Effect of Glenohumeral Position on Contact Pressure Between the Capsulolabral Complex and the Glenoid in free ALPSA and Bankart Lesions

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감사의 글

먼저 석박사 통합과정 동안 아낌없는 격려와 지도를 해주신 김두섭 교수님께 진심으로 감사 드립니다. 그리고 저의 논문 심사를 맡아주시고, 소중한 충고와 조언을 해주셨던 윤여승 교수님, 나중호 교수님, 정원길 교수님, 그리고 김성훈 교수님께 깊은 감사를 드립니다.

저를 의사로 키워주신 담임반 차병호 교수님 외 많은 은사님들께 감사의 말씀을 전합니다. 정형외과 의사로 성장시켜주신 황성관 교수님, 박희전 교수님, 오진록 교수님께도 감사드립니다.

연구과정에서 많은 도움을 준 후배님들께 깊은 감사 드립니다. 내일처럼 실험 및 논문과정에서 도와준 정회정 교수님 외 여러 의국 후배님들께 고마움을 전합니다.

일하면서 학위연구를 병행할 수 있도록 도와준 허만승 원장님과 조태연 원장님께도 감사드립니다.

항상 저를 믿고 응원해주신 부모님과 늘 격려해주신 장인, 장모님 그리고 언제나 옆에서 힘이 되어준 가족들에게 감사를 전합니다.

사랑으로 격려하고 응원해준 제 아내 박정민과 아들 양하준, 딸 양하린 에게 이 논문을 바칩니다. 이제는 이러한 가족들의 은혜에 조금이나마 보답할 수 있도록 노력하겠습니다.

마지막으로 지면으로 통해서 일일이 언급을 하지 못했지만 그 동안 저를 아끼고 사랑해주신 모든 분들께 다시 한번 진심으로 감사 드립니다.

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Abstract

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(Directed by Professor Doosup Kim)

Purpose

Anterior shoulder dislocation is a common injury, but proper management method for the dislocation has been still controversial. We hypothesized that reducing shoulder in externally rotated position enhances the reduction of the capsulolabral lesion. Thus, in this study, we measured the contact pressure

between the capsulolabral lesion of the free ALPSA and Bankart lesions and the glenoid using a cadaveric model to examine our hypothesis.

Methods

In 10 specimens, the humerus was externally rotated with abducting on coronal plane to measure the contact pressure between capsulolabral complex and glenoid in the free ALPSA and Bankart lesions using Tekscan pressure system at each designated position. The joint stability were confirmed using the Vicon motion analysis system.

Results

In the normal shoulder joint, the peak pressure between the subscapularis muscle and the anterior capsule according to the location of the glenohumeral joint decreased to 83.4±21.2 kPa in the 0° abduction and -30° external rotation positions, and showed a 300.7±42.9kPa peak value in the 60° abduction and 60° external rotation positions. In both free ALPSA and Bankart lesion, the lowest pressure was measured at 0° abduction and -30° external rotation, and the highest pressure was recorded at 60° external rotation and 60° abduction.

Discussion

The contact pressure between capsulolabral complex and glenoid significantly increased when abduction and external rotation angle increased. It showed that the increase was much higher in free ALPSA lesion than in Bankart lesion.

Key words : Free ALPSA lesion, Bankart lesion, Shoulder dislocation, Cadaveric study, Biomechanical study

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I. Introduction

Although anterior shoulder dislocation is a common pathologic condition, no treatment method has been identified as the gold standard.[3] One of the most widely used treatment methods is immobilization using an arm sling or brace with adduction and internal rotation, but this treatment results in a high recurrence rate[20], especially in young or athletic patients.[2]

In 1999, Itoi et al.[9] reported the presence of a ‘coaptation zone’ during the immobilization period, and suggested positions (such as adduction and external rotation or abduction and neutral rotation) for maintaining the zone based on a cadaver study. These suggestions incited new techniques for treating anterior shoulder dislocations and spawned further discussion. In 2003, Itoi et al.[7] suggested a new method of immobilization. They found that patients treated with external rotation had a lower recurrence rate than those treated with internal rotation after initial dislocation of the shoulder. Many other studies have confirmed these findings[5,13,23,25], determining that immobilization with external rotation is more effective than internal rotation. However, other studies[14,16] and systemic reviews[10,17,27] found that the use of conventional immobilization methods with either internal or external rotation did not affect recurrence rates after the initial anterior shoulder dislocation. Moreover external rotation was associated with low compliance among patients.

Current practice divides patients into first time and recurrent shoulder dislocation groups, and distinct lesions resulting from the first and recurrent dislocations have been described. Such differentiation was first attempted by Antonio et al.[1] and later by Kim et al[12]. According to these studies, the two most common lesions are free ALPSA and Bankart lesions, and the prevalence of free ALPSA and Bankart lesions in first time dislocation patients ranges from 23 to 27%. Thus, it was hypothesized that externally rotating the arm promoted contact pressure in the capsulolabral complex by enhancing the reduction of the capsulolabral lesion. The contact pressures between the capsulolabral lesion and the glenoid were compared between free ALPSA and Bankart lesions during external rotation of the glenohumeral joint using a fresh frozen cadaver shoulder model. To determine the effects of conservative treatment on two types of lesions(free ALPSA and Bankart lesions) commonly occurred in the first time shoulder dislocation, the contact pressures at each lesion were observed.

