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ORIGINAL PAPER
PŮVODNÍ PRÁCE

The Association between SLAP Lesions and Critical Shoulder Angle and Glenoid Depth

Souvislost mezi SLAP lézemi a kritickým úhlem ramena a hloubkou glenoidu

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ABSTRACT

PURPOSE OF THE STUDY

The critical shoulder angle (CSA) is formed by the combination of glenoid inclination and acromial index and has been shown related to rotator cuff tears and glenohumeral osteoarthritis. SLAP lesions today have an important place among bicipitolabral pathologies that cause intensive shoulder pain. We aimed to investigate the relationship between CSA and glenoid depth and SLAP lesions.

MATERIAL AND METHODS

Between March 2017 and January 2022, 279 consecutive shoulder arthroscopy patients' MRI images were retrospectively examined. After the exclusion criteria, 191 patients were eligible. Patients with SLAP lesions (n=37) were assembled as the study group (Group 1), and patients with intact superior labrum (n=154) were named as the control group (Group 2). Critical shoulder angle (CSA) and glenoid depth measurements were performed using the preoperative MRI images.

RESULTS

A total of 191 patients, of whom 84 were male (44%) were included. The mean age was 49.9±14.96 (range 18–79). There was a statistically significant difference between the SLAP group (Group 1) and the control group (Group 2) in terms of CSA (p=0.032). The mean CSA was 31.66°±3.51° in Group 1 and 33.57° ±5.01° in Group 2. The cut-off value for CSA in patients with SLAP lesions was calculated as 32.85° and the area under the curve was 0.61, therefore a satisfactory association was observed between the groups. The mean glenoid depth was 4.32 ±1.25 mm in Group 1, and 4.39 ±0.32 mm in Group 2. There was no statistically significant difference between the groups in terms of glenoid depth (p=0.136) and also no association between the glenoid depth and SLAP lesions was observed (cut-off=4.45 mm, AUC=0.32).

CONCLUSIONS

Low CSA is associated with SLAP lesions, just as in glenohumeral osteoarthritis. Further prospective clinical studies are needed to enlighten the predisposing effect of CSA to SLAP lesions and the success of superior labral repairs.

Level of evidence: Retrospective comparative study, Level III.
Keywords: Critical shoulder angle, SLAP lesion, shoulder arthroscopy, glenoid depth.

INTRODUCTION

Superior labrum tears were first proposed by Andrews in 1985 (1), and later defined by Snyder as SLAP (anterior-posterior tears of the superior glenoid labrum) lesions (26). While the prevalence of the SLAP lesion, which has a history of approximately 30 years, was initially reported to be very low, this pathology became more recognizable with the widespread use of arthroscopy, and its repair rate increased by 464% in an 8-year period (18). SLAP lesions today have an important place among bicipitolabral pathologies that cause intensive shoulder pain.

As the labrum is the attachment site of the glenohumeral ligaments, it is exposed to many forces such as compression, traction, and shearing, and labral tears may occur secondary to chronic repetitive microtrauma (1, 4, 5). In addition to repetitive microtrauma, acute direct trauma is also among the factors implicated in the etiology (26). The importance of the biceps-superior labrum complex in shoulder stability has been stated in many studies (9, 10, 19, 22), and it has been reported that especially SLAP lesions may contribute to the glenohumeral translation and lead to anterior shoulder instability (2, 14, 17).

The critical shoulder angle (CSA), which has gained popularity in recent years is formed by the combination of glenoid inclination and acromial index and has been shown related to specific shoulder disorders, especially in rotator cuff tears and glenohumeral osteoarthritis (3, 11, 27). The CSA is defined as the angle between the line from the infraglenoid to the supraglenoid tubercle and the most lateral acromial edge. Although a true anteroposterior (AP) shoulder X-ray was used to measure the critical shoulder angle in the literature, it has recently been reported that it can also be measured with magnetic resonance imaging (MRI) (8). It has been recently emphasized that a CSA of more than 35 degrees is associated with rotator cuff rupture (16), and a CSA of less than 30 degrees is associated with osteoarthritis (3, 8, 16, 25, 27). The role of CSA in rotator cuff lesions and osteoarthritis has been investigated many times, and to the best of our knowledge, there is only one study investigating the relationship of this angle with SLAP lesions, which was conducted by Patzer et al. (21). Since the intrinsic factors affecting SLAP lesions have not been adequately clarified, the etiology also remains controversial. In this study, the association between SLAP lesions and radiological measurements of the CSA and glenoid labrum depth was investigated, and it was hypothesized that these parameters, which affect the distribution of forces acting on the shoulder, may predispose to SLAP lesions.

