The Effect of Arm Position on the Repaired Capsulolabrum after Arthroscopic Bankart Repair: Magnetic Resonance Imaging Study

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**Purpose:** To evaluate and describe the findings of immediate postoperative, magnetic resonance (MR) arthrography of repaired capsulolabrum using two different arm positions (internal rotation and external rotation) for patients who had undergone arthroscopic Bankart repair.

**Materials and Methods:** Arthroscopically-repaired Bankart lesions were examined in the axial T2-weighted images of MR-arthrogram in twenty-two shoulders on the immediate postoperative day. We measured three parameters (height, slope, and medial overhang) on the axial images at the anteroinferior portion of the glenoid in internal and external rotation of the adducted arm. The mean internal rotation of the arm was 30° (range, 14° to 45°) and the mean external rotation was 19° (range, 2° to 44°). The two heights and slopes were compared using the paired t-test. For medial overhang, crosstable McNemar test was used. Statistical analyses were performed with the SPSS software package.

**Results:** There were 21 male and 1 female patients with a mean age of 24 years (range, 17 to 36 years). The arms in internal rotation position showed a loss of capsulolabral buttress in all patients. When the arm was in external rotation, the height and slope of the labrum were both greater, being on average 1.47 mm and 7°, respectively (p<0.001 for both measures), than those in the internal rotation position. Medial overhang on the glenoid rim was 81% positive when the arm was in the internal rotation position but 86% negative with the arm externally rotated (p<0.001).

**Conclusion:** Loss of repaired capsulolabral buttress seems to be inevitable when the arm is immobilized in the internal rotation position after arthroscopic Bankart repair. To prevent this, we recommend immobilization of the arm in external rotation after the surgery.

**Key Words:** Arthroscopic Bankart repair, Magnetic resonance-arthrogram, Postoperative arm immobilization

Repair of a torn capsulolabral complex, the Bankart lesion, back to the glenoid rim is essential in preventing recurrent shoulder instability. Development in arthroscopic technique have challenged the traditional open technique due to reduced morbidity with almost equal outcomes, according to recent reports. Furthermore, recent suture anchor repair enables anterior fixation of the anterior labrum instead of transosseous procedure. However, majority of the reports shows that arthroscopic suture anchor repair is still less satisfactory in terms of the recurrence rate. In an effort to improve the surgical outcome in arthroscopic Bankart repair with suture anchors, a few critical surgical steps have been emphasized. A list of some technical points includes use of motorized shaver to freshen and create bleeding surface of the labrum, mobilization of the labrum from the glenoid neck using arthroscopic elevators, decortication of the anterior glenoid neck, capsulolabral shift in a cephalad direction, and over-the-top placement of suture anchors on the glenoid surface. Especially, over the top (slight laterization on the glenoid surface) position of the suture anchor has recently been emphasized.

In addition to these precise surgical procedures, debate continues regarding the postoperative immobilization posi-
tion to improve the outcome. Traditionally, most surgeons have their patients immobilized in adduction and internal rotation position with the elbow in 90° flexion for 3 to 6 weeks, despite the lack of much clinical or experimental evidence supporting such a position of immobilization\(^4,5,14,23,24\). However, recent studies by Itoi et al.\(^12,13\) show that immobilization of the arm in external rotation better approximates the Bankart lesion to the glenoid than the conventional internal rotation position in acute dislocation of the glenohumeral joint. This statement was verified with cadaveric experiment as well as magnetic resonance imaging MRI studies showing that coaptation of anterior capsulolabral tissue is better when the arm is immobilized in such position which increases anterior soft-tissue tension\(^12,13\). We raised a question of whether this finding can be applied in repaired capsulolabral tissue after arthroscopic Bankart repair.

The authors coined a new term “the edge-slack phenomenon”, as a possible inherent weak point of the arthroscopic Bankart repair. We defined this edge-slack phenomenon as the falling down of the repaired capsulolabral tissue from the edge of the glenoid due to a point fixation in the arthroscopic suture anchor repair when the tension of the capsule is relieved by removing the traction of the arm and by immobilizing the arm in the internal rotation position with a sling (Fig. 1). This phenomenon results in the loss of conformity of the repaired capsulolabral buttress (or complex) by incomplete restoration of the glenoid depth and eventually may cause a less-stable shoulder. The purpose of this study was to evaluate the effect of postoperative arm position on the repaired capsulolabral buttress in arthroscopic Bankart repair using postoperative MRI.