II. Materials and Methods

Experiments were conducted on 14 shoulders of seven fresh frozen cadavers. All cadaver donors were male and their mean age was 52.3 ± 2.7 years. Of the 14 shoulders, those with histories of shoulder fracture, shoulder surgery, shoulder dislocation, shoulder joint arthritis, rotator cuff tear, anatomical variation and damage in the labrum, and glenoid deformity were excluded, and the remaining 10 shoulders were selected for this study.

III. Preparation

The fresh frozen cadavers were frozen at -20℃ and thawed at room temperature for 36 hours before experiments. The humerus and scapula were dissected, excluding the glenohumeral joint capsule and the rotator cuff. When the deltoid muscle was dissected, the center of the deltoid insertion site of the humerus shaft was marked. The rotation center of the humerus was marked considering the locations of the medial and lateral epicondyles, and excised 10 cm inferior to the deltoid insertion center. A hole was made at the center of the deltoid insertion using a drill, and tension was applied using a wire after a screw was inserted (deltoid force was applied to the opposite side using a pulley and a wired screw). The supraspinatus muscle, infraspinatus muscle, subscapularis muscle, and teres minor muscle bellies were detached from the scapula, and the musculotendinous junction was sutured using no. 5 Ethibond Excel (Ethicon, Somerville, NJ, USA) to apply tension separately to the muscles. The muscle loads were determined based on the outcomes of previous studies on the cross-sectional area (Table 1).[19] The humerus shaft was fixed on a custom-made jig, and the scapula was fixed on the jig after four holes were made in the body with the medial border perpendicular to the ground.

Table 1. Static weights which loaded to rotator cuff muscles

Muscle	**Loads(N)**
Deltoid	43
Suprascapularis	9
Subscapularis	26
Infrscapularis & Teres minor	22

A three-dimensional motion capture system(Vicon Nexus, Vicon Motion System Ltd., UK) with six camerasMX-T10, Vicon Motion System Ltd., UK) was used to determine the joint stability, glenohumeral abduction and rotation angle. The accuracy of the system was proven in previous studies.[28] Based on the results of a study by Poitras et al.[19], six reflective markers were attached to the anatomical locations of the scapula(trigonum spinae scapulae, angulus infecrior and angulus acromoalis) and the humerus(glenohumeral rotation center, lateral epicondyle and medial epicondyle) to define the coordinate system of the scapula and humerus according to the recommendations of the International Society of Biomechanics.[29] The coordinate system of the scapula and the humerus was defined using the trajectories of the reflective markers obtained during the experiments. The glenohumeral angle was calculated using the Y-X-Y Euler rotation sequence.

Pressure was measured using a Tekscan pressure sensor model 4205 (Tekscan Inc., MA, USA) of the K-scan™ system (Tekscan Inc., MA, USA). This sensor was 45.7 mm wide, 41.9 mm tall, and 0.178 mm thick and could minimize interference in normal joint movement. In prior real testing, the sensor was calibrated with the maximum pressure of 2068kPa using an Instron® (Illinois Tool Works Inc., MA, USA); thus the minimum pressure was 8.1kPa. The pressure data were recorded using an I-scan® software (Tekscan Inc., MA, USA).

The Tekscan pressure sensor was inserted between the subscapularis muscle and the anterior capsule of 10 normal fresh frozen shoulders. The humerus was externally rotated in 0°, 30°, 45°, and 60° coronal abduction positions to -30° (internal rotation), 0° (neutral), 30°, 45°, and 60° to measure the pressures at the respective angles. Then, posterior capsulectomy was performed. The posterior capsule was medially displaced and the labrum was almost detached freely, but still remained through the intact anterior glenoid periosteum to the scapula in five shoulders to make free ALPSA lesion (not adherent ALPSA) (Figure 1) in the 3- to 6-o’clock position of the labrum (the anteroinferior labrum) using a curved periosteal elevator. We surgically detached the labrum and tore the anterior glenoid periosteum of the five remaining shoulders to make Bankart lesions

(Figure 2). The Tekscan pressure sensor was positioned between the capsulolabral complex and the glenoid with the labral lesion to measure the pressure at the same positions as in previous experiments.