MATERIAL AND METHODS

Following the approval of the local ethics committee in accordance with international agreements (Helsinki Declaration), 279 consecutive patients who underwent arthroscopic shoulder repair between March 2017 and January 2022 were examined. After exclusion criteria, 191 patients who underwent shoulder arthroscopy and had MRI images adequate for radiological measurement were included. Patients with SLAP lesions (n=37) were assembled as the study group (Group 1), and patients with intact superior labrum (n=154) were named as the control group (Group 2).

The inclusion criteria for the study group were consecutive patients with arthroscopically validated SLAP lesions type 1–5 according to Snyder et al. (26). For the control group, consecutive patients who underwent arthroscopic repair and were found to have an intact superior labrum were evaluated. Exclusion criteria were as follows: patients under the age of 18, history of previous shoulder surgery, incompatible magnetic resonance images, history of previous glenoid or acromion fractures, massive unrepairable cuff tears, avascular necrosis, neuromuscular disorders, infectious or inflammatory arthritis. Anatomical variations such as sublabral recess and foramen were also excluded from the study group.

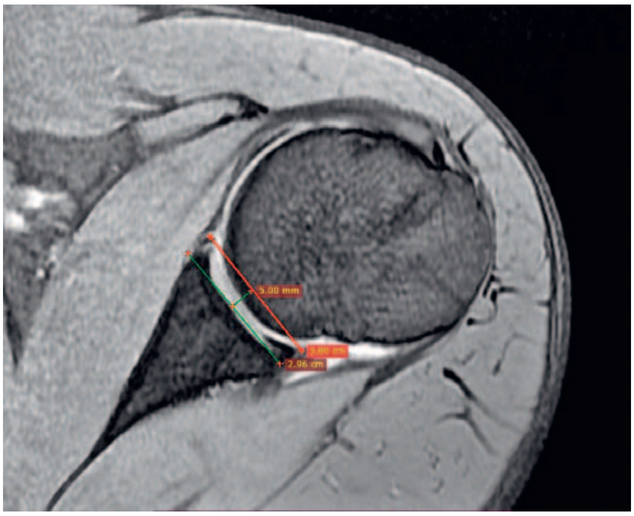

Fig. 1. Measurement of the glenoid depth on axial magnetic resonance image.

The shoulder joint was visualized using the standard posterior imaging portal, anterior and lateral portals, in the beach chair position, and under the interscalene nerve block. Labrum, biceps tendon, rotator interval, subscapularis tendon, and other glenohumeral intra-articular structures were evaluated. The accessory anterior portal was used for SLAP repair. Additionally, bicipitolabral complex integrity was examined using a probe via the standard anterior portal. SLAP lesions were diagnosed according to the criteria defined by Burkhart et al. which were as follows; osseous bare area of the superior labral footprint, displaced biceps anchor, and more than 5 mm depth of the superior labral sulcus (5).

MRI sections of patients in both the study and control groups were compiled by one of the researchers and presented to the other two researchers for blind radiological assessment. The measurements were performed using Radiant PACS DICOM Viewer v.3.4 software and the blinded radiological parameters made by two different researchers were averaged. Using the compiled MRI images, the glenoid depth was measured in axial sections (Fig. 1), and the critical shoulder angle was measured in coronal sections (Fig. 2). On the coronal plane of the MRI images, the CSA was measured with the method described by Incesoy et al. (8). To measure the CSA, the most lateral edge of the acromion was initially identified and marked, then the CSA was measured on the MRI slice that passed through the center of the glenoid where the glenoid inclination was best observed. The CSA was measured as the angle between the line passing from the supraglenoid and infraglenoid tubercles in the coronal plane and the line passing from the infraglenoid tubercle to the most lateral edge of the acromion.

