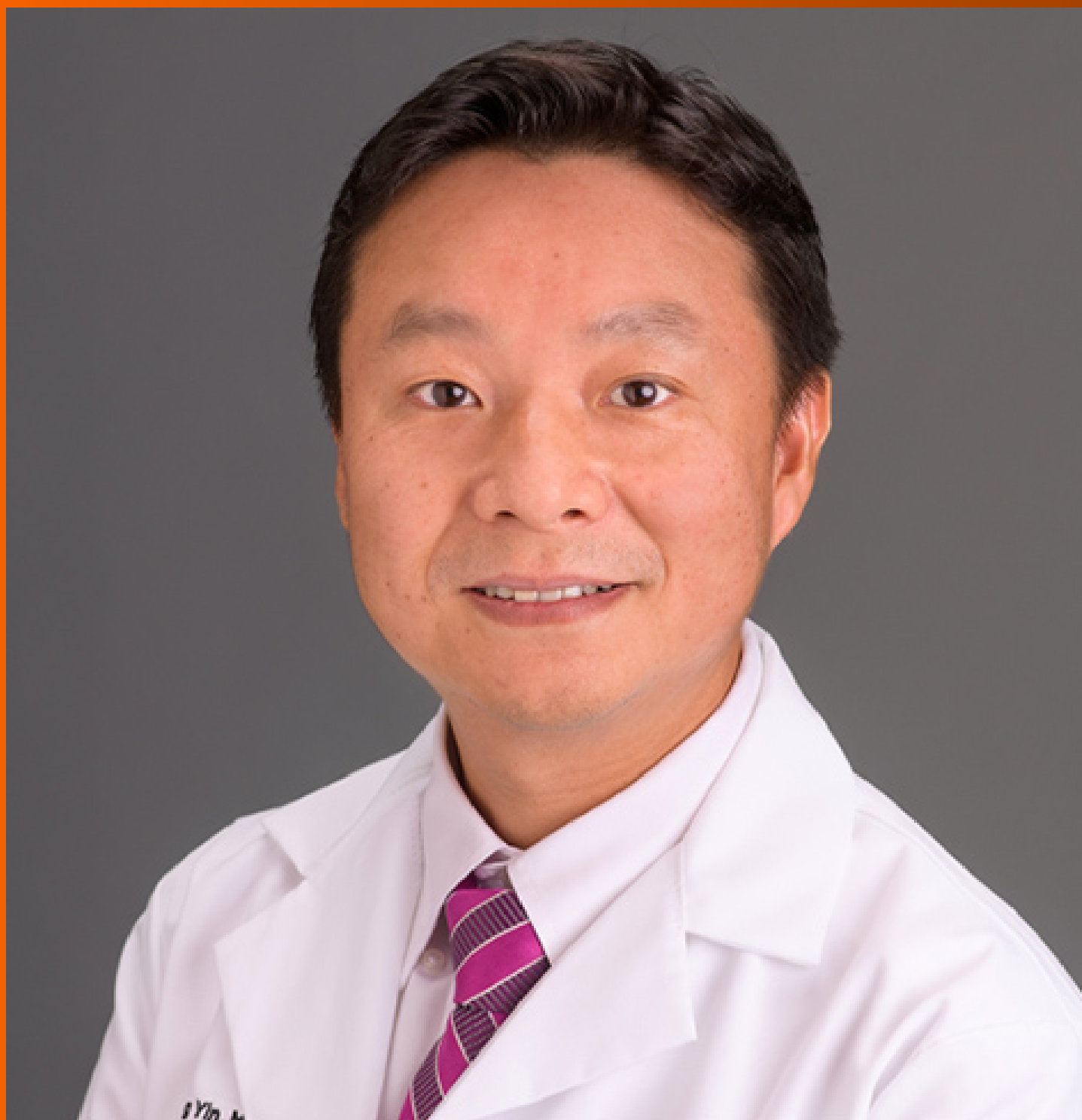


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ABOUT COVER

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Case Control Study

Usefulness of the acromioclavicular joint cross-sectional area as a diagnostic image parameter of acromioclavicular osteoarthritis