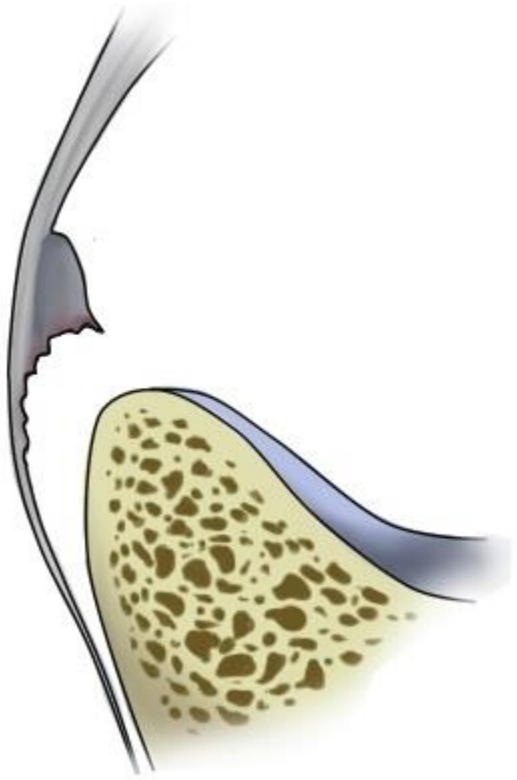

Figure 1. Schematic view of free ALPSA lesion

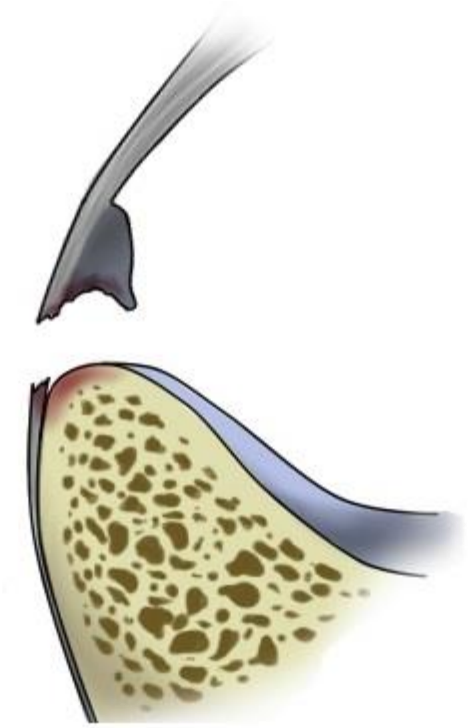

Figure 2. Schematic view of Bankart lesion

This study was approved by the Institutional Review Board of Wonju College of Medicine, Yonsei University (Approval No.YWMR-12-0-038).

IV. Statistical Analysis

Two-way ANOVA was performed to determine if there were any interactions between the abduction and rotation angles on the peak pressure. Then, post hoc analysis was performed using Tukey's method for multiple comparisons of mean differences in peak pressure. The significance level was set at 0.05 ($p < 0.05$), and all statistical analyses were performed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA).

V. Results

The mean area of the surgically formed free ALPSA lesions was 2.5±0.2 cm^2, and of the Bankart lesions was 2.9±0.1 cm^2. The average humeral head translation was 4.0±0.2 mm superiorly and 2.5±0.2 mm anteriorly. The angular repeatability in abduction was 1.6±0.3° and 1.1±0.3° in external rotation.

Table 2. The contact pressure between the subscapularis and the anterior capsule (Normal shoulder)

ER \ ABD	0°	30°	45°	60°
-30°	83.4 ± 21.2	106.7 ± 30.5	110.5 ± 27.6	110.3 ± 24.9
0°	95.5 ± 23.5	152.1 ± 34.8	163.6 ± 43.2	157.3 ± 33.7
30°	197.9 ± 31.2	229.9 ± 32.7	243.1 ± 35.4	262.8 ± 39.5
45°	217.4 ± 37.5	252.2 ± 37.7	259.9 ± 32.7	275.4 ± 36.7
60°	240.2 ± 36.1	275.2 ± 34.7	283.5 ± 35.5	300.7 ± 42.9

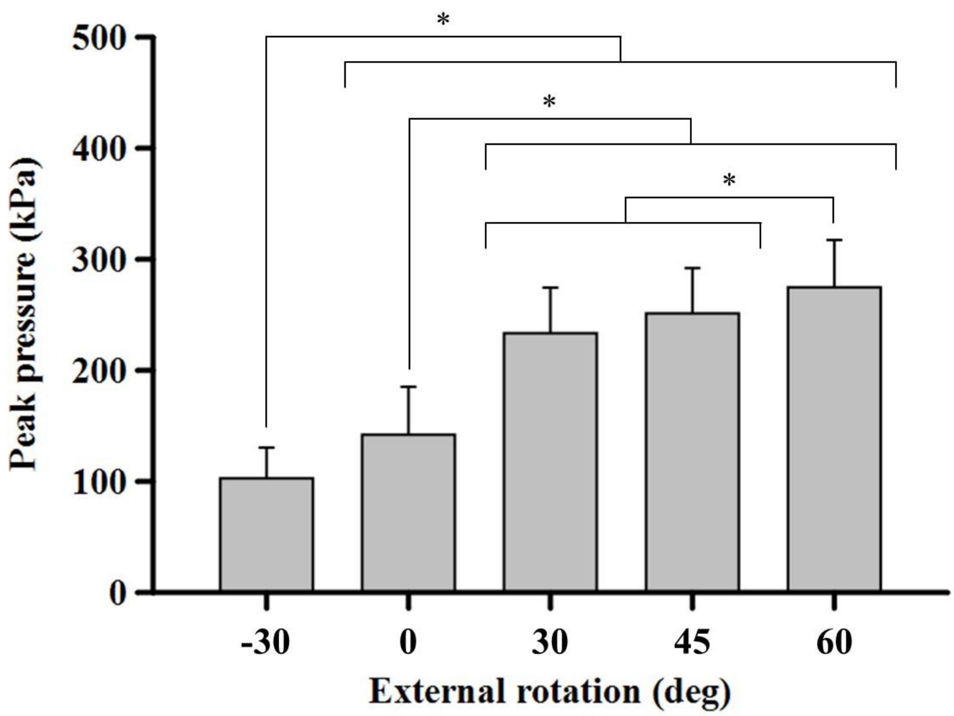

Figure 3. The contact pressure in normal shoulder among the external rotation angles * The mean is $p<0.05$

