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A comprehensive analysis of the acromial morphology and etiological factors of partial rotator cuff tears

Yukihiro Kajita, MD, PhD[a,*], Yohei Harada, MD, PhD[b], Ryosuke Takahashi, MD[a], Ryosuke Sagami, MD[a], Yusuke Iwahori, MD, PhD[c]

[a]Department of Orthopaedic Surgery, Ichinomiya Nishi Hospital, Ichinomiya, Japan
[b]Department of Orthopaedic Surgery, Hiroshima University, Higashihiroshima, Japan
[c]Department of Orthopaedic Surgery, Asahi Hospital, Chiba, Japan

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Background: Rotator cuff tears are divided into complete and partial tears, and partial rotator cuff tears include articular-sided tears and bursal-sided tears. Tears are caused by extrinsic, intrinsic, or traumatic factors; however, the mechanisms by which partial tears occur remain unknown. Recent reports have described the correlation between acromial morphology and rotator cuff tears. To date, no reports have investigated acromial morphology in partial tears. The purpose of this study is to evaluate the incidence of abnormal acromial morphology in both partial articular-sided and bursal-sided rotator cuff tears.

Methods: Patients with supraspinatus tendons that had articular-sided tears were categorized into Group A, and patients who had bursal-sided tears were categorized into Group B. Patients who underwent arthroscopic rotator cuff repair for rotator cuff tears were assessed based on their diagnosis of Group A or Group B according to arthroscopic findings. The following items were examined: age, sex, presence of diabetes mellitus, acromiohumeral distance (AHD), critical shoulder angle (CSA), lateral acromial angle (LAA), sagittal and coronal morphologies of the acromion, and traumatic shoulder tears.

Results: There were 39 patients in Group A and 95 patients in Group B. A significantly greater rate of presence of diabetes was found in the Group A. There were no significant differences in age, sex, or frequency of traumatic shoulder tears. The mean AHD, CSA, and LAA in Group A and Group B were as follows: AHD, 9.4 ± 1.5 and 9.3 ± 1.4 mm; CSA, 32.1 ± 4.6 and 35.3 ± 4.4 degrees; LAA, 82.2 ± 7.2 and 79.9 ± 7.0 degrees. There were no significant differences between the groups. Although the CSA was significantly greater in Group B, there was no significant difference in the AHD or LAA. There was no significant difference in sagittal acromial morphology; however, Group B had significantly more inferior osteophytes of the acromial center in the coronal plane.

Conclusion: Group B was found to have a significantly larger mean CSA compared to Group A. Group B occurred more often in patients with inferior osteophytes of the acromial center on the acromion, suggesting the involvement of extrinsic factors.

Rotator cuff tears frequently cause shoulder pain, functional impairment, and disability.[25] Rotator cuff tears are classified as either partial thickness or full thickness, depending on their depth.[6] As imaging modalities and arthroscopic techniques have advanced in recent years, the diagnostic rate of partial-thickness rotator cuff tears has also garnered increasing attention.[4,16] Research indicates that the prevalence of partial-thickness rotator cuff tears is approximately twice that of full-thickness tears.[29] Partial-thickness rotator cuff tears sometimes cause more significant pain and dysfunction than full-thickness rotator cuff tears. Ellman classified partial-thickness rotator cuff tears based on their location within the articular, bursal, and intratendinous regions.[5] Among these, bursal-sided and articular-sided tears are often indicated for arthroscopic rotator cuff repair (ARCR). Although the specific pathogenesis of partial-thickness rotator cuff tears is not completely understood, previous reports have suggested the involvement of intrinsic and extrinsic factors.[3,21,22] The most important intrinsic factors that cause rotator cuff tears are degenerative changes, hypovascularity, and microstructural collagen fiber

The Ethics Committee Review of Ichinomiya Nishi Hospital approved this study; Approval Number: 2024004.

*Corresponding author: Yukihiro Kajita, MD, PhD, Department of Orthopaedic Surgery, Ichinomiya Nishi Hospital, 1 Kaimei-hira, Ichinomiya, Aichi 494-0001, Japan.

E-mail address: yukiohirokajita@gmail.com (Y. Kajita).

