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The Relationship Between the Morphology of the Shoulder Joint and Supraspinatus Tendinosis: An MRI Study

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Abstract

Objective: To examine the relationship between the morphological parameters of the shoulder joint and supraspinatus tendinosis.

Methods: A patient group (n=44) was formed from patients diagnosed with supraspinatus tendinosis from medical records and magnetic resonance imaging (MRI) findings. A control group (n=44) was formed by randomly selecting people of similar age and gender to the patient group, who met the exclusion criteria for the patient group, and had normal rotator cuffs on MRI. Coracoacromial ligament thickness (CLT), acromial angle [(AA), delta angle], acromioglenoid angle (AGA), supraspinatus fossa (SFA) glenoid angle on the axial (SGAX) views, SFA glenoid angle on the anterior-posterior (SGAP) views, acromiohumeral distance (AHD), and coracoacromial arch angle (CAA) were measured on MRI images in both groups. Morphological differences between groups were compared using Student's t-test.

Results: Patient group had statistically significant higher CLT and lower AHD values (0.73±0.33 mm and 6.55±0.97 mm, respectively; p=0.007) than control group (1.02±0.53 mm and 7.45±1.61 mm, respectively; p=0.006). Also, there were statistically significant differences between the groups in terms of acromial angle (3.09±5.04° for patient group and 7.9±8.1° for control group; p=0.006). However, there were no statistically significant differences between the groups for AGA, SGAX, SGAP, and CAA (p>0.05).

Conclusion: These findings suggest that CLT, AA, and AHD are important predisposing anatomical factors for developing supraspinatus tendinosis.

Keywords: Supraspinatus tendinosis, magnetic resonance imaging, rotator cuff, coracoacromial ligament thickness, acromial angle

INTRODUCTION

Injuries of the rotator cuff tendon are the most prevalent cause of shoulderache and affect repetitive movements related to work and daily living. Rotator cuff pathologies result from genetic and anatomical risk factors (1). Tendinopathy is a large group of diseases that affect tendons and surrounding structures; it was revealed that rotator cuff lesions are a process that starts with inflammation and progresses to the tear, and the first pathological change is tendinosis (2,3). This change is mostly observed in the supraspinatus tendon. Because of the role of the initiation of abduction of the supraspinatus muscle, supraspinatus tendinosis can cause an important loss of function (4).

It is extremely important to reveal the anatomical factors that predispose patients to supraspinatus tendinosis to better understand this common pathology, which can cause serious deterioration in quality of life. For this reason, there has recently been an increase in the number of studies examining the differences in shoulder morphology in the literature. However, these studies mainly investigated the relationship between shoulder morphology and rotator cuff tears (5-8). To the best of our knowledge, no study has investigated the relationship between shoulder morphology and supraspinatus tendinosis.

This study examined the relationship between supraspinatus tendinosis and morphological parameters of the shoulder.

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METHODS

This case-controlled study was designed as randomized and conducted in a university hospital between 2020 and 2021. Shoulder magnetic resonance imaging (MRI) images of adult patients aged 18-65 years who presented with decreased shoulder function such as painful shoulder movements, weakness, restlessness, and stiffness and who were referred to our clinic with the preliminary diagnosis of supraspinatus tendinosis due to the presence of weakness in external rotators, weakness in supraspinatus, and impingement findings in clinical evaluation were retrospectively analyzed.

The patient group was formed from cases with tendinosis [increased intensity in the short time echo (TE) sequence, which is not as bright as the fluid signal in T2-weighted image (WI)] in the supraspinatus tendon on shoulder MRI.

To distinguish tendinosis from the magic angle phenomenon, the persistence of the signal change in the long TE sequence was used to distinguish tendinosis from the magic angle (55°) phenomenon that can be observed in the normal tendon. Patients with a history of trauma or shoulder surgery, inflammatory arthritis, mass lesions, pathology in the tendons forming the rotator cuff other than the supraspinatus tendon, adhesive capsulitis, and a tear or calcific tendinitis in the supraspinatus tendon were excluded from the study.

A control group was formed by randomly selecting people of similar age and gender to the patient group who met the exclusion criteria for the patient group and had normal rotator cuffs on MRI.