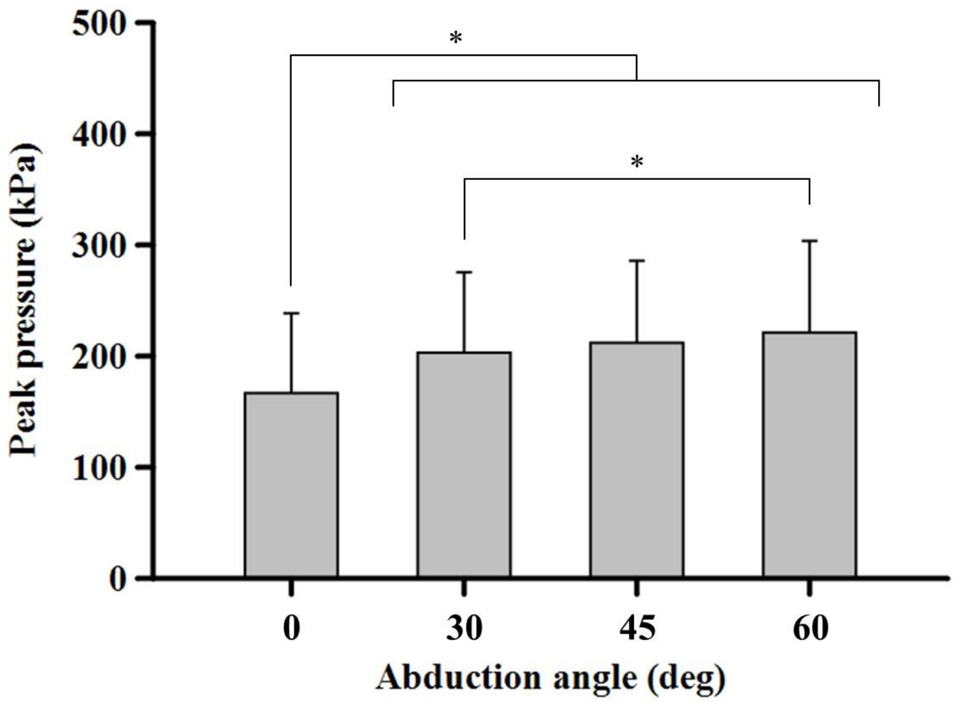

Figure 4. The contact pressure in normal shoulder among the abduction angles

* The mean is $p<0.05$

In the normal shoulder joint, the peak pressure between the subscapularis muscle and the anterior capsule according to the location of the glenohumeral joint decreased to 83.4±21.2 kPa in 0° abduction and -30° external rotation positions, and showed a 300.7±42.9kPa peak value in the 60° abduction and 60° external rotation positions (Table 2). Generally, as the glenohumeral joint was externally rotated, the mean peak pressure was significantly increased (p<0.05) except between the 30° and 45° (n.s.)(Figure 3). Similarly, the glenohumeral abduction resulted in the increase in the peak pressure, showing a significance between the 0° and others (i.e., 30°, 45° and 60°)(p<0.01), and the 30° and 60° (p<0.043) only(Figure 4). Table 3 shows the peak pressures between the capsulolabral complex and the glenoid according to glenohumeral joint location in the free ALPSA lesion. The lowest pressure of 122.1±26.7 kPa was observed at 0° abduction and -30° external rotation, and the highest pressure of 382.4±57.7 kPa, at 60° abduction and 60° external rotation. As the glenohumeral joint externally rotated, the peak pressure was significantly increased (p<0.01) except between -30° and 0°(n.s.), 30° and 45° (n.s.), and 45° and 60° (n.s.)(Figure 5). Similarly, the peak pressures at 60° abduction was significantly greater than other abduction postions (p<0.01)(Figure 6).

Table 3. The contact pressure between the capsulolabral complex and the glenoid in free ALPSA lesions

ER \ ABD	0°	30°	45°	60°
-30°	122.1 ± 26.7	164.6 ± 32.1	182.5 ± 32.8	236.9 ± 36.8
0°	134.6 ± 35.8	173.8 ± 40.7	208.9 ± 43.3	267.7 ± 40.4
30°	242.2 ± 49.4	255.3 ± 46.8	276.6 ± 47.7	303.8 ± 54.4
45°	267.3 ± 36.5	296.4 ± 45.5	298.4 ± 55.1	330.1 ± 45.8
60°	289.8 ± 41.1	312.7 ± 47.3	329.3 ± 47.3	382.4 ± 57.3