**MATERIALS AND METHODS**

1. **Patient selection**
   Among the 77 patients treated at our institute for recurrent shoulder dislocation from July 2001 to June 2002, we selected those patients who previously had recurrent dislocation with Bankart lesion and negative sulcus sign. Patients with bony Bankart lesion, rotator cuff tears, superior labral lesion, and revision cases were excluded from the study. Twenty-two patients, 21 male and 1 female, 13 with right shoulder involvement and 9 with left, with a mean age of 24 years (range, 17 to 36 years), met the criteria and were able to undergo MRI within one postoperative day. The mean number of dislocation was 11.3 times (range, 1 to 50 times) and the average period from injury to surgery was 7.3 years (range, 4 months to 27 years).

2. **Magnetic resonance imaging and measurements**
   A 1.5-tesla MR magnetic resonance imager (Signa; General Electric Medical Systems, WI, USA) was used for all patients. Just prior to the imaging, 2-3 cc of Iomeron 300 (Bracco Imaging SpA, Milano, Italy) dye was injected to verify the proper joint space under fluoroscope. Afterwards, 40 cc of saline mixed with Magnevist (250:1 Schering AG, Germany) was injected into the shoulder joint for arthrogram.

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**Fig. 1.** Diagram illustrating the edge-slack phenomenon. (A) Suture anchor repair on the edge of glenoid can maintain the labral height when the arm is in traction and external rotation during surgery. (B) The edge-slack phenomenon is the phenomenon of falling down of the repaired capsulolabral tissue from the edge of the glenoid due to a point fixation in the arthroscopic suture anchor repair, when the tension of the capsule is relieved by removing the traction of the arm and by immobilizing the arm in the internal rotation position with a sling.
The MRI was performed with 4-mm thick slices with a 1-
mm gap between slices, a 16-cm field of view, and a matrix
size of 256 × 192. The arm was held at the side of the trunk
and was positioned first in internal rotation and then in
external rotation. The internal rotation was simulated such
that the elbow was flexed 90 degrees by resting the forearm
on the abdomen, which is the conventional position of post-
operative immobilization. Since the respiration movement
of the abdomen results in blurred images, the elbow was
extended while maintaining the internal rotation of the
shoulder with a strap. External rotation images were obtain-
ed in maximum possible external rotation, which the patient
could perform without discomfort. T2-weighted spin-echo
axial images were obtained.

All the measurements were performed on the PACS (Pic-
ture Archiving and Communications System, GE, IL, USA)
monitor system using a mouse point cursor and automated
computer calculation of distance and angle. An axial slice
at the inferior one-third level of the glenoid, just above the
most inferior anchor, was used to assess the degree of recre-
ation of the labral buttress of the repaired Bankart lesion.
Measurements were performed at the 4 and 8 o’clock posi-
tions in the right and left shoulders, respectively. We com-
pared the position of the anterior labrum relative to the
glenoid with the use of three parameters: height, slope, and
medial overhang. Height was defined as the distance (in
millimeters) between the lowest portion of the glenoid and
the tip of the labrum. Slope was defined as the angle formed
by a straight tangential line drawn at the lowest portion of
the glenoid and the line made by con-

![Fig. 2. Diagram illustrating the height and slope. Height was defined as the vertical distance in millimeters from the lowest portion of the glenoid to the tip of the labrum. Slope was defined as the angle formed by a straight tangential line drawn at the lowest portion of the glenoid and the line connecting the lowest portion of the glenoid and the tip of the anterior labrum. H: height, S: slope.](image)

![Fig. 3. Diagram showing the medial overhang of the repaired labrum. A tangential line is drawn from the anterior border of the glenoid and the status of capsulolabral complex. (A) If the capsulolabral complex is medial to this line, we defined it as a positive medial overhang. (B) Whereas if it was within the glenoid cavity, lateral to the line, it was defined as a negative medial overhang.](image)

![Fig. 4. Graph comparison of the three variables in relation to the rotation of the arm. Labral height and slope all showed increase with external rotation, whereas medial overhang was marked reduced.](image)
necting the lowest portion of glenoid and the tip of the labrum (Fig. 2). For medial overhang, a tangential line was drawn from the anterior border of the glenoid and the repaired capsulolabral complex. When the capsulolabral complex was medial to this line, we defined it as positive medial overhang, whereas if it was within the glenoid cavity, lateral to the line, we defined it as negative medial overhang (Fig. 3).