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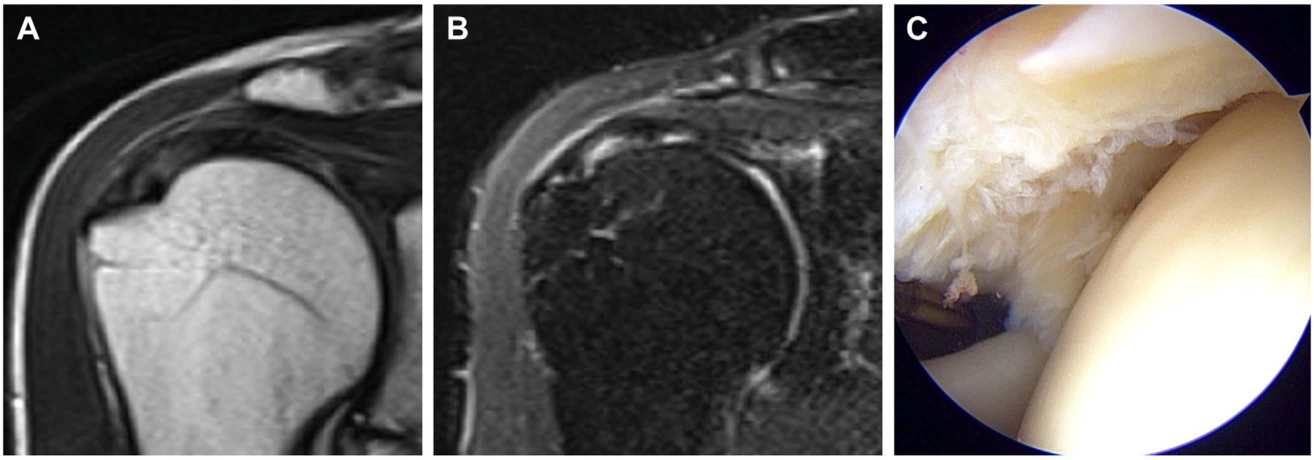

Figure 1 Articular-sided tears (Group A). (**A**) MRI T2WI, (**B**) T2 fat-suppressed MRI, and (**C**) arthroscopic findings. *MRI*, magnetic resonance imaging; *T2Wi*, T2 weighted image.

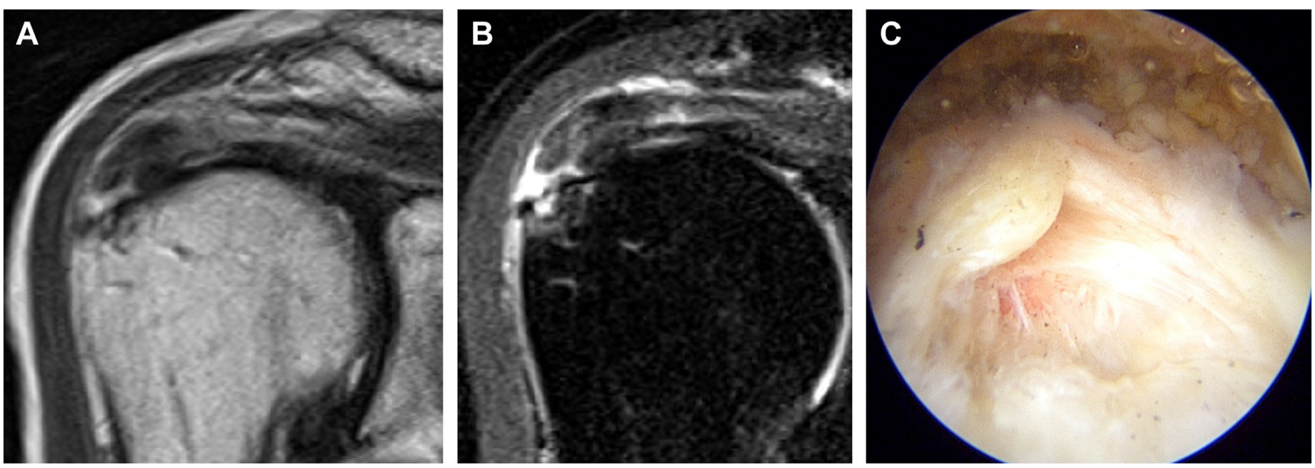

Figure 2 Bursal-side tears (Group B). (**A**) MRI T2WI, (**B**) T2 fat-suppressed MRI, and (**C**) arthroscopic findings. *MRI*, magnetic resonance imaging; *T2Wi*, T2 weighted image.

