What are the anatomical predictive factors of degenerative superior labrum anterior to posterior lesion in rotator cuff tear?☆

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ABSTRACT

The purpose of this study was to evaluate the influence of anatomical factors degenerative superior labrum anterior to posterior lesion in rotator cuff tear. The study included 421 middle-aged patients treated using arthroscopic surgery for rotator cuff tears. Patients were divided into two groups based on the superior labrum anterior-to-posterior (SLAP). Glenoid inclination, glenoid length, humeral head diameter, acromio-humeral distance (AHD) head-glenoid difference (HGD), head glenoid angle (HGA), size and retraction of rotator cuff tears were evaluated in both groups. In conclusion, a HGD exceeding 10 mm could be anatomically predictive of degenerative SLAP.

Level of evidence: Case series, Level IV.

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1. Introduction

Tears of the superior glenoid labrum and the origin of the long head of the biceps tendon were first described by Andrews et al.¹ They can lead to shoulder pain and highly impaired shoulder function. The first classification and the designation as superior labrum anterior-to-posterior (SLAP) lesion, was presented by Snyder et al.²²

The incidence of SLAP lesion surgery has increased in the United States in the past decade.^{17,24} An appreciable proportion of patients undergoing SLAP lesion surgeries are middle-aged.^{17,24} Recent studies have demonstrated that combined lesions in the shoulder are very common and that rotator cuff tears are frequently associated with concomitant labral lesions.⁴ One study found that 74% of individuals with full-thickness rotator cuff tears had associated intra-articular lesions, with labral tears being the most commonly associated disorder.¹⁵

Snyder et al.^{21,22} originally described that the etiology of SLAP lesions is traumatic. Several injury mechanisms for SLAP lesions are described in the literature.^{1,10,23} However, there has been no

evaluation concerning the influence of anatomical factors to degenerative SLAP lesion diagnosed by arthroscopic findings.

The purpose of this study was to evaluate anatomical predictive factors of superior labrum anterior to posterior lesion through the diagnosis by arthroscopic findings in the rotator cuff tears of people 40 and 60 years of age. The hypothesis was that higher glenoid inclination, humeral head diameter, head-glenoid difference (HGD) and head glenoid angle (HGA), and lower glenoid length and acromio-humeral distance (AHD) are related with degenerative SLAP.

2. Methods

2.1. Patients

Following Institutional Review Board exempt approval (Dankook University Medical IRB: 2017-05-009), a total of 421 patients with rotator cuff tears (267 males, 154 females) were enrolled retrospectively from February 2005 to March 2017. Only middle-aged (mean age 52.45 years; range 40–60 years) patients were included. Trauma history within 1 year before the surgery was excluded to define degenerative SLAP. The inclusion criterion was arthroscopic surgery diagnosed as rotator cuff tear. Exclusion criteria were poor radiologic images, athletes of any level, neuromuscular disease, suprascapular nerve palsy, shoulder instability, acromioclavicular joint arthritis, humeral head arthritis, adhesive capsulitis, bilateral shoulder disease and previous surgery on the affected shoulder. Furthermore, large to massive

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tears were excluded to permit the evaluation of the influence of bony anatomical factors.

Patients were divided into two groups based on the SLAP. Group A comprised combined degenerative SLAP type I and II ($n = 146$ cases). Group B comprised intact labrum ($n = 275$). Only type I and II SLAP lesions were included in group A; the other types of SLAP lesions were excluded. Subjects were also allocated to two other groups based on HGD ≥ 10 mm (group I, $n = 184$) and < 10 mm (group II, $n = 237$).

All patients were diagnosed using the same magnetic resonance imaging (MRI) protocol so that they could be evaluated under the same conditions. The 421 rotator cuff tears comprised 296 right rotator cuff tears and 125 left rotator cuff tears, with 303 in the dominant arm and 118 in the non-dominant arm (Table I).

2.2. Radiological evaluation

Magnetic resonance imaging protocol included oblique coronal proton density-weighted and T2-weighted fat saturated spin-echo images (3300/14–95 [repetition time ms/echo time ms]; section thickness, 4 mm; intersection gap, 0.8 mm; field of view, 16 cm), oblique coronal T1-weighted fat saturated spin echo images (777/12 [repetition time ms/echo time ms]; section thickness, 3 mm; intersection gap, 0.6 mm; field of view, 16 cm); oblique sagittal T1-weighted spin echo images (images (600/12 [repetition time ms/echo time ms]; section thickness, 4 mm; intersection gap, 1.2 mm; field of view, 16 cm) and transverse T1-weighted spin echo images (images (600/12 [repetition time ms/echo time ms]; section thickness, 3 mm; intersection gap, 0.9 mm; field of view, 16 cm).