The angle of arm rotation was also measured on MRI-arthrogram. As a previous study stated that the bicipital groove faces directly anteriorly when the arm is in 10° of internal rotation, we measured the angle formed by the bicipital groove and the vertical. We calculated the rotation by adding or subtracting 10° from the internal or external rotation. All of the measurements were performed by one radiologist who was blind to the results. The mean angle of internal rotation was 30° (range, 14° to 45°; standard deviation, 10°), and the mean angle of external rotation was 19° (range, 2° to 44°; standard deviation, 11°). To assess the intraobserver repeatability, the measurements were repeated twice for all patients at different dates.

3. Statistical analysis

1) Patient sample size

Since this study aimed to compare the effect of two different positions on MRI, the null hypothesis (H0) was that there is no difference in the capsulolabral height and slope between the two positions. (H0: R1 = R2). To determine the appropriate sample size, we utilized a statistical program (nQuery Advisor 3.0, Statistical Solutions Ltd., Cork, Ireland), which incorporated the difference of means. With a two-sided level of significance set at 0.05 and 90% power, it was postulated that the expected difference in the means of the two positions (internal and external rotations) was 1 mm and 5 degrees for height and slope, respectively. The common standard deviation was 0.85 mm and 3.86 degrees for height and slope, respectively. Assuming that the paired t-test was used, a sample size of this study group was determined to be 10 patients, which was well satisfied by the 22 patients of the present study.

2) Outcome analyses

The measurements of height and slope were normalized by dividing the data by the ratio of the measured diameter of the individual humeral head to the mean diameter of the all patients’ humeral heads. (\( \alpha \) Height = \( \alpha \) Height/ \( \alpha \) HH/...
Mean ø HH/ Normalized ø HH/ mean ø HH/ (HH=Humeral Head, N=Normalized, ø=diameter, a=one individual). Intraobserver reliability of repeated measurements was assessed with the use of the correlation coefficient between the measurements at two different times. The two measurements (height and slope) of the two rotational positions on MR images were compared with the use of the paired t-test. For medial overhang, the relevance between two rotational positions in all individuals were compared with crossstable McNemar test. Statistical analyses were performed with the SPSS software package (SPSS for Windows Release 11.0, SPSS Inc, IL, USA). All analyses were set at a 95% confidence interval for statistical significance.

RESULTS

The reliability of repeated measurements by one observer was highly consistent with the intraobserver repeatability coefficient ranging from 0.84 to 0.98.

1. Capsulolabral parameter measures

Since both the height and slope differences in the normality plot were greater than 0.05, we used paired t-test for statistical analysis. The mean height in internal rotation was 5.3 mm (range, 3.3 to 6.8 mm), and in external rotation was 6.9 mm (range, 4.3 to 8.9 mm). The mean height difference between external rotation and internal rotation was 1.47 mm (range, 0.6 to 3.5 mm, p<0.001). The mean slope was 20° (range, 14° to 25°) and 27° (range, 21° to 32°) in internal and external rotation positions, respectively. The mean difference of slope was 6.91° (range, 2.2° to 11.2°, p<0.001). In internal rotation position, the positive medial overhang was positive in 18 of 22 patients (82%), whereas in external rotation position, it was negative in 19 of 22 patients (86%) (Fig. 4). Using the crossstable McNemar test, the difference was significant (p<0.001).

DISCUSSION

This study demonstrated that the status of repaired capsulolabral buttress in Bankart repair could be influenced to some extent by the postoperative arm immobilization position. External rotation position further restored the anterior labral height, whereas positioning of the arm resulted in overhanging of the repaired capsulolabral complex by caus-

Fig. 7. Diagram demonstrating the effect of over-the-top repair and external rotation position. (A) When operation is performed in lateral decubitus position, arm is placed under traction and external rotation with over-the-top position. (B) However if the traction is released and the arm left in internal rotation position, the repaired capsulolabral tissue loses some of its tautness and height.

Fig. 8. The patient was immobilized in slight external rotation with brace in immediate postoperative period.
ing the edge-slack phenomenon.

The edge-slack phenomenon mainly occurs in the arthroscopic suture anchor repair because of the point fixation on the edge of the glenoid. The normal attachment of the anterior labrum covers a broad area, which has several millimeters of overhang on the glenoid surface (Fig. 5). If the suture anchors are fixed at the corner of the glenoid rim, even though the repair appears to restore the normal labral overhang when the traction of the arm is maintained and the arm is externally rotated during the surgery, the point fixation of the suture anchor repair may fall off the glenoid after surgery when the traction is released and the arm is immobilized in the internal rotation position using a sling and eventually the repair will lose the labral overhang which was apparently achieved intraoperatively.