Young Joo, Jee Youn Moon, Jung Youn Han, Yun-Sic Bang, Keum Nae Kang, Young Su Lim, Young-Soon Choi, Young-Uk Kim

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Abstract

BACKGROUND

Acromioclavicular joint (ACJ) space narrowing has been considered to be an important diagnostic image parameter of ACJ osteoarthritis (ACJO). However, the morphology of the ACJ space is irregular because of osteophyte formation, subchondral irregularity, capsular distention, sclerosis, and erosion. Therefore, we created the ACJ cross-sectional area (ACJCSA) as a new diagnostic image parameter to assess the irregular morphologic changes of the ACJ.

AIM

To hypothesize that the ACJCSA is a new diagnostic image parameter for ACJO.

METHODS

ACJ samples were obtained from 35 patients with ACJO and 30 healthy individuals who underwent shoulder magnetic resonance (S-MR) imaging that revealed no evidence of ACJO. Oblique coronal, T2-weighted, fat-suppressed S-

MR images were acquired at the ACJ level from the two groups. We measured the ACJCSA and the ACJ space width (ACJSW) at the ACJ on the S-MR images using our imaging analysis program. The ACJCSA was measured as the cross-sectional area of the ACJ. The ACJSW was measured as the narrowest point between the acromion and the clavicle.

RESULTS

The average ACJCSA was $39.88 \pm 10.60 \text{ mm}^2$ in the normal group and $18.80 \pm 5.13 \text{ mm}^2$ in the ACJO group. The mean ACJSW was $3.51 \pm 0.58 \text{ mm}$ in the normal group and $2.02 \pm 0.48 \text{ mm}$ in the ACJO group. ACJO individuals had significantly lower ACJCSA and ACJSW than the healthy individuals. Receiver operating characteristic curve analyses demonstrated that the most suitable ACJCSA cutoff score was 26.14 mm^2 , with 91.4% sensitivity and 90.0% specificity.

CONCLUSION

The optimal ACJSW cutoff score was 2.37 mm, with 88.6% sensitivity and 96.7% specificity. Even though both the ACJCSA and ACJSW were significantly associated with ACJO, the ACJCSA was a more sensitive diagnostic image parameter.

Key Words: Acromioclavicular joint; Osteoarthritis; Cross-sectional area; Diagnosis

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Core Tip: An acromioclavicular joint (ACJ) space narrowing has been considered to be an important diagnostic image parameter of ACJ osteoarthritis. However, the morphology of ACJ space is irregular, because of osteophyte formation, subchondral irregularity, capsular distention, sclerosis, and erosions. Therefore, we created the ACJ cross-sectional area as a new diagnostic image parameter to assess the irregular morphologic change of ACJ.

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INTRODUCTION

Acromioclavicular joint osteoarthritis (ACJO) is frequently diagnosed in patients older than the fifth decade[1-4]. ACJO is the main cause of shoulder pain relating to the acromioclavicular joint (ACJ). Clinically, the relevance of ACJ abnormalities is tested by the body cross-test and palpation. The body cross-test is performed by elevating the affected arm on the same side. The physician adducts the arm across the body and takes the patient's elbow. Positive results on this test reproduce pain around the ACJ. Some pathologic and radiographic studies also have been performed to evaluate symptomatic ACJO. However, investigations using shoulder magnetic resonance (S-MR) scans have usually focused on disorders of the labrum and rotator cuff tears but rarely on the ACJ[1,2,5,6]. Only a few studies have been conducted to assess S-MR findings in symptomatic ACJO. However, the research findings varied. Shubin Stein *et al*[6] reported that bone edema at the distal clavicle or acromion was related to symptomatic ACJO whereas. In another study, S-MR findings were not related to symptomatic ACJO [7]. We think this discrepancy may be because the previous studies assessed ACJ space narrowing using only a single measurement called the ACJ space width (ACJSW) at the approximate halfway point of the ACJ[8]. However, partial narrowing and irregular osteophyte formation could occur anywhere. Thus, measurement mistakes can occur at any time. We think that it may be worthwhile to reconsider the morphological value of S-MR findings in the diagnosis of symptomatic ACJO.