Radiologic Evaluation

All MRI studies of the shoulder were performed on a 1.5 Tesla Signa HD, GE Medical Systems (Milwaukee, USA) using an 8-channel dedicated shoulder coil.

The patients were placed in the supine position with the arm in external rotation. In accordance with the study of Madden, the arm was in the external rotation position throughout the acquisition to reduce the frequency of the magic angle (55°) effect due to the orientation of the supraspinatus tendon to the magnetic field (9). Proton density (PD), T1WI, T2WI, and fat-suppressed spin echo (SE) images were obtained in the axial, oblique coronal, and oblique sagittal imaging planes. To avoid misinterpretations due to magic angle artifacts, abnormal signal intensity in PD images was compared with T2WI. The magic angle effect was distinguished from tendinopathy because it had a weaker signal in the long TE sequence than in the short TE sequence (9).

All measurements were performed electronically using digital images. Each measurement was repeated twice and averaged to minimize random errors. The pathological changes and measurements detected in shoulder MRI were reached because of the joint decision of two radiologists experienced in musculoskeletal radiology.

Measured Parameters

Coracoacromial ligament thickness (CLT): CLT was measured at the insertion site of the coracoacromial ligament in the lateral part of the acromion (Figure 1) (10).

Acromial angle (AA) (delta angle): It is the angle between the line parallel to the lower surface of the acromion (a) and the ground plane (b) (Figure 2) (10).

Acromioglenoid angle (AGA): The angle between the lower surface of the acromion (a) and the line parallel to the glenoid bone structure (b) (Figure 3) (11).

Supraspinatus fossa glenoid angle on the axial views (SGAX): This angle was measured on axial MRIs taken immediately beneath the supraspinatus muscle as the angle between the glenoid cavity and the axis of the supraspinatus fossa (SFA) (Figure 4) (12).

Glenoid Version (GV): GV is calculated by subtracting 90° from α angle (GV=α-90°) (13).

Supraspinatus fossa glenoid angle on the anterior-posterior views (SGAP): The SGAP was measured as the angle between the bed of the supraspinatus muscle (supraspinatus fossa) and the bony outline of the glenoid cavity on the oblique coronal MR

Figure 1. Coracoacromial ligament thickness (CLT)

image (true anteroposterior view) taken immediately posterior to the acromioclavicular joint (Figure 5) (12).

Acromiohumeral distance: This is the shortest distance between the acromion and humerus (Figure 6) (14).

Coracoacromial arch angle (CAA): The angle between the coracocromial ligament axis (which extends from the coracoid process to acromion) (a) and the line tangential to the inferior surface of the acromion (acromial axis) (b) (Figure 7) (15).

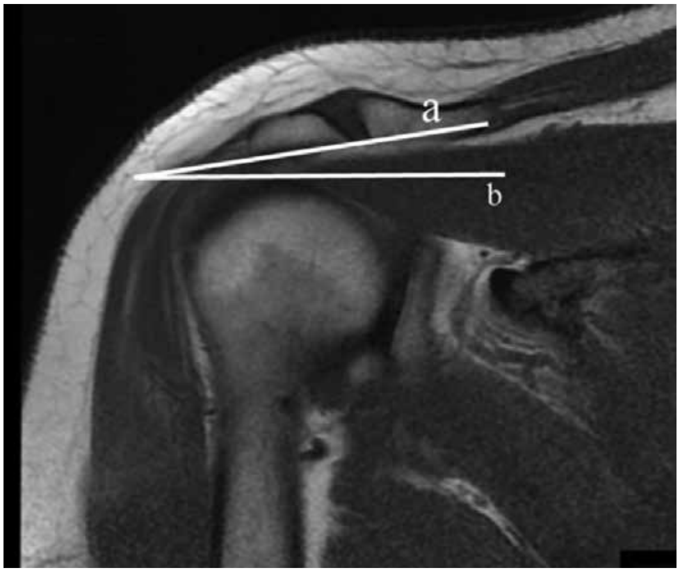

Figure 2. Acromial angle (delta angle)