Statistical analysis

Statistical analysis was performed by using SPSS 22.0 software (IBM Corp., Armonk, NY, USA). The conformity of the data to the distribution was evaluated using the Shapiro-Wilk test. Numerical variables showing normal distribution were stated as mean±standard deviation values and those not showing normal distribution as median (minimum-maximum) values. Intraobserver and inter-observer reliability was assessed using the Fleiss' Kappa test. Kruskal-Wallis test was used for comparison between groups and Receiver Operating Characteristic (ROC) analysis was used for association assessment. Mean differences between groups were presented with 95% confidence intervals (CI) and P values less than 0.05 were accepted as statistically significant.

RESULTS

A total of 191 patients were included in the study. (92 right shoulders (48.2%) and 99 left shoulders

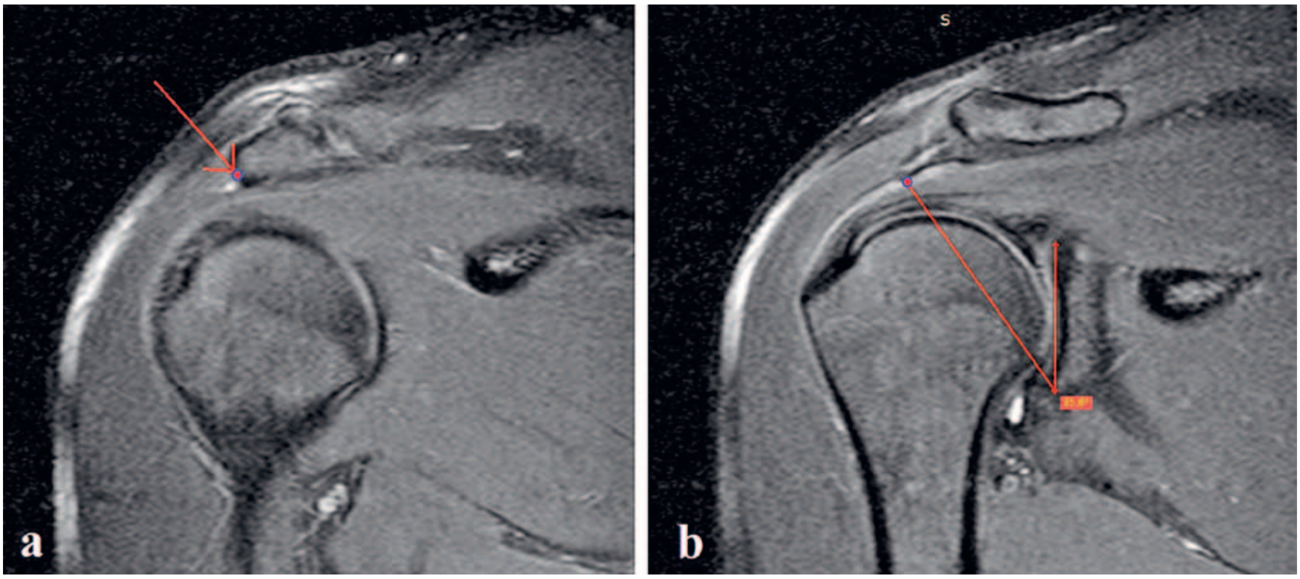

Fig. 2. Measurement of the critical shoulder angle on coronal magnetic resonance image.

(51.8%)). The mean age of the patients was 49.9±14.96 (range 18–79). 84 patients were male (44%) and 107 patients were female (56%).

Patients' MRI images were evaluated by an experienced radiologist and an orthopedic surgeon specialized in shoulder disorders. Excellent intra-observer and inter-observer reliabilities were obtained. ICC for intra-rater reliability was 0.96 with 95% confidence intervals (95% CIs) of 0.94 and 0.97; while ICC for inter-rater reliability was 0.95 with 95% CIs of 0.92 and 0.97.