To prevent this edge-slack phenomenon, the repair should be made a few millimeters lateral from the edge of the glenoid. This over-the-top fixation can be successfully achieved by creation of a small pilot marking at the rim of the glenoid and by aiming the tip of the bone punch or drill at the lateral end of the pilot marking. The authors recommend using a the pituitary punch with a 2-mm tip width to create a pilot marking (Fig. 6). This over-the-top fixation restores the normal geometry of the labral attachment, which overhangs on the glenoid surface rather than being at the edge of the glenoid.

Although slight lateral positioning of the anchor may reproduce normal labral attachment, this anchor position alone, however, cannot fully prevent the edge-slack phenomenon and thus appropriate tensioning of the repaired capsulolabral complex toward the glenoid surface may also be helpful after Bankart repair. In many recurrent anterior shoulder dislocation patients, the anterior capsule is attenuated, and external rotation of the arm might possibly aggravate this weakness. Nevertheless, we feel that the bumper effect of the repaired capsulolabral complex is more important than this capsular attenuation. In addition, we observed that the external rotation produced more coaptation of the Bankart lesion. Just as in acute dislocation\(^1\),\(^2\),\(^3\), we demonstrated in this study that an external rotation position after Bankart repair might aid in tensioning the capsulolabral tissue which will somewhat lessen this edge-slack phenomenon, and ultimately increase the success rate of Bankart repair (Fig. 7). Therefore, a certain extent of external rotation immobilization may keep the anterior capsulolabrum in proper position after surgery so that the repaired capsulolabral complex holds tension on the glenoid. We believe that immobilization in the external rotation position can be crucial, especially during the immediate postoperative period when the repaired tissue is still friable and apt to adaptation, in order to give some time to heal after arthroscopic or open Bankart repair, as the healing process for soft tissues or bone depends on the approximation and immobilization.

Several points are worthy of comment in our study. There is no recent, to the best of our knowledge, describing the immediate MRI findings after arthroscopic Bankart repair. Since the quantitative errors in measurement are much smaller in spin-echo imaging\(^13\),\(^28\), we used only spin-echo imaging for the measurement to minimize the difference. Furthermore, using PACS for MRI measurement by an independent observer reduced possible bias and error. Measuring all data twice at a different date reduced intraobserver error. This study also includes power analysis in the statistical analysis. The study did, however, have some limitations. First, although the requirement for minimal sample size was exceeded, the number of subjects remained small at 22. Second, although we tried to minimize the errors in measurement, there remained the possibility for some intraobserver error. Third, since the MRI examination was performed immediately after the operation, some patients were able to gain maximal external rotation while others achieved only slight external rotation due to discomfort. Although almost all the patients showed a decrease in the edge-slack phenomenon on external rotation, this may not represent the true optimal range for postoperative immobilization. With our current number of study subjects, it remains too early to conclude optimal position for immobilization without the risk of detachment of repaired tissue. Nonetheless, we feel confident in recommending slight external rotation immobilization (Fig. 8).

In conclusion, loss of repaired capsulolabral buttress (edge-slack phenomenon) seems to be inevitable when the arm is immobilized in the internal rotation position after arthroscopic Bankart repair using suture anchors. To prevent this, we recommend immobilization of the arm in the external rotation position after surgery.
REFERENCES


관절경 방카트 술식시 복원된 관절외순-막 복합체와 어깨회전과의 관계
: 자기공명영상 소견

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목적: 관절경적 Bankart 수술시 복원된 관절낭-순이 수술 후 관절의 고정 위치(내회전과 외회전 상태)에 따라 변화가 있는지를 관절 조영 자기공명영상으로 평가하고자 하였다.

대상 및 방법: 관절경으로 Bankart 수술을 한 22명의 환자에서 수술 후 당일에 관절 조영 자기공명영상을 촬영하여 평가하였다. 환자는 내전된 상지의 내회전 및 외회전 상태에서 관절와 하방에서 촬영한 T2 축상면 영상을 이용하여 세가지 변수(관절낭-순의 높이, 경사도, medial)를 측정하였다. 평균 내회전은 30°(범위, 14-45°)였고 외회전은 19°(범위, 2-44°)였다. 복합된 관절낭-순의 높이와 경사도의 비교에는 paired t-test를 이용하였으며, medial overhang은 McNemar test를 이용하여 통계 처리하였다.

결과: 총 22명 중 21명이 남자였고 1명이 여자였으며, 평균 나이는 24세(범위, 17-36세)였다. 모든 환자에서 관절경적 내회전시 관절낭-순의 buttress가 감소하였다. 관절경적 내회전시 관절낭-순의 높이는 1.47 mm, 경사도는 7° 이상의 차이를 보였으며, 이는 통계학