The size of the rotator cuff tear was measured using the maximum diameter of the tear in the oblique sagittal T2-weighted images. When the width of a tear was too large to measure with one straight line over the convex humeral head, more than one straight line was drawn. The patients were divided into 6 groups reflecting the diameter: group A (< 10 mm), group B (≥ 10 mm, < 15 mm), group C (≥ 15 mm, < 20 mm), group D (≥ 20 mm, < 25 mm), group E (≥ 25 mm, < 30 mm) and group F (≥ 30 mm).²⁰

The retraction of the rotator cuff tear was measured using the maximum diameter of the tear in the oblique coronal T2-weighted images. When the retraction of a tear was too large to measure with one straight line over the convex humeral head, more than one straight line was drawn. The patients were divided into 6 groups reflecting the diameter: group a (< 10 mm), group b (≥ 10 mm, < 15 mm), group c (≥ 15 mm, < 20 mm), group d (≥ 20 mm, < 25 mm), group e (≥ 25 mm, < 30 mm) and group f (≥ 30 mm).²⁰

All radiologic measurements were evaluated on scapula anteroposterior radiography except for AHD. The glenoid inclination was determined the angle between the line from the most superior to inferior points of the glenoid and the line from the most inferior point of the scapula to the most superior point of the glenoid (Fig. 1). The humeral head diameter was determined as the diameter largest circle in the humeral head (Fig. 2). The glenoid length was measured the distance of connecting the most superior and inferior points of the glenoid (Fig. 2). The HGA was determined the angle between the line from the center of humeral head to the center of glenoid length and the line connecting the perpendicular line from the center of glenoid length (Fig. 3).

The AHD was evaluated on the Rockwood view. The distance was measured between a radio-dense line on the inferior acromial cortex and a line parallel to it tangent to the humeral head. (Fig. 4)

All measurements of distance or areas described below were performed electronically on the simple radiography and MRI using the measurement software of a picture archiving and communication system. All images were measured by consensus readout of two blinded observers (L.J.Y and H.K.H). Measurements were

Fig. 1. Measurement of glenoid inclination on scapula anteroposterior radiography. The angle (α) between the line from the most superior to inferior points of the glenoid and the most superior point of the glenoid to the line from the most inferior point of the scapula are depicted.

Fig. 2. Scapula anteroposterior radiography. Measurement of humeral head: the diameter (A, arrow line) of largest circle in the humeral head, measurement of glenoid length: The distance (B, dotted line) of connecting the most superior and inferior points of the glenoid.

performed independently, and the results were not disclosed to the other surgeon. The mean value of the duplicate scores was used as the representative value.

2.3. Arthroscopic evaluation

Under general anesthesia, all patients were prepared in the beach chair position. Through standard posterior and anterior portals the glenohumeral joint, articular cartilage and rotator cuff were examined. If a SLAP lesion was detected during the arthroscopy, a careful evaluation of the supraglenoid tubercle, long head of the biceps tendon, insertion of the biceps anchor, anterior and posterior parts of the labrum and the joint capsule was done arthroscopically in a standard fashion. Type I and II SLAP lesions comprised group A, with the other type of SLAP lesions excluded in this study according to the modified Snyder

Fig. 3. Measurement of head-glenoid angle on scapula anteroposterior radiography. The angle (β) between the line from the center of humeral head to center of glenoid and the line from the perpendicular line of the center of glenoid. Superior migration of humeral head is presented as the positive value and inferior migration of humeral head is presented as the negative value.

Fig. 4. Acromiohumeral distance on the Rockwood view (C) was measured between a radio-dense line on the inferior acromial cortex and a line parallel to it tangent to the humeral head.

classification by single orthopedic shoulder surgeon (S.J.B.) (Fig. 5).^{13,19,22} Arthroscopic images were repeatedly interpreted by a consensus readout of another blinded observer (shoulder fellow; L.J.Y.). The operator (S.J.B.) was considered the main assessor, the evaluation by the orthopedic fellow (L.J.Y.) was used to assess the interobserver correlation.