abnormalities.[3,21] Notable extrinsic factors may involve subacromial impingement with chronic repetitive use and tensile overload.[22] Therefore, the pathogenesis of articular-sided and bursal-sided partial-thickness rotator cuff tears differs.

Moor et al introduced the conceptual framework to define the critical shoulder angle (CSA).[18] The authors observed that a greater CSA was associated with rotator cuff tears. Banas et al described a low lateral acromion angle (LAA) that occurs in rotator cuff tears.[1] In a study of acromial morphology and rotator cuff tears using the Bigliani classification, repeated subacromial impingement reportedly increased the number of Type 3 hooked-type rotator cuff tears.[2,30] Although reports on the relationships among CSA, LAA, acromial morphology, and rotator cuff tears have been described with respect to complete tears, few reports have described their relationship in partial tears.

Partial tears of the rotator cuff can be divided into articular-sided and bursal-sided tears. The causes of articular-sided and bursal-sided tears are thought to differ. Previously reported clinical, biomechanical, epidemiologic, and biological data suggest that most tears become larger than smaller tears over time and often develop into complete tears.[13,17,31] Therefore, it is important to develop an understanding of the pathogenesis of partial-thickness rotator cuff tears.

However, to our knowledge, the morphological characteristics and mechanisms underlying the occurrence of this tear pattern remain unclear in the literature. We hypothesized that the associated acromial morphology would differ between articular-sided and bursal-sided partial-thickness rotator cuff tears.

Methods

Patient selection

We retrospectively reviewed a database of all ARCRs performed by a single surgeon between 2015 and 2022. A total of 543 patients who underwent ARCR were included. The inclusion criteria were as follows: the presence of rotator cuff tear, including the supraspinatus tendon; patients who underwent ARCR; patients with intraoperatively confirmed partial articular-sided or bursal-sided rotator cuff tears; and patients who underwent preoperative radiographic imaging and magnetic resonance imaging (MRI). The exclusion criteria were as follows: revision surgery; patients with a history of fractures of the scapula, humerus, or clavicle; and shoulder osteoarthritis. Patients were placed in the beach chair position, and surgeries were performed under general anesthesia with an additional interscalene nerve block. In all patients, articular-sided and bursal-sided tears were intraoperatively confirmed. Patients with a supraspinatus tendon that had articular-sided tears under arthroscopy were categorized into Group A (Fig. 1), and patients who had bursal-sided tears were categorized into Group B (Fig. 2).