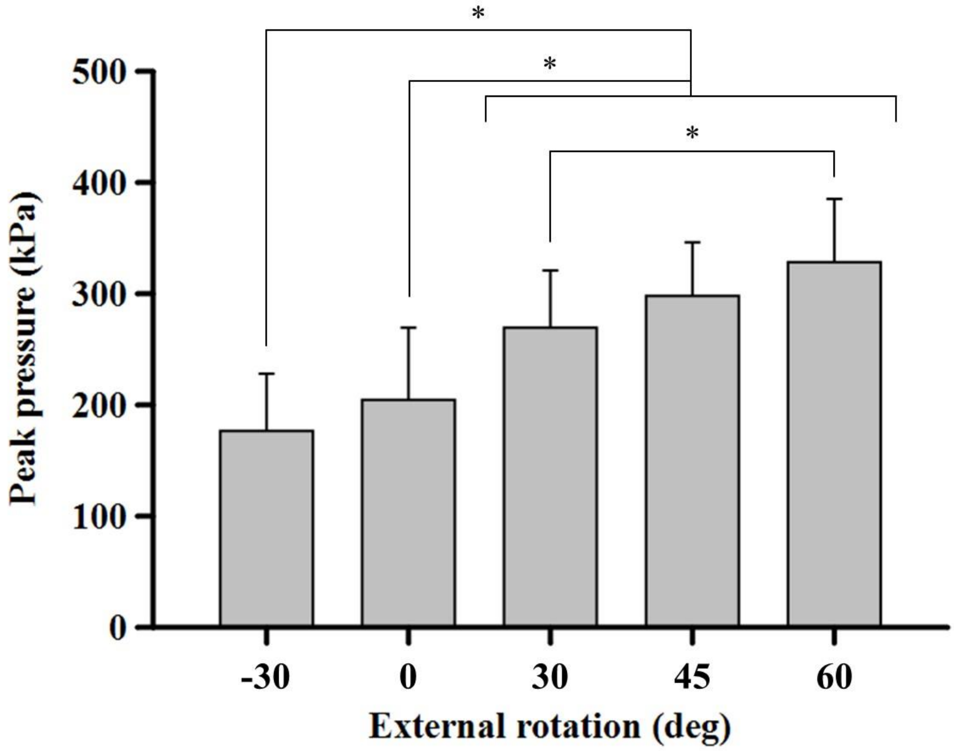

Figure 5. The contact pressure in free ALPSA lesions among the external rotation angles * The mean is p<0.05

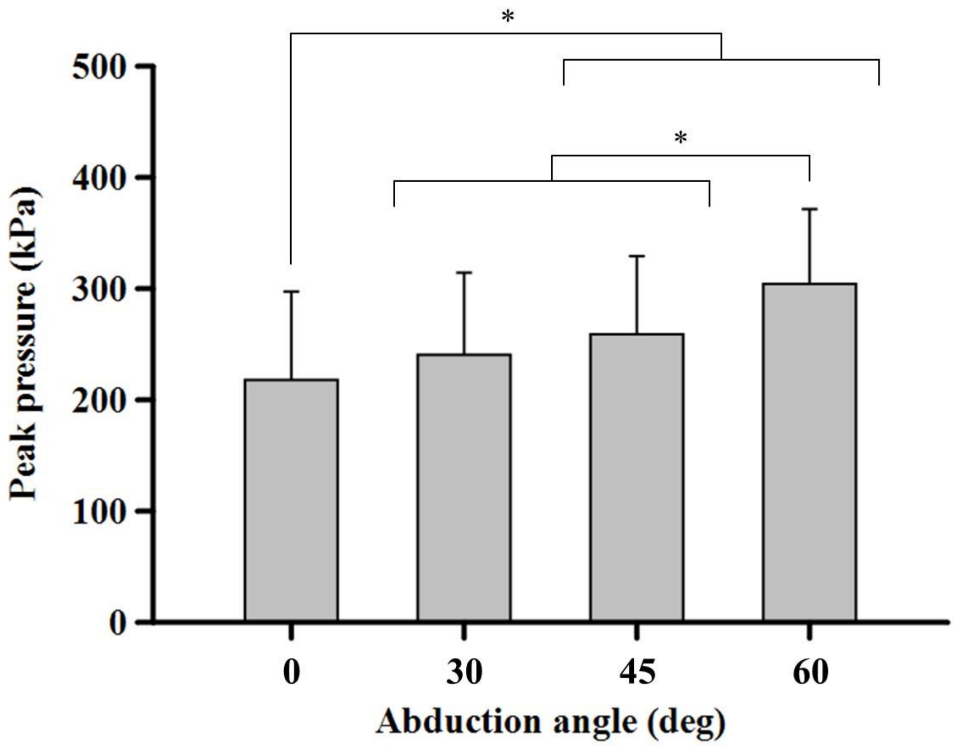

Figure 6. The contact pressure in free ALPSA lesions among the abduction angles

* The mean is p<0.05

The peak pressures between the capsulolabral complex and the glenoid according to glenohumeral joint location in the Bankart lesion was shown in Table 4. The lowest pressure of 91.6±30.1 kPa was observed at 0° abduction, -30° external rotation, and 60° abduction, and the highest pressure of 363.1±49.3 kPa at 60° external rotation. The differences between the -30° and 0° (n.s.), 30° and 45° (n.s.), and 45° and 60° (n.s.) external rotations were not significant, but those between all other external rotation angles were significant (p<0.01) (Figure 7). The difference between the 0° and 30° abductions (n.s.) was not significant but tended to increase, while the differences between all the other abduction angles were significant (p<0.01) (Figure 8).

Table 4. The contact pressure between the capsulolabral complex and the glenoid in Bankart lesions

ER \ ABD	0°	30°	45°	60°
-30°	91.6 ± 30.1	108.8 ± 33.2	122.8 ± 32.4	183.8 ± 38.3
0°	109.6 ± 33.0	130.7 ± 35.6	176.5 ± 41.3	211.1 ± 51.5
30°	143.8 ± 37.2	166.4 ± 40.4	230.3 ± 39.9	327.4 ± 49.3
45°	154.6 ± 39.5	181.4 ± 39.5	251.5 ± 45.0	351.6 ± 46.5
60°	163.4 ± 36.5	200.2 ± 40.0	288.3 ± 49.4	363.1 ± 49.3

