in samples. Further, the angle was measured around the center of the circle without considering the glenoid morphology and hence did not reflect the changes in the anterior and posterior acromial coverage due to the glenoid sagittal tilt. In contrast, Beeler et al. reported in their study comparing RCTs and concentric OA that the two groups did not differ in the anterior coverage of glenoid. However, the RCT group had a wider posterior coverage. In the present study, the AP coverage was larger in the RCT group than in the non-RCT group; however, it was not an independent risk factor for RCTs.

Several previous studies have reported that the retear rate after arthroscopic RCR increases when the lateral extension of the acromion is large. Franceschetti et al. reported that clinical score and retear rate were significantly lower in patients who underwent lateral acromioplasty during arthroscopic RCR in RCT patients with > 35° CSA. Gerber et al. also reported that lateral acromioplasty combined with arthroscopic RCR reduced

| Table 6. Predictive Values of the Acromial Morphology for the RCT |
|---------------------|-----------------|------------------|
| Logistic regression | OR (95% CI)      | p-value          |
| CSA                 | 1.37 (1.24–1.52) | < 0.001*         |
| APCI                | 2.82 (1.96–4.07) | < 0.001*         |
| AHI                 | 0.84 (0.72–0.99) | 0.043*           |
| Anterior glenoid coverage | 1.06 (0.99–1.13) | 0.074           |
| Posterior glenoid coverage | 1.03 (0.99–1.08) | 0.196           |

| Table 7. Multinomial Regression Analysis of the Acromial Morphology for RCT Size |
|---------------------|-----------------|------------------|
| Multinomial logistic regression | OR (95% CI) | p-value          |
| Small-to-medium [ref. massive] | LAA | 0.99 (0.92–1.06) | 0.663 |
|                        | CSA | 0.89 (0.76–1.04) | 0.132 |
|                        | AHI | 1.10 (0.99–1.23) | 0.078 |
|                        | APCI | 1.17 (0.60–2.26)| 0.649 |
|                        | AHI | 3.37 (2.42–4.69) | < 0.001* |
| Anterior glenoid coverage | 1.017 (0.95–1.09)| 0.647 |

| Large [ref. massive] | LAA | 0.94 (0.87–1.00) | 0.057 |
|                      | CSA | 0.84 (0.73–0.98) | 0.022* |
|                      | AHI | 1.05 (0.95–1.11) | 0.366 |
|                      | APCI | 1.20 (0.63–2.27)| 0.577 |
|                      | AHI | 1.72 (1.32–2.24) | < 0.001* |
| Anterior glenoid coverage | 1.04 (0.97–1.12)| 0.246 |

RCT: rotator cuff tear, OR: odds ratio, CI: confidence interval, CSA: critical shoulder angle, APCI: anteroposterior coverage index, AHI: acromiohumeral interval. *Statistically significant. †According to the classification by Beeler et al.
CSA and that the retear rate increased when acromioplasty was insufficient. In this study, although cuff integrity was not evaluated after RCR, the AP coverage, as well as the lateral coverage, of the acromion had a significant effect on the occurrence of RCTs. Anterior acromioplasty was performed to simply remove the anteroinferior spur of the acromion, but based on the results of this study, it is thought that anterior acromioplasty should be performed during RCR to reduce the AP coverage of the acromion, as well as the bony spur.

CSA and AHI are two parameters related to RCT size. Previous studies have reported that the CSA was correlated with the increase in the RCT size. Saipe et al. reported that the RCT size was associated with lower AHI. However, a correlation with other parameters has not yet been reported. We hypothesized that the AP coverage of the acromion would also predict the RCT size; however, APCI was not significantly associated with the tear size. Similar to previous findings, CSA and AHI were independently associated with the tear size, and AHI, in particular, affected all tear size groups.

This study has several limitations. First, as this is a retrospective study, selection bias may be present. Second, as we defined the non-RCT group as patients with OA and calcific tendinitis, the results may not be generalizable to other populations. Further, we could not measure AI, a widely known parameter for lateral coverage, based on OA-related joint space narrowing or humeral head deformity. Third, 3D-CT diagnostic images of patients with RCTs are not used generally yet. Fourth, the effect of the AP coverage of the acromion on the anterior rotator cuff (subscapularis or biceps long head tendon) was not analyzed. Fifth, AHI is not a definite parameter that reflects the AP acromial coverage. However, since Kaur et al. reported that RCTs were associated with decreased AHI, we included AHI as one of the parameters to evaluate the AP coverage of acromion. Despite these limitations, the strengths of this study are that we proposed a new method for measuring the AP coverage of the acromion and that this new parameter may be used to measure the AP coverage of the acromion to predict the RCT.

Large CSA, high APCI, and low AHI were predictors of RCTs, with the APCI showing the strongest correlation. In addition to the large CSA, low AHI was also correlated with the size of RCTs and affected the entire size groups. We suggest that both the lateral coverage and AP coverage of the acromion should be considered essential factors for predicting RCTs and tear size.

CONFLICT OF INTEREST
No potential conflict of interest relevant to this article was reported.

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