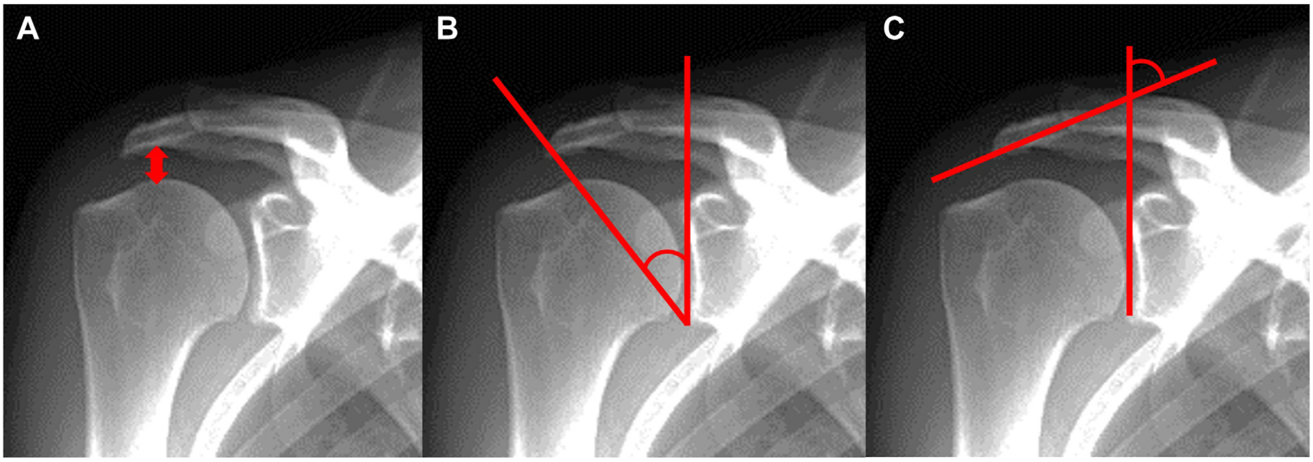

Figure 3 Standard anteroposterior radiographs of the AHD, CSA, and LAA. (**A**) The AHD is defined as the distance from the inferior surface of the acromion to the apex of the humeral head. (**B**) The CSA is defined as the angle between a line intersecting the superior and inferior edges of the glenoid fossa and another line intersecting the inferior edge of the glenoid with the most inferolateral edge of the acromion. (**C**) The LAA is defined as the intersection of 2 lines representing the glenoid cavity and the inferior surface of the acromion. *AHD*, acromiohumeral distance; *CSA*, critical shoulder angle; *LAA*, lateral acromial angle.

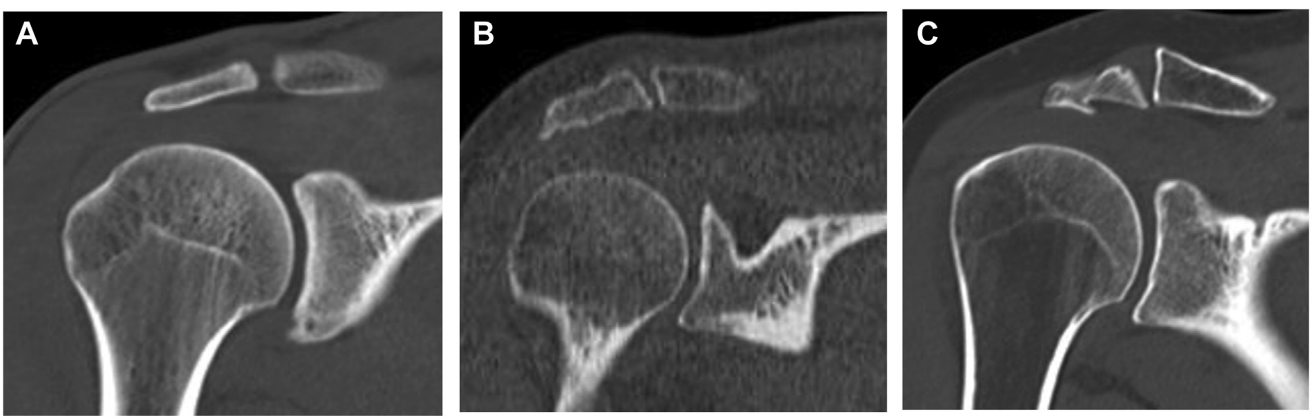

Figure 4 Acromial morphology. (**A**) Flat type, no osteophytes. (**B**) Beak type, lateral osteophytes. (**C**) Double-floor type, inferior osteophytes of the acromial center.

This study adhered to the Declaration of Helsinki and was approved by the ethics committee at our hospital. Informed consent was obtained from all patients for the research.

Evaluation criteria

Age, sex, presence of diabetes mellitus, acromiohumeral distance (AHD),[19] CSA,[18] lateral acromial angle (LAA),[1] sagittal and coronal morphologies of the acromion, and traumatic tears were evaluated and compared between Group A and Group B. Traumatic tears were defined as tears without shoulder pain prior to trauma and with onset of acute shoulder pain after trauma.