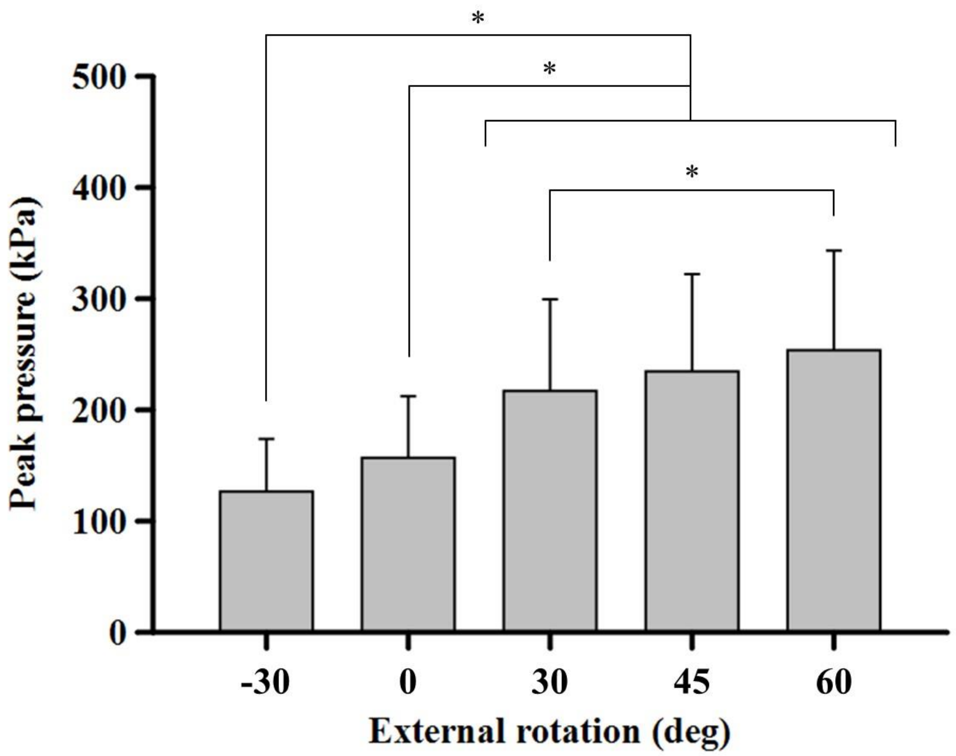

Figure 7. The contact pressure in Bankart lesions among the external rotation angles * The mean is $p<0.05$

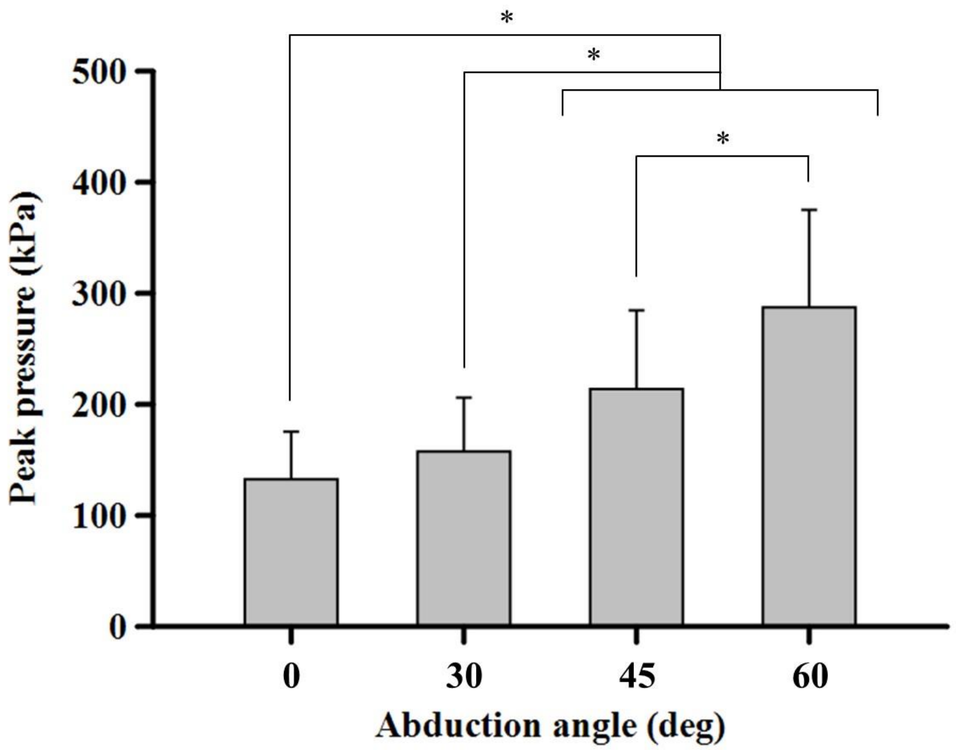

Figure 8. The contact pressure in Bankart lesions among the abduction angles

* The mean is p<0.05

VI. Discussion

The purpose of this study was to examine the effects of the conservative treatment on free ALPSA and Bankart lesions through direct measurement of contact pressure between the capsulolabral lesion and glenoid. As a result, the contact pressure significantly increased as the abduction and external rotation angles were increased, and the increase in contact pressure was greater in free ALSPA lesions than in Bankart lesions. These could lead that free ALPSA lesions would be better in reduction than Bankart lesions through immobilization in external rotation in first time anterior shoulder dislocation.

Anterior shoulder dislocation frequently develops in association with high-energy trauma or sports activities with mean recurrence rates of 33-52%, which can increase to up to 66-82% in patients 20 years of age or younger and in athletes.[6,24] Due to high recurrence rates, new approaches that are unlike conservative treatments for first-time anterior shoulder dislocation have been suggested.