2.4. Statistical analyses

Group results (size and retraction of rotator cuff tear, incidence of degenerative SLAP) were compared using the Pearson chi-square and the Student *t*-test for continuous variables (HGD, HGA, humeral head diameter, glenoid length, glenoid inclination and AHD). The weighted kappa (κ) coefficient was used to estimate the interobserver reliability when evaluating the diagnosis of degenerative SLAP through the arthroscopic findings. Interobserver

Fig. 5. Arthroscopic findings. (A) Intact labrum, (B) type I degenerative SLAP was divided as labral and biceps fraying with intact anchor, (C) type II degenerative SLAP was divided as Labral fraying with detachment of the superior labrum and biceps anchor.

reliability was classified according to the κ coefficients: “slight agreement”, 0.00–0.20; “fair agreement”, 0.21–0.40; “moderate agreement”, 0.41–0.60; “substantial agreement”, 0.61–0.80, and “almost perfect agreement”, 0.81–1.00. Statistical analyses were performed with use of SPSS ver. 21.0 (IBM Co., Armonk, NY, USA), and *p*-values of <0.05 were considered statistically significant.

3. Results

There were no significant differences between the groups with respect to demographic data, except for sex. There were more males in group A than in group B ($p=0.007$). There were no differences in the other demographic data, including age ($p=0.466$), Ratio of dominant arm ($p=0.859$), and ratio of right versus left shoulder ($p=0.635$). Size and retraction of rotator cuff between the groups were not significantly different (Table 1).

There were no significant differences between the groups in all radiological measurements, except for HGD. HGD of group A (degenerative SLAP, mean: 10.53 ± 4.03) was statistically significantly higher than group B (intact SLAP, mean: 9.03 ± 3.84 , $p=0.001$). There were no differences in the other radiological measurement, including HGA ($p=0.316$), humeral head diameter ($p=0.115$), glenoid length ($p=0.102$), glenoid inclination ($p=0.884$) and AHD ($p=0.388$) (Table 2).

Interobserver reliability of diagnosis degenerative SLAP through arthroscopic finding was in ‘substantial agreement’, with a weighted kappa coefficient of 0.74. SLAP incidence of group I

Table 1

Demographic data of degenerative SLAP group and intact labrum group.

	Degenerative SLAP group (n = 146)	Intact labrum group (n = 275)	p-value
Age	52.86 ± 8.37	52.23 ± 8.70	0.466
Sex (male: female)	105: 41	162: 113	0.007
Dominant arm: non-dominant arm	104: 42	199: 76	0.859
Right shoulder: Left shoulder	105: 41	192: 83	0.635
Size of RCT			
<10 mm	57 (39%)	94 (34%)	0.112
≥10 mm, <15 mm	42 (29%)	80 (29%)	
≥15 mm, <20 mm	28 (19%)	48 (17%)	
≥20 mm, <25 mm	16 (11%)	37 (13%)	
≥25 mm, <30 mm	3 (2%)	16 (6%)	
Retraction of RCT			
<10 mm	68 (47%)	118 (43%)	0.174
≥10 mm, <15 mm	48 (33%)	94 (34%)	
≥15 mm, <20 mm	18 (12%)	37 (13%)	
≥20 mm, <25 mm	9 (6%)	19 (7%)	
≥25 mm, <30 mm	3 (2%)	7 (3%)	

Table 2

Mean values for radiologic measurements in rotator cuff tears with degenerative SLAP and those with intact labrum.

	Degenerative SLAP group (n = 146)	Intact labrum group (n = 275)	p-value
Head-glenoid difference	10.53 ± 4.03	9.03 ± 3.84	0.001
Head-glenoid angle	7.15 ± 5.52	6.62 ± 4.42	0.316
Humeral head diameter	48.30 ± 4.50	47.54 ± 4.85	0.115
Glenoid length	37.76 ± 4.27	38.50 ± 4.44	0.102
Glenoid inclination	36.57 ± 6.97	36.67 ± 6.79	0.884
Acromiohumeral distance	9.04 ± 2.79	9.45 ± 5.29	0.388

Fig. 6. The incidences of SLAP between the group I (HGD ≥ 10 mm) and the group II (HGD < 10 mm).

(50.00%) was statistically significantly higher than group II (22.78%, $p < 0.001$) (Fig. 6).

4. Discussion

The most important findings were that HGD of group A (degenerative SLAP, mean: 10.53 ± 4.03) was statistically significantly higher than group B (intact SLAP, mean: 9.03 ± 3.84 , $p = 0.001$) and the incidence of SLAP of group I (HGD ≥ 10 mm; 50.00%) was statistically significantly higher than group II (HGD < 10 mm; 22.90%, $p < 0.001$).