The AHD was previously defined by Ellman et al (Fig. 3, *A*). The CSA was defined as the angle between a line connecting the superior and inferior edges of the glenoid fossa and another line connecting the inferior edge of the glenoid with the most inferolateral edge of the acromion (Fig. 3, *B*). The LAA was defined as the intersection of 2 lines representing the glenoid cavity and the inferior surface of the acromion (Fig. 3, *C*). Standard anteroposterior radiographs were used to measure the AHD, CSA, and LAA.

The sagittal acromial morphology was classified according to a method described by Bigliani et al.[2] Assessments were made on scapular Y radiographs and classified as Type 1 (flat), Type 2 (curve), or Type 3 (hook) acromia. The coronal acromial morphology was classified by computed tomography or MRI using the following classification: flat type refers to the absence of osteophytes, beak type involves lateral osteophytes, and double-floor type features inferior osteophytes of the acromial center (Fig. 4).[11] These findings were evaluated by a single orthopedic surgeon who specialized in shoulder surgery.

Statistical analysis

SPSS software (ver. 18.0; SPSS Inc., Chicago, IL, USA) was employed for all statistical analyses. The *t*-test and Fisher's exact test were used for statistical analysis, with the level of statistical significance set to $P < .05$.

Results

A total of 33 patients in Group A and 39 patients in Group B were included in this study. The mean ages of Groups A and C were 60.1 ± 8.8 years (standard deviation [SD]) and 59.2 ± 8.6 (SD) years, respectively. There were 20 males and 19 females in Group A and 49 males and 46 females in Group B. The presence of diabetes mellitus was found in 14 patients (35.9%) in Group A and 14 patients (14.7%) in Group B. The mean duration of conservative treatment was 15.7 ± 16.0 months in Group A and 12.2 ± 15.2 months in Group B.

Table I
Patient demographics.

	Group A	Group B	*P* value
Number of patients	39	95	
Age (y)	60.1 ± 8.8	59.2 ± 8.6	.60
Sex (male/female)	20/19	49/46	.98
Diabetes [%]	14 [35.9%]	14 [14.7%]	.01
Duration of conservative treatment (mo)	15.7 ± 16.0	12.2 ± 15.2	.26
History of trauma [%]	10 [25.6%]	33 [34.7%]	.39

Table II
Results of CSA, LAA, and AHD.

	Group A	Group B	*P* value
CSA (°)	32.1 ± 4.6	35.3 ± 4.4	.004
LAA (°)	82.2 ± 7.2	79.9 ± 7.0	.27
AHD (mm)	9.4 ± 1.5	9.3 ± 1.4	.87

CSA, critical shoulder angle; *LAA*, lateral acromial angle; *AHD*, acromiohumeral distance.

Table III
Results of acromial morphology.

	Group A	Group B	*P* value
Acromial morphology of the sagittal plane (Bigliani classification)			
Type 1	16 (41.0%)	32 (33.7%)	.21
Type 2	21 (53.8%)	43 (45.3%)	
Type 3	2 (5.1%)	20 (21.1%)	
Acromial morphology of the coronal plane			
Flat type	23 (59.0%)	37 (38.9%)	.006
Beak type	11 (28.2%)	17 (17.9%)	
Double-floor type	5 (12.8%)	41 (43.2%)	

There were 10 patients (25.6%) with a history of trauma in Group A and 33 patients (34.7%) in Group B. A history of diabetes was significantly more common in Group A (Table I). The mean AHD, CSA, and LAA in Groups A and B were as follows: AHD, 9.4 ± 1.5 and 9.3 ± 1.4 mm (SD); CSA, 32.1 ± 4.6 and 35.3 ± 4.4 degrees (SD); and LAA, 82.2 ± 7.2 and 79.9 ± 7.0 degrees (SD). The CSA was significantly greater in Group B (Table II).

The sagittal acromial morphology was categorized according to the Bigliani classification. In Group A, there were 16 patients with Type 1, 21 with Type 2, and 2 with Type 3 disease. In Group B, there were 32 cases of Type 1, 43 of Type 2, and 20 of Type 3. There was no significant difference between the 2 groups ($P = .21$).

The coronal acromial morphology consisted of flat, beak, and double-floor types. In Group A, there were 23 patients with flat-type, 11 with beak-type, and 5 with double-floor–type acromia. In Group B, there were 37 flat-type, 17 beak-type, and 41 double-floor–type acromia. Significantly, more double-floor–type acromia were observed in Group B ($P = .006$) (Table III).