Hart et al.,[4] performed arthroscopy to treat first-time anterior shoulder dislocation and observed improvements in external rotation of the arm and tightening of the anteroinferior portion of the capsulolabral complex. These improvements in the external rotation of the arm consequently enhanced the reduction of Bankart lesions. Itoi et al.[8] supported that result, showing that capsulolabral complex reduction with 10° external rotation immobilization could reduce the recurrence rate of shoulder dislocation. Pennecamp et al.,[18] found that MRI of anterior shoulder dislocation patients showed that labrum location was more physiologic in the external rotation than in other positions. Seybold et al.,[22] confirmed that the capsulolabral complex was more significantly reduced in the external rotation position than in the internal rotation position using MRI. In the present study, the peak pressure between the capsulolabral complex and the glenoid showed increases in external rotation. In free ALPSA and Bankart lesions, the peak pressure significantly increased between the 0° and 30° rotations, and also increased, but not significantly, between the -30° and 0° external rotations. Therefore, 30° external rotation in the neutral position may be better than internal rotation for maintaining reduction in the capsulolabral complex and the glenoid.

The coaptation effect of the subscapularis muscle is required for capsulolabral complex reduction through external rotation. Limpisvasti et al.[16] denied that coaptation of the subscaplularis muscle occurs in external rotation, while Itoi et al.[9] proposed that the coaptation effect was unlikely due to bony geometry, as the lesser tuberosity protrudes anteriorly. However, coaptation pressure caused by the subscapularis muscle was observed in the abduction and external rotation of the glenohumeral joint in the present study. The coaptation power tended to increase with external rotation angle rather than abduction angle. We confirmed that the peak pressure significantly increased at -30° in the 0°, 30°, 45°, and 60° external rotations, but pressure differences were nonsignificant between the 30° and 45° and 45° and 60° abductions.

It was necessary to confirm whether the coaptation pressure that functioned on the capsulolabral complex actually reduced capsulolabral complex lesions. Unlike previous studies,[21,26] which suggested that Bankart lesions are the most common lesions in shoulder dislocation, recent studies suggested that shoulder dislocations are observed in conjunction with various intra-articular lesions. Kim et al.[12] reported the presence of various intra-articular lesions in patients with first time shoulder dislocations, and of these, free ALPSA (27.2%) and Bankart (24.2%) lesions were most common pathologies. There are many discrepant results among previous studies because of their methodology of approaching the shoulder dislocation as a whole instead of accounting the particular lesions occurring within the dislocation. Thus, it is our thought that without considering the particular lesions found within first time shoulder dislocations, past studies inevitably obtained contradictory outcomes. Seybold et al.[23] support this perspective as well, noting that significant improvements were observed using external rotation for labroligamentous lesions on the glenoid rim. Perthes lesions showed better reduction than Bankart lesions in external rotation. Considering these results, we chose to examine free ALPSA and Bankart lesions in this study, because reduction was expected to occur through coaptation pressure of the subscapularis muscle only in bony Bankart, Bankart, and free ALPSA lesions, which are near the glenoid, whereas capsular tear and HAGL lesions were not effectively reduced through external rotation. Although the Bankart and free ALPSA lesions are representative capsulolabral lesions caused by anterior shoulder dislocations, they differ because in free ALPSA lesions, the labrum is attached to the periosteum, so lesion reduction is possible not only through coaptation pressure of the subscapularis muscle, but also through tension of the capsule connected to the periosteum via the external rotation of the glenohumeral joint. However, Bankart lesions are not connected to the labrum and the periosteum, and therefore can only be reduced only by coaptation pressure. Bankart and free ALPSA lesions are most frequently targeted in studies of intra-articular lesions after first time anterior shoulder dislocation, so we used these lesions in the present study.[1,11,12,15]

In Bankart and free ALPSA lesions, the pressure between the capsulolabral complex and the glenoid increased with abduction and external rotation. Free ALPSA lesions showed greater peak pressure and increased pressure compared to Bankart lesions, because the tightening of the anterior capsulolabral complex in the external rotation position on the lesions was the same but the periosteal ligamentotaxic effect was significantly reduced in the free ALPSA lesions. The pressure also increased in Bankart lesions according to glenohumeral position, but according to studies examining the usefulness of external rotation, the pressure was fixed at the 0° abduction and 10° external rotation positions. Accordingly, the increase in pressure in the Bankart lesion was not significant, and was also nonsignificant between -30° and 0° because Bankart lesions showed less pronounced ligamentotaxic effects than did free ALPSA lesions, which consequently showed less reduction. These diverse results for immobilization in external rotation drawn from the previous studies of Bankart lesions are explained by the diversity of intra-articular lesions and ligamentotaxic effects.

The limitations of this study included its small sample size, the fact that it was not an in vivo study, but a cadaveric study, the restrictions in scapular dynamic movement according to shoulder motion, and measurements of passive motion instead of active motion according to muscle power. In addition, we created labral lesions to incite shoulder instability, but gross evaluations of the degree of instability were not possible. Pressure measurement using the K-scan™ system (Tekscan Inc., MA, USA) is inaccurate on surfaces compared to planes. Nevertheless, our results suggest that first-time anterior shoulder dislocations may be successfully treated by reducing the shoulder in the externally rotated position. Our study is meaningful because we have shown that in anterior shoulder dislocation patients, free ALPSA lesions exhibited better reduction and recovery than Bankart lesions through immobilization in external rotation. Thus, differential diagnoses of intra-articular lesions through MRA and MRI are essential, since the identification of these intra-articular injuries may be helpful when selecting patients who may benefit from bracing in the externally rotated position.