Thus, to assess irregular narrowing of the ACJ, we devised the ACJ cross-sectional area (ACJCSA) as a new diagnostic image parameter. Contrast with the ACJSW, the ACJCSA does not influenced by measurement mistakes because the ACJCSA measures the entire irregular area of the ACJ. We hypothesized that the ACJCSA is an important diagnostic image parameter in ACJO diagnosis. Therefore, we used S-MR images to compare the ACJCSA and ACJSW between patients with ACJO and normal controls.

MATERIALS AND METHODS

Patients

This original study was approved by the Catholic Kwandong University (Incheon, South Korea) Institutional Research Board (CKUIRB). The retrospective data used to support the findings of this research may be released upon application to the CKUIRB. A total of 35 patients with radiologically confirmed ACJO from January 2015 to October 2019 were enrolled in the study. The inclusion criteria of the ACJO group were as follows: (1) A history of pain and tenderness in the front of the shoulder around the ACJ; (2) A positive cross-arm adduction test; or (3) A positive active compression test. We excluded subjects if they had the following disorders: (1) history of shoulder infection; (2) inflammatory arthritis; (3) acute clavicle fracture; (4) humerus bone fracture, or (5) any history of shoulder surgery.

There were 14 (40.0%) men and 21 (60.0%) women with an average age of 60.60 ± 9.31 years (range, 45 to 80 years) in the study (Table 1). We enrolled normal individuals to compare to the ACJO patients. The normal group was people who voluntarily wanted to undergo S-MR imaging for an exact diagnosis of shoulder pain but no evidence of ACJO. In the normal group, 30 subjects (9 males and 21 females) were enrolled with an average age of 57.30 ± 7.56 years (range, 40 to 69 years).

Imaging parameters

S-MR analysis was performed using a 3T magnetic resonance imaging Magnetom system (Siemens Medical care, Skyra, Germany) and 3T scanners (Philips, Healthcare, Angina, Netherlands). For all S-MR images, we acquired oblique coronal T2-weighted fat-suppressed turbo spin-echo imaging with a layer thickness of 3 mm, an intersection gap of 0.9 mm, a repetition time of 4010 ms, an echo time of 76 ms, a 512×256 matrix, a $150 \text{ cm} \times 150 \text{ cm}$ field of view, and > 3 echo train length.

Image analysis

The ACJCSA and ACJSW data were acquired by the corresponding author who was blinded to the group of shoulder images. We obtained oblique coronal T2-weighted S-MR images at the narrowest visualization of the ACJ. We examined the ACJCSA and ACJSW on S-MR images using an image analysis program (INFINITT PACS; Incheon, South Korea) (Figures 1 and 2). We measured the ACJSW at the narrowest ACJ using the PACS system. The ACJCSA was examined as the cross-sectional whole area of the ACJ at the same point of the ACJSW.

Statistical analysis

We compared the ACJCSA and ACJSW between the ACJO and the normal group using unpaired *t*-tests. The predictive value of the ACJCSA and ACJSW in the diagnosis of ACJO was estimated by receiver operating characteristic (ROC) analysis. The area under the curve (AUC), sensitivity, and specificity were calculated. Statistical Package for Social Sciences (SPSS) version 22.0 software (SPSS Inc., Chicago, IL, USA) was used. *P* values of < 0.05 were considered statistically significant. All values are presented as the mean and standard deviation.

RESULTS

The mean ACJCSA was $39.88 \pm 10.60 \text{ mm}^2$ in the normal group and $18.80 \pm 5.13 \text{ mm}^2$ in the ACJO group. The mean ACJSW was $3.51 \pm 0.58 \text{ mm}$ in the normal group and $2.02 \pm 0.48 \text{ mm}$ in the ACJO group. The ACJO patients had significantly lower ACJCSA and ACJSW than the normal individuals (Table 1). The ROC analysis demonstrated that the most suitable ACJCSA cutoff value was 26.14 mm^2 , with an AUC of 0.98 (95%CI: 0.94-1.00), 91.4% sensitivity, and 90.0% specificity (Table 2 and Figure 3). The best ACJSW cutoff score was 2.37 mm, with an AUC of 0.97 (95%CI: 0.92-1.00), 88.6% sensitivity, and 96.7% specificity (Table 3 and Figure 3).