There was a statistically significant difference between the SLAP group (Group 1) and the control group (Group 2) in terms of CSA (p=0.032). While the mean CSA was 31.66°±3.51° in Group 1, the mean CSA was 33.57°±5.01° in Group 2. In order to evaluate the correlation power between the SLAP group and the control group, ROC analysis was performed. According to the ROC analysis, the cut-off value for CSA in patients with SLAP lesions was calculated as 32.85° and the area under the curve was calculated 0.61, therefore a satisfactory association was observed between the groups (Fig. 3).

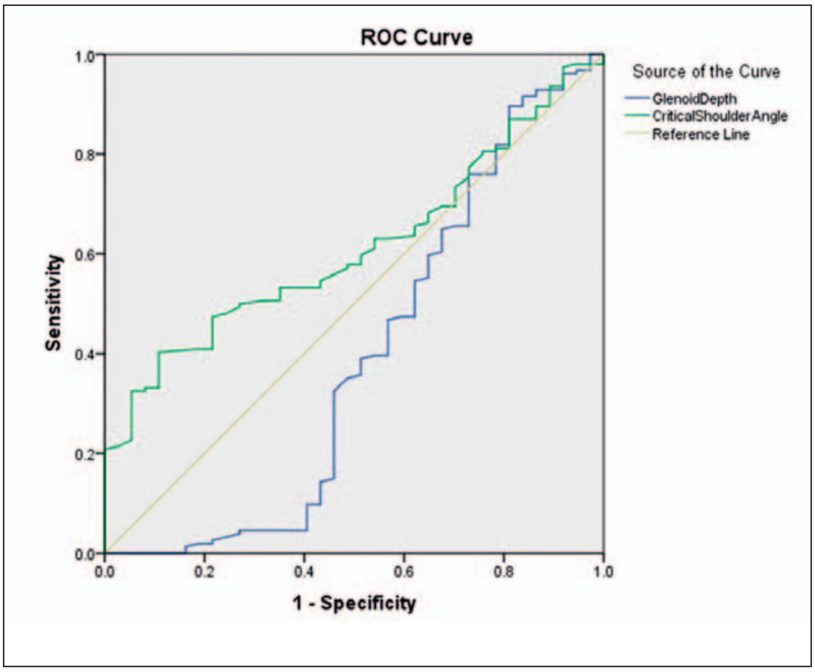

Fig. 3. Receiver operating characteristic (ROC) analysis of the groups.

The mean glenoid depth was 4.32±1.25 mm in Group 1, while the mean glenoid depth was 4.39 ±0.32 mm in Group 2. There was no statistically significant difference between the groups in terms of glenoid depth (p=0.136). In the ROC analysis, there was no association between the glenoid depth and the lesion in patients with SLAP lesions (cut-off = 4.45 mm, AUC = 0.32) (Fig. 3).

DISCUSSION

The incidence of SLAP lesions in patients undergoing shoulder arthroscopy is reported to be 6% (20). In our study, we calculated the incidence as 19.3% which was higher compared to the literature. We attribute our high incidence to the fact that our clinic is the only tertiary hospital in the region and the only center where shoulder lesions are referred.

CSA is a radiological parameter that has recently gained popularity and is frequently studied in shoulder diseases (3, 11, 27). The relationship of CSA with specific shoulder pathologies such as rotator cuff rupture and osteoarthritis has been investigated in the literature, and significant results have been revealed (6, 21, 23-25). Cunningham et al. reported that CSA is an independent radiological marker that reliably predicts rotator cuff rupture. At the same time, they stated that this marker was not affected by the demographic characteristics of the patients and environmental factors (6). Rose-Reneau et al. stated that small CSA is associated with osteoarthritis and large CSA is associated with rotator cuff pathologies, and they advocated that CSA measurement can reduce the need for costly and time-consuming radiological tests (23). In a study by Scheiderer et al., the authors reported that high CSA and acromial index significantly increased the risk of re-tear after arthroscopic supraspinatus tendon repair, and a CSA value above 38° increased the re-tear rate 4-fold (24).