VII. Conclusion

Contact pressure between the capsulolabral complex and the glenoid was significantly increased with abduction and increases in the external rotation angle. The increase in contact pressure was much higher in free ALPSA lesions than in Bankart lesions. In first time anterior shoulder dislocation patients, free ALPSA lesions showed better reduction than Bankart lesions through immobilization in external rotation, indicating that differential diagnosis of intra-articular lesions through MRA or MRI is essential.

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국문요약

ALPSA병변과 Bankart병변에서 관절와 상완관절의 위치에 따른

병변과 관절와 사이의 압력에 대한 고찰

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양 재 형

견관절 전방 탈구는 비교적 흔히 보는 손상이면서도 아직 최초 탈구 시 치료 방법의 원칙에 대한 여러 가지의 의견들이 발표되어 있다. 기존의 치료는 팔걸이나 보조기를 이용한 보존적 치료로 이 경우 재탈구율이 너무 높게 보고되고 있으며 연령대가 낮은 환자일수록 이러한 경향이 강하게 나타나고 있다. 이에 일부 저자들은 보존적 치료 시 관절와 상완관절을 외회전 상태로 고정해야 관절낭과 관절와순의 병변의 정복에 유리하고 추후 병변의 치유에도 유리하다고 주장하고 있다. Itoi등은 실제로 견관절 전방 탈구 환자에서 보조기 착용시 외회전 상태로 고정함으로써 재발을 줄일 수 있었다고 발표하였다. 이러한 주장의 이론적 근거는 다음과 같다. 관절와 상완관절을 외회전하여 고정하게 되면, 전방의 관절낭-관절와순 복합체가 긴장되고 견갑하근에 의한 coaptation pressure가 발생하여 병변이 제위치로 정복되며, 이를 유지하게 되면, 병변의 치유에 유리하다는 것이다.

그러나 이러한 주장에는 몇 가지 의문점이 있다. 최근 견관절 전방 탈구 환자에 있어 MRA, 관절경 등의 진단 도구의 발달로 인해 전방 탈구 시 발생할 수 있는 병변이 매우 다양함이 밝혀졌는데, 관절와 상완관절의 외회전이 이러한 다양한 병변에서 모두 효과를 보일 수 있을 지는 보고된 바가 없다. 견관절 전방 탈구로 인해 생기는 관절낭-관절와순 병변 중 가장 대표적인 것이 Bankart병변과 ALPSA 병변 인데 ALPSA 병변에서는 관절와순에 골막이 부착되어 있어 이론적으로 관절와 상완관절의 외회전을 통한 병변의 긴장을 통해 정복을 꾀하는 것이 가능하겠지만, Bankart 병변은 관절와순과 골막의 연결이 없어 병변의 정복에 같은 효과를 볼 수 있을 지는 의문이다. 또한 관절와 상완관절의 외회전 고정이 병변의 치유에 도움을 준다면 과연 얼마만큼 외회전을 시행해야 관절낭-관절와순 복합체의 긴장과 견갑하근의 coaptation을 유도할 수 있는 지에 대한 기준 또한 알려진 바가 없다.

이에 저자들은 사체를 이용하여 Bankart병변, ALPSA병변에 따라 관절와 상완관절의 외회전시 병변과 관절와사이의 압력에 차이가 있는지를 알아보려 하였다. 또한 병변과 관절와 사이에 가장 높은 압력을 얻을 수 있는 외회전 각도를 알아보기 위해 실험을 진행하였다.

5구, 10개의 견관절을 대상으로 실험을 하였다. 우선 정상 견관절 모델에서 K-scan pressure sensor를 견갑하근과 전방 관절낭 사이에 넣고 상완골을 각각 0, 30, 45,60도 외전한 상태에서 각 외전각도 마다 -30,0,30,60까지 외회전을 시행하여 각 각도에 따른 견갑하근과 전방 관절낭의 압력을 Tekscan pressure system을 이용하여 측정하였다.

그 후 cadaveric model을 5개의 견관절씩 두 군으로 나누고 ALPSA lesion과 Bankart 병변을 만들었다. 관절낭-관절와순 복합체와 관절와 사이에 K-scan pressure sensor를 위치시킨 후 이전 실험과 동일하게 각 외전, 회전 위치에서 pressure를 측정하였다. 관절의 안정성은 Vicon motion analysis system을 이용하여 확인하였다.

정상 견관절에서 견갑하골과 전방 관절낭 사이의 압력은 0도 외전, 30도 내회전시 83.4±21.2 kPa로 측정되었으며 60도 외전, 60도 외회전시 300.7±42.9kPa로 측정되었고 외전 및 외회전 각도가 증가할수록 압력은 증가하는 경향을 보였다.

ALPSA병변과 Bankart병변 모두 병변과 관절와순 사이의 압력이 0도 외전, 30도 내회전 시 가장 낮게 측정되었으며 60도 외전, 60도 외회전 시 가장 높게 측정되었다. 두 병변 역시 병변과 관절와순 사이의 압력은 외전, 외회전 각도가 증가함에 따라 유의미하게 증가하였고 ALPSA 병변에서 Bankart병변보다 더 증가하는 경향을 보였다.

결론적으로 외회전하여 고정했을 때 ALPSA병변에서 Bankart병변에 비해 정복이 잘 될 것으로 예상되며 보존적 치료 시 더 좋은 결과를 보일 것으로 생각된다. 따라서 견관절 전방탈구 시 병변의 감별진단을 위하여 MRA나 MRI등의 검사가 필수적이라 하겠다.

Key words : Free ALPSA 병변, Bankart 병변, 견관절 탈구, 사체실험, 생역학 연구