DISCUSSION

ACJO is a disabling and painful disorder in association with the more common diagnosis of shoulder impingement syndrome[1,7,9,10]. Inferiorly protruding osteophytes as well as soft tissue hypertrophy of the ACJ accelerates narrowing of the supraspinatus outlet[11-13]. Narrowing of the outlet space, whose borders are formed by the coracoacromial ligament, coracoid process, anterior aspect of the acromion, and ACJ, has been reported as the primary cause for the development of rotator cuff tears and subsequent impingement syndrome[14-24]. Thus, positive associations regarding the incidence of rotator cuff tears and the severity of ACJ degeneration have been demonstrated. Clinically, the possibility of ACJ abnormalities is examined using the body cross-test and palpation[4,9,25]. The body cross-test is performed by elevating the affected arm on the same side. The physician adducts the arm across the body and takes the patient's elbow. Positive results on this test reproduce pain around the

Table 1 Comparison of the demographic data of the control and acromioclavicular joint osteoarthritis groups

Variable	Control group, <i>n</i> = 30	ACJO group, <i>n</i> = 35	Statistical significance
Gender (male/female)	9/21	14/21	NS
Age (yr)	57.30 ± 7.56	60.60 ± 9.31	NS
ACJSW (mm)	3.51 ± 0.58	2.02 ± 0.48	<i>P</i> < 0.001
ACJCSA (mm ²)	39.88 ± 10.60	18.80 ± 5.13	<i>P</i> < 0.001
Location (Rt/Lt)	13/17	22/13	NS

ACJO: Acromioclavicular joint osteoarthritis; ACJSW: Acromioclavicular joint space width; ACJCSA: Acromioclavicular joint cross-sectional area; NS: Not statistically significant (*P* > 0.05).

Table 2 Sensitivity and specificity of each acromioclavicular joint cross-sectional area cutoff point

ACJCSA (mm ²)	Sensitivity (%)	Specificity (%)
9.75	2.9	100
15.55	22.9	100
18.43	60.0	100
26.14 ^a	91.4	90.0
29.32	94.3	76.7
40.08	100	46.7

^aThe most suitable cutoff point in the receiver operating characteristic curve. ACJCSA: Acromioclavicular joint cross-sectional area.

Table 3 Sensitivity and specificity of each acromioclavicular joint space width cutoff point

ACJSW (mm)	Sensitivity (%)	Specificity (%)
1.41	8.6	100
1.86	34.3	100
2.04	54.3	100
2.37 ^a	88.6	96.7
3.32	97.1	60.0
3.68	100	33.3

^aThe most suitable cutoff value in the receiver operating characteristic curve. ACJSW, acromioclavicular joint space width.

ACJ[2]. S-MR imaging and plain X-rays have been used to assess the severity and presence of ACJO[6]. Although plain shoulder X-rays are the first-choice imaging modality for the diagnosis of ACJ pathology, an exact diagnosis is impossible. The severity of ACJO has frequently been judged differently, with S-MR imaging compared to conventional radiography[1,11,12,26]. In S-MR imaging, the excellent soft tissue contrast and the associated benefits of multiplanar acquisition have optimized the assessment of ACJO. Subchondral bone marrow edema, osteophytes, sclerosis, subchondral cysts, and soft-tissue abnormalities (joint effusion and capsular hypertrophy) and may also be seen on S-MR images[1]. However, only a few studies have been performed to assess the predictability of S-MR findings in diagnosing symptomatic ACJO. Moreover, the previous conclusions of these studies varied. Gordon *et al*[8] insisted that ACJO may mimic the clinical symptoms of rotator cuff disorder. Several S-MR features are common to distal clavicle osteolysis, os acromiale. Shubin Stein *et al*[6] reported that bone edema at the distal clavicle or acromion was related to symptomatic ACJO. Hawkins *et al*[7] insisted that any S-MR findings were not related to symptomatic ACJO. Moreover, previous studies only investigated ACJ space narrowing using a single measurement called the ACJSW at the approximate halfway point of the ACJ. However, partial narrowing and irregular osteophyte formation can occur at any time. Thus, measurement mistakes could occur at any time.