Discussion

Partial-thickness rotator cuff tears represent a prevalent type of shoulder disorder. Surgical intervention is typically advised for patients with partial-thickness rotator cuff tears who experience persistent pain or develop shoulder dysfunction. Articular-sided tears have been reported to be 2-3 times more common than bursal-sided tears.[6,16] Kim et al[15] reported that bursal-sided tears were more likely to result in retears than articular-sided tears, while other authors did not observe a difference in outcomes. A detailed assessment of various features is warranted to further understand the differences in pathogenesis between articular-sided and bursal-sided tears.

In this study, there were significantly more patients in Group B with double-floor osteophytes on the lower surface of the acromion. Several studies have investigated acromion spurs. A cadaveric study by Ozaki et al[23] reported that pathological and structural changes on the undersurface of the acromion were associated with bursal-sided tears, while those with articular-sided tears remained unaffected. Kim et al[14] reported a greater incidence of impingement on preoperative examination in patients with bursal-sided tears, often accompanied by protruding spurs on the undersurface of the acromion. In addition, the CSA in this study was significantly greater in Group B. A biomechanical study by Gerber et al[7] demonstrated that a high CSA may result in overloading of the supraspinatus tendon, especially during low degrees of active abduction. Double-floor–type osteophytes and high CSA on the inferior surface of the acromion have been suggested to be associated with bursal-sided tears.

In this study, there were significantly fewer patients with acromial spurs and significantly more patients with diabetes in Group A. Inui et al[10] compared preoperative plain radiographs and MRI of articular-sided and bursal-sided tears and reported that patients with articular-sided tears had a lower incidence of acromial spurs; however, a greater incidence of fibrosis was found in the rotator interval. Intrinsic factors often contribute to the development of articular-sided tears. These factors leading to degenerative tearing include age-related alterations, metabolic changes, and vascular changes. To clarify the causes of tears, Hashimoto et al[8] performed histochemical, histopathological, and morphometric studies on 80 stumps of torn rotator cuff tendons. A high prevalence and diffuse distribution of degenerative changes, including thinning and disorientation of collagen fibers, fatty infiltration, hyaline degeneration, and myxoid degeneration, were found in rotator cuff tendons. Moreover, Nho et al[20] reported decreased cellularity, fascicular thinning and disruption, granulation tissue accumulation, and dystrophic calcification. Shin et al[26] reported that because these changes occur on the articular side of the rotator cuff, intrinsic factors are often involved in articular-sided tears. Numerous reports have described diabetes as a risk factor for both rotator cuff tears and retears following rotator cuff repair.[9,24,32] However, to our knowledge, there have been no previous reports indicating that patients with articular-sided tears have a high incidence of diabetes.

Shinohara et al[27] compared the levels of advanced glycation end products in the shoulder capsule of patients with rotator cuff tears, both with and without diabetes. They reported that the diabetes mellitus group exhibited significant advanced glycation end product deposition in the shoulder capsule. In addition, Kim et al[12] compared the severity of synovitis in the glenohumeral joint and subacromial space in patients with rotator cuff tears using a synovitis score based on endoscopic findings and reported that synovitis of the glenohumeral joint was more common in patients with diabetes and was associated with rotator cuff tears. These reports suggest that diabetes and the occurrence of articular-sided tears are related, which support the results of this study.

There are several limitations to this study. First, the sample size of included patients was small relative to the initial population. Second, the study examined only patients who underwent surgery. Third, the study did not consider other factors that place stress on the shoulder, such as work or exercise. Fourth, previous studies have suggested that the CSA value varies according to patient positioning and angle of the scapula during radiography.[28] Finally, the severity of diabetes was not considered.

Conclusion

There was a statistically significant difference in CSA between the groups, with the larger CSA being found in the bursal-sided tear group. Partial-thickness bursal-sided rotator cuff tears occurred more often in patients with a large CSA and in patients with double-floor–like bone spurs on the acromion, suggesting the involvement of extrinsic factors.

Disclaimers:

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Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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