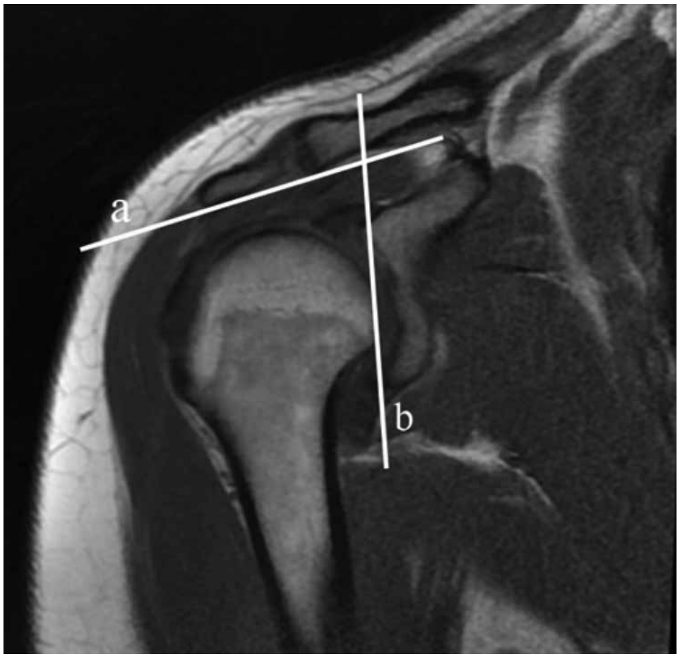

Figure 3. Acromioglenoid angle (AGA)

Ethical Principles

The Alanya Alaaddin Keykubat University Ethics Committee approved the study protocol (date/issue: 07.07.2021,10354421-2021/12-06). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Analysis

Statistical program SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.)

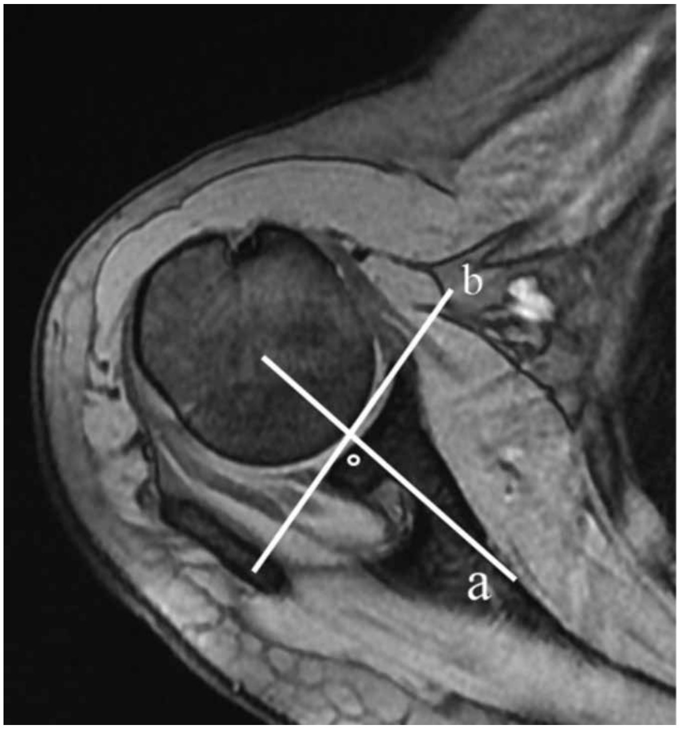

Figure 4. Supraspinatus fossa glenoid angle on axial views (SGAX)

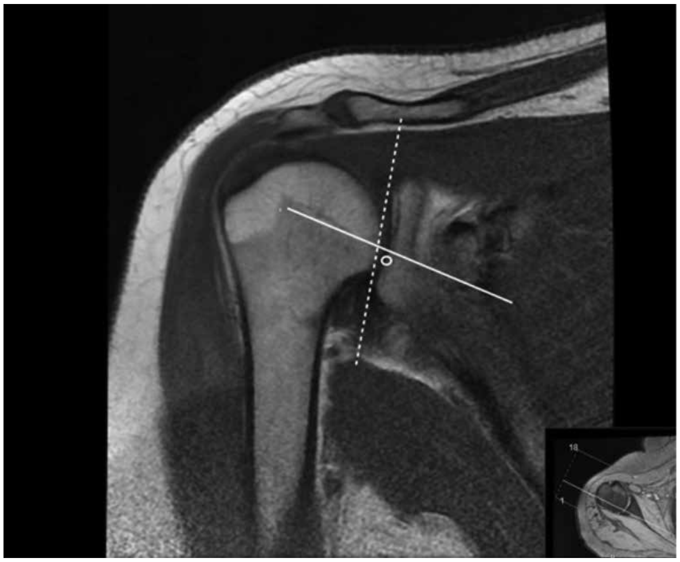

Figure 5. Supraspinatus fossa glenoid angle on anterior-posterior views (SGAP)