SLAP lesions are characterized by labral abrasion and splitting between 10 o'clock and 2 o'clock.²² These lesions are one of the causes of shoulder pain and instability. Incidence of these lesions

has been variously reported ranging from 5.9 to 26% in shoulder arthroscopy.^{2,11}

The etiology of SLAP lesions is trauma and several injury mechanisms are described in the literature.^{1,10,23} A fall on the extended arm in a slightly flexed and abducted position can lead to a lesion of the superior labrum caused by compression force and subluxation of the humeral head cranially.²² With trauma from an external rotation and abduction force of the shoulder that induces anterior shoulder instability, SLAP lesions are often apparent as concomitant lesions.⁸ But, in most cases SLAP lesions are overuse injuries. The most frequent cause of SLAP lesions is due to microtrauma and overuse from repeated throwing motions, such as for baseball pitchers.^{22,23} However, there has been no study addressing the anatomical etiology of SLAP.

Recently, Mauro et al.¹⁴ reported that increased glenoid width predicts better outcomes after posterior capsulolabral repair; higher glenoid retroversion was noted in this patient population as compared with previous studies in normal populations.

Abnormal morphology of the glenoid has been reported to be associated with severe full-thickness tears.⁷ A two-dimensional radiological study of the orientation of the glenoid in the coronal plane of the scapula, described as glenoid inclination, showed that in shoulders with tears the glenoid faced more superiorly.⁷ This finding correlated with that of a previous biomechanical study, which found that the force required to translate the humeral head superiorly decreased significantly when the glenoid inclination was more superior.²⁵ In this study, several radiological measurements were evaluated to deduce the anatomical etiology of degenerative SLAP.

4.1. Limitations

There are several limitations in this study. It is a retrospective study evaluating rotator cuff tears, not solitary SLAP lesions. Because the purpose of this study was to evaluate the anatomical predictive factors of degenerative SLAP in middle-aged patients.

Moreover, Snyder et al.²¹ arthroscopically examined 140 superior labral lesions and found that 40% were associated with a full- or partial-thickness rotator cuff tear. Therefore, evaluation of degenerative SLAP in rotator cuff tear was a reasonable study design with selective inclusion and exclusion criteria of this study.

A second limitation is that the diagnosis of degenerative SLAP depends solely on arthroscopic finding; MRI and physical examination findings of SLAP were not evaluated. Many physical examination tests have been defined to diagnose SLAP lesions. However, none is truly diagnostic and their diagnostic specificity rates are low.^{6,16} Clinical examination tests are inconsistent and not reliable for the diagnosis of SLAP lesion, which can be caused by additional shoulder lesions of the patients.^{6,21}

For these reasons, MRI and MRI arthrography have come to the forefront in the diagnosis of shoulder pain. However, the accuracy of detecting SLAP lesions by MRI is variable. Legan et al. reported 75% sensitivity and 99% specificity using 1.5 T MRI.¹² Phillips et al. compared sensitivity (86%) and specificity (13%) of MRI with the arthroscopic findings and found that additional shoulder lesions did not change the result.¹⁸ Connell et al. prospectively evaluated 102 SLAP lesions and reported 98% sensitivity, 89.5% specificity and 96% reliability.³ Connolly et al. reported a sensitivity and specificity of 38% and 94%, respectively, in their multicenter study including 144 patients to detect type 2 SLAP lesions.³

Diagnosis of SLAP by arthroscopic examination also has limitations. Gobeze et al. [5] and Parentis et al.⁹ questioned shoulder arthroscopy as the gold standard, given the differing diagnosis and classification results. However, the orthopedic literature reveals that shoulder arthroscopy is the best method in diagnosis of SLAP lesions.^{22,26} In this study, interobserver reliability of diagnosis degenerative SLAP though arthroscopic finding was classified as good (ICC: 0.82).

A third limitation is that radiologic measurements of glenoid inclination and HGA were evaluated on the scapular anteroposterior view. This view was not better to figure out the relation of gleno-humeral joint than Graphey's view (glenohumeral joint anteroposterior view). However, the purpose of this study was a comparison between degenerative SLAP group and intact labrum group, and not to deduce the absolute values of these radiologic measurements. Furthermore, measurements were performed independently by consensus readout of two blinded observers and the mean value of the duplicate scores was used as the representative value to obtain the accurate results and minimize the observer bias.

5. Conclusion

Glenoid inclination, glenoid length, humeral head diameter, AHD and HGA did not differ in shoulder with SLAP or without SLAP. However, HGD exceeding 10 mm could be a predictive anatomical factor of degenerative SLAP.

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