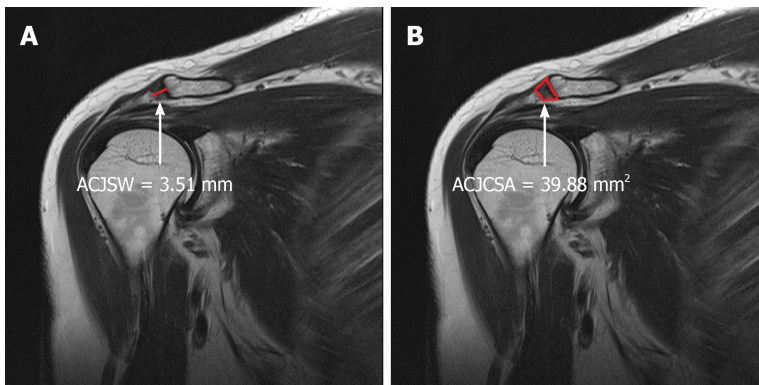


Figure 1 Measurement of both the acromioclavicular joint space width (A) and acromioclavicular joint cross-sectional area (B) in the normal control group was carried out on coronal T2-weighted shoulder-MR acromioclavicular joint images.

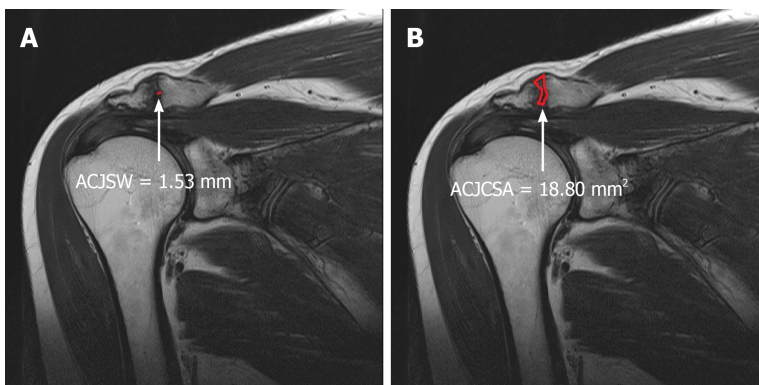


Figure 2 In the acromioclavicular joint osteoarthritis group, both the acromioclavicular joint space width (A) and acromioclavicular joint cross-sectional area (B) were measured on coronal T2-weighted shoulder-MR images.

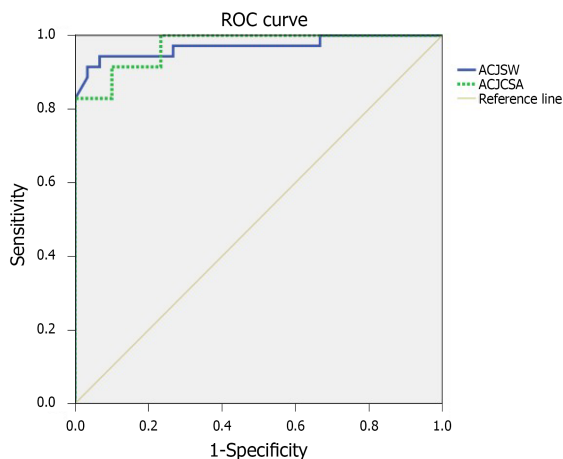


Figure 3 Receiver operating characteristic curve of both the acromioclavicular joint cross-sectional area and the acromioclavicular joint space width to detect acromioclavicular joint osteoarthritis. The most suitable acromioclavicular joint cross-sectional area cutoff point was 26.14 mm² vs 2.37 mm for the acromioclavicular joint space width, with 91.4% sensitivity vs 88.6%, and 90.0% specificity vs 96.7%, respectively.