was used to analyze the data. The Kolmogorov-Smirnov test was performed for normality analysis. Means and standard deviations are given as descriptive statistics. Student 's t-test to compare differences between both groups was used. P<0.05 was considered significant.

Power and Sample Size Software (PASS; NCSS, Utah, USA) was used to calculate the sample size.

Figure 6. Acromiohumeral distance

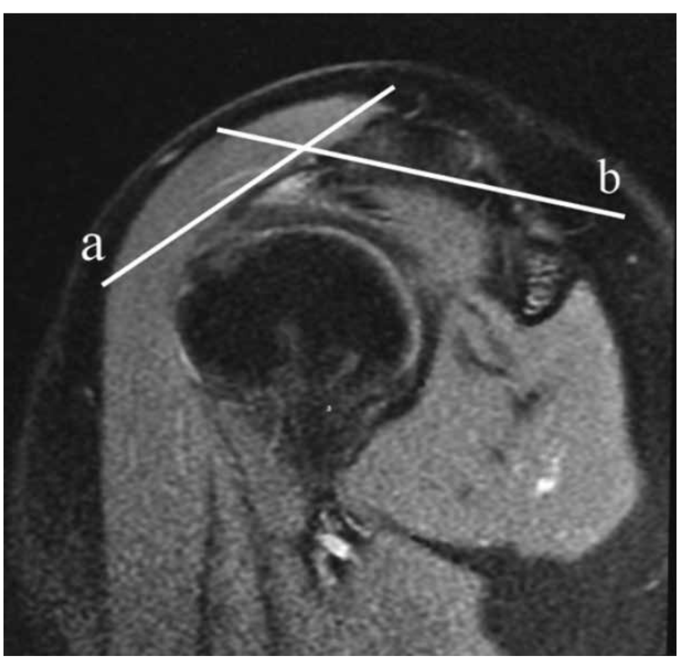

Figure 7. Coracoacromial arch angle (CAA)

With reference to the study of Longo et al., the power of the study was 80%; When the type-1 error was accepted as 0.05 and the effect size was 0.5, it was seen that 88 patients should be included (16).

RESULTS

Eighty-eight subjects were included in the study. There were 25 females (mean age 52.16±6.039) and 19 males (mean age 48.64±4.829) in the patient group and 29 females (mean age 52.18±8.015) and 15 males (mean age 50.34±8.453) in the control group (Table 1). There was no statistically significant difference between the groups in terms of age and gender (p=0.057 and 0.384 respectively).

The patient group had statistically significantly higher CLT values (0.73±0.33 mm) than the control group (1.02±0.53 mm) (p=0.007). The patient group had statistically significantly lower AA values (3.09±5.04°) than the control group (7.87±8.07°) (p=0.006) (Table 2).

The mean AGA values were measured as 80.51±6.38° for the patient group and 82.27±7.75° for the control group (p=0.243). The mean SGAX values were measured as 85.40±4.28° for the Patient Group and 82.27±7.75° for the control group (p=0.655). The mean GV values were measured as -4.593±4.287° for the patient group and -5.472±9.096° for the control group (p=0.655). The mean SGAP values were measured as 79.62±4.44° for the Patient Group and 77.72±5.87° for the control group (p=0.317). There were no statistically significant differences between the groups for AGA, SGAX, and SGAP values (p>0.005) (Table 2).

The patient group had statistically significantly lower AHD values (6.55±0.97 mm) than the control group (7.45±1.61 mm) (p=0.027) (Table 2).

The mean CAA values were measured as 124.12±10.80° for the patient group and 149.00±12.66° for the control group (p=0.667). There were no statistically significant differences between the groups for CAA between the groups (p>0.05) (Table 2).