The most important finding of our study was a significant difference in the CSA in patients with SLAP lesions compared with the intact labrum group. In our study, the mean CSA value was calculated as 31.66° in patients with SLAP lesions and 33.57° in patients with intact superior labrum. To the best of our knowledge, there is only one study in the literature investigating the relationship between SLAP lesions and CSA which is conducted by Patzer et al. (21). Patzer reported that the mean CSA was 29.6° in patients with SLAP lesions and 33.8° in patients with intact labrum. The authors concluded that SLAP lesions were associated with a low CSA < 30°, while no association were observed regarding acromial index, acromial slope and lateral acromial angle. The authors stated that as a result of the peel-back mechanism proposed by Burkhart, the anterior translation of the humeral head and the compressive forces created by the humeral head increased, and they claimed that the compressive forces directed towards the medial side were compensated by the low CSA angle. Our results based on CSA measurements seem to be quite consistent with the results of the study of Patzer et. al. We calculated the cut-off value for CSA as 32.85°, which was slightly above Patzer's 29.6°. In addition, Patzer calculated the AUC as 0.83 and stated that there was a strong association, while the AUC in our study was 0.61, which is lower, but still an acceptable association. This means there is a probability of 61% patients with SLAP lesions to be associated with a specific CSA. A CSA of less than 30 degrees has been associated with glenohumeral osteoarthritis (3, 12, 15, 23). In the literature, the theory is focused on that low CSA directs the force vector towards the deltoid acting on the shoulder medially, and therefore the development of osteoarthritis accelerates because the humeral head puts more pressure on the glenoid. Parallel to this, we focus on the theory that the increasing pressure of the humeral head to the glenoid may cause repetitive microdamage to the bicipitolabral complex and cause SLAP lesions. This theory on this subject is also emphasized in the study of Patzer et al. (21).

Snyder et al. reported that the superior labral injury was caused by a combination of compressive force on the superior joint surface and a proximal subluxation force on the humeral head. The labrum and biceps tendon would be pinched between the glenoid and humeral head which may cause a tear of the glenoid labrum (26). Burkhart investigated the mechanisms affecting the shoulder joint in athletes and stated that the humeral head exerts varying forces on the bicipitolabral complex of the glenoid in different phases of the throwing activity. He also explained that this scenario of maximum superior labral shear force combined with maximum peel-back force at the exact moment that maximum acceleration forces are being transmitted into the glenohumeral joint creates a potentially disastrous situation for the "shoulder-at-risk" (5). The theory of the development of SLAP lesions as a result of the compression and shear forces applied by the humeral head to the bicipitolabral complex is consistent with the results of our study. In this context, it has been evaluated that CSA less than 30 degrees may be a potential risk factor for the development of SLAP lesions by increasing the force vector acting on the shoulder.

The depth of the glenoid was also examined, but no statistically significant difference was found between patients with SLAP lesions and patients with the intact labrum. There was also no correlation between the SLAP lesion and glenoid depth (AUC=0.38). There is no study in the literature examining the effect of glenoid depth on the bicipitolabral complex. Drakos et al. reported that the glenoid depth was significantly different between shooting athletes and sedentary patients in a study they conducted, and they also reported that glenoid retroversion was increased in shooters (7). According to the results of our study, we could not indicate the glenoid depth as an effective factor for the development of SLAP lesions.

In our study, we used MR images for CSA and glenoid labrum depth measurement. When we take a look at the methods defined in the literature, we can see studies that have measured both true AP X-rays and MRI sections for determining the CSA(8, 13). Generally, the most frequently used radiological technique for the CSA assessment is direct roentgenogram, however the intra-observer reliability of the X-rays may be relatively low due to the fact that the X-rays are not always taken in the appropriate and standard position, and at the same time, true AP radiographs are not routinely taken in our clinic. For that reason, we preferred to measure the CSA values on MRI images instead of direct roentgenograms. The other reason is that, the MRI images taken in the MRI unit of our university hospital are of high quality and closer to the standards.

The limitations of our study were its retrospective design and the possibility that the patients we included in the study had additional pathologies such as rotator cuff rupture and that these pathologies may also affect the results. However, it does not seem possible to avoid this interaction, since isolated SLAP lesions are not very frequent and are mostly encountered with other shoulder pathologies.

CONCLUSIONS

Low CSA is associated with SLAP lesions, just as in glenohumeral osteoarthritis. Further prospective clinical studies are needed to enlighten the predisposing effect of CSA to SLAP lesions and the success of superior labral repairs.

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