We think it can be worthwhile to reconsider the morphological value of S-MR findings in the diagnosis of symptomatic ACJO. Thus, to evaluate the irregular narrowing of the ACJ, we devised the ACJCSA as a new morphological parameter. Compared to the ACJSW, the ACJCSA does not influenced by these measurement biases because the ACJCSA measures the entire cross-sectional area of the ACJ. Eventually, we concluded that the ACJCSA was better than the ACJSW as a diagnostic image parameter of ACJO. In this research, we demonstrated that the ACJCSA had 91.4% sensitivity, and an AUC of 0.98 to evaluate ACJO. The ACJSW had 88.6% sensitivity, and an AUC of 0.97. Our results suggest that the

ACJCSA was a better morphological parameter of ACJO than the ACJSW. We hope our results will help to improve the quality of ACJO diagnosis.

The current research had several limitations. There are several isolated ACJ pathologies in symptomatic shoulders such as distal clavicle osteolysis, acromiale syndrome, and ACJO. However, we only focused on ACJO because the ACJ is the most commonly damaged area. Second, some different methods to assess ACJO, such as subchondral bone marrow edema, osteophytes, subchondral cysts, sclerosis, and soft-tissue abnormalities, have been reported to be effective in discriminating ACJO. However, in this research, we only analyzed the ACJCSA and ACJSW measurements on S-MR images. Third, we enrolled a relatively small sample. Fifth, this study was retrospective in nature.

CONCLUSION

We demonstrated the optimal ACJCSA cutoff value as 26.14 mm², with 91.4% sensitivity and 90.0% specificity. The best ACJSW cutoff value was 2.37 mm, with 88.6% sensitivity and 96.7% specificity. When evaluating patients with ACJO, physicians should carefully assess the ACJCSA rather than the ACJSW.

ARTICLE HIGHLIGHTS

Research background

Acromioclavicular joint (ACJ) space narrowing has been considered to be an important diagnostic image parameter of ACJ osteoarthritis (ACJO).

Research motivation

The morphology of the ACJ space is irregular because of osteophyte formation, subchondral irregularity, capsular distention, sclerosis, and erosion. Therefore, we created the ACJ cross-sectional area (ACJCSA) as a new diagnostic image parameter to assess the irregular morphologic changes of the ACJ.

Research objectives

To hypothesize that the ACJCSA is a new diagnostic image parameter for ACJO.

Research methods

ACJ samples were obtained from 35 patients with ACJO and 30 healthy individuals who underwent shoulder magnetic resonance (S-MR) imaging that revealed no evidence of ACJO. Oblique coronal, T2-weighted, fat-suppressed S-MR images were acquired at the ACJ level from the two groups. We measured the ACJCSA and ACJ space width (ACJSW) at the ACJ on S-MR images using our imaging analysis program. The ACJCSA was measured as the cross-sectional area of the ACJ. The ACJSW was measured as the narrowest point between the acromion and the clavicle.

Research results

The average ACJCSA was 39.88 ± 10.60 mm² in the normal group and 18.80 ± 5.13 mm² in the ACJO group. The mean ACJSW was 3.51 ± 0.58 mm in the normal group and 2.02 ± 0.48 mm in the ACJO group. ACJO individuals had significantly lower ACJCSA and ACJSW than the healthy individuals. Receiver operating characteristic curve analysis demonstrated that the most suitable ACJCSA cutoff score was 26.14 mm², with 91.4% sensitivity and 90.0% specificity.

Research conclusions

The optimal ACJSW cutoff score was 2.37 mm, with 88.6% sensitivity and 96.7% specificity. Even though both the ACJCSA and ACJSW were significantly associated with ACJO, the ACJCSA was a more sensitive diagnostic image parameter.

Research perspectives

We enrolled a relatively small sample.

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FOOTNOTES

Author contributions: Kim Y and Joo Y designed the experiment; Moon JY, Han JY, Bang Y, Choi Y, and Lim YS collected the data; Kim Y, Joo Y, and Kang KN analyzed and interpreted data; Kim Y and Joo Y wrote the article.

Institutional review board statement: This retrospective study was approved by the Ethics Committee of The Catholic Kwandong Medical School, No. IS21RIS10048.

Informed consent statement: Patients were not required to give informed consent to this study because the retrospective analysis used anonymous data that were obtained after each patient agreed to treatment by written consent.

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