DISCUSSION

This study is the first to examine the relationship between shoulder joint morphology and supraspinatus tendinosis, and we believe that our study is extremely important in terms of revealing a close relationship between shoulder morphology and the presence of supraspinatus tendinosis. Some studies have been conducted on changes in shoulder morphology related to age and gender. Syed et al. (17) reported significant differences in humeral diameter, humeral head size, greater tuberosity

Table 1. Demographic characteristics of the patient and control groups

Variables	Patient group (n=44)	Control group (n=44)	p
Age (mean ± SD)	50.16±5.603	53.30±9.00	**0.111**
Sex (female/male)	25/19	29/15	**0.384**

SD: Standard deviation

Table 2. Comparison of morphological parameters of patient and control groups

Variables	Patient group (n=44) mean ± SD	Control group (n=44) mean ± SD	p
Coracoacromial ligament thickness (CLT)	0.725±0.332 mm	1.02±0.53 mm	**0.007***
Acromial angle (delta angle) (AA)	3.097±5.042°	7.87±8.07°	**0.006***
Acromioglenoid angle (AGA)	80.51±6.38°	82.27±7.75°	**0.243**
Supraspinatus fossa glenoid angle on axial views (SGAX)	85.40±4.28°	84.53±9.09°	**0.655**
Glenoid version (GV)	-4.593±4.287°	-5.472±9.096°	**0.655**
Supraspinatus fossa glenoid angle on anterior-posterior views (SGAP)	79.62±4.44°	77,72±5,87°	**0.317**
Acromiohumeral distance (AHD)	7.45±1.61 mm	6.55±0.97 mm	**0.027***
Coracoacromial arch angle (CAA)	124.12±10.80°	149.00±12.66°	**0.667**

*p<0.05, SD: Standard deviation

width, and glenoid neck length between men and women. Tackett and Ablove (18) found that humeral head height, width, and greater tuberosity distance differed significantly between genders. Gumina et al. (19) found that the mean critical shoulder angle (CSA) was significantly lower in the 15-19 age group than in other age groups. They also reported that CSA showed a positive correlation with age (19). For this reason, in order to eliminate the differences that can be observed in shoulder morphology depending on age and gender, this study was conducted by forming a control group from patients of similar age and gender with the patient group, and it was determined that the shoulder structure is a determinant in the development of supraspinatus tendinosis.

Previous studies have clearly mentioned that age-dependent changes due to chronic stress and cellular degradation can cause thickening of the CLT, which may contribute to rotator cuff pathologies (20). Coracoacromial ligament changes and coracoacromial arch angle are associated with rotator cuff tears (21). In Kanatli et al. (22), it was found that coracoacromial ligament degeneration is a strong predictive factor for impingement syndrome. On the other hand, in a study by Cay et al. (15), the authors investigated the relationship between coracoacromial arch structures and rotator cuff pathologies and revealed that there was no statistically significant difference between normal subjects and patients with rotator cuff tear in terms of CLT. Similarly, Zuckerman et al. (23) found no statistically significant difference between normal and tore rotator cuffs for CLT in their study with cadaveric subjects. Consistent with Cay et al. (15) and Zuckerman et al. (23) studies, we found no significant difference in CLT between the patient and control groups.

MRI is the best imaging method for the diagnosis of rotator cuff tendinopathy. Kjellin et al. (24) compared MRI findings with histological analysis of cadaver shoulders and showed that the articular side of the supraspinatus tendon on PD-weighted images corresponded to scarring with eosinophilic, fibrillar, and mucoid degeneration at the unclear border and in the area where the signal intensity increased (without further increasing the signal intensity on T2-weighted images). Williams et al. (25) Gagey et al. (26) found that MRI abnormalities of the rotator cuff correspond to histological changes consistent with tendon degeneration.

In McGinley et al. (10), the authors revealed that steep acromion angulation is associated with CLT and decreased subacromial space. They showed that; a delta angle greater than 7.5° is significantly associated with a higher incidence of supraspinatus tendon tear (10). The results of this study were consistent with McGinley's study; we found a statistically significant difference between the groups for AA.

AGA and SGAP are known parameters that represent the space for the supraspinatus tendon outlet (13). Tokgoz et al. (13) retrospectively studied 42 subjects with supraspinatus tendon tear and 50 asymptomatic controls and found no significant difference in AGA and SGAP. On the other hand, in a study by Tétreault et al. (12), 94 patients who underwent rotator cuff repair and 30 controls with increased SGAP and decreased AGA were found in the patient group when compared with the control group. The results of this study were consistent with Tokgoz et al.'s (13) study. There was no significant difference in AGA and SGAP between the patient and control groups. Different from these studies, our study population had no shoulder surgery; therefore, further studies with subjects both who underwent surgery and who did not undergo surgery should be designed.

The glenohumeral joint has a high susceptibility to instability because of its high mobility. Therefore, the glenoid version (GV) may have an important place in rotator cuff pathologies. Tetrault's study revealed a highly significant difference between patient and control groups in terms of GV (12). Maalouly et al. (27) conducted a study with 41 patients (rotator cuff tears) and 41 controls; they found a significant difference between the groups for GV.

Superior dislocation of the humeral head results in a smaller AHD, which is associated with rotator cuff tears (14,28). Previous studies revealed that the mean AHD in patients with an intact rotator cuff is 10 mm (7-14 mm) (14,29). Goutallier et al. (30) defined the cut-off value as 6 mm for the diagnosis of a full-thickness rotator cuff tear. Various studies have evaluated the relationship between AHD and rotator cuff pathologies (5-8). In Cay et al. (15) study, AHD was found to be narrower than normal limits in patients with rotator cuff tears. In another study by Park et al. (31), investigators measured AHD at three different points in 56 male and 24 female patients; they found that AHD measurement from the lateral and center of the acromion decreased in subjects with impingement syndrome. Similarly, in Ertekin and Kasar's (32) study with 159 patients with impingement syndrome and 201 controls, a correlation was found between AHD and impingement syndrome. Consistent with these studies, we found a significant difference between the patient and control groups for AH distance.

The coracoacromial arch results from the continuous parts of the acromion, coracoacromial ligament, and the coracoid process with each other (33). It is known that if the coracoacromial arch is located lower, then the pressure over the rotator cuff may increase; due to this possibility, some studies have investigated the relationship between CAA and rotator cuff pathologies (33). In a study by Cay et al. (15), with 40 patients having shoulder arthroscopy due to rotator cuff tears and 28 patients with normal shoulder MRI; they found a significant difference between two groups for CAA. On the other hand, in another cadaveric study, there was no significant difference between them (23). There were different measurements in Cay et al. (15) and Zuckerman et al.'s (23) studies. In this study, we measured CAA as in Cay et al. (15). In contrast to Cay et al. (15) study, there was no statistically significant difference in CAA between patients and normal patients. Different from Cay et al. (15) study, the patient group in our study was more specific; this study only included patients with supraspinatus tendinosis, no other shoulder problem. There is a need for further studies with various shoulder pathologies and different measurements of CAA.

Study Limitations

This study has some strengths and limitations. Being a randomized controlled study, evaluating different parameters and the selection of sampling group from specific age and gender to eliminate degenerative changes and gender-related differences are the strengths of this study. When examining the shoulder joint, which is a dynamic and three-dimensional structure, static and two-dimensional evaluation methods may give insufficient results. On the other hand, examining only supraspinatus tendinosis, not examining different gender and age conditions in different patient groups, and not knowing the duration of symptoms and physical activity of the subjects are the limitations of this study.

CONCLUSION

The results of this study suggest that CLT, acromial angle, and AHD are important predisposing anatomical factors for the development of supraspinatus tendinosis. Prospective randomized controlled studies with larger samples should be planned in the background by comparing them with other imaging modalities and considering other leading pathologies related to the rotator cuff.

Ethics

Ethics Committee Approval: This study was conducted in accordance with the principles of the Declaration of Helsinki. This study was approved by the Alanya Alaaddin Keykubat University Medical Ethics Committee (approval date/issue: 07.07.2021,10354421-2021/12-06).

Informed Consent: A retrospective study.

Peer-review: Externally and internally peer reviewed.

Authorship Contributions

Concept: Y.Y., E.T., Design: Y.Y., Data Collection or Processing: Y.Y., E.T., Analysis or Interpretation: Y.Y., E.T., Literature Search: Y.Y., Writing: Y.Y., E.T.

Conflict of Interest: No conflict of interest was declared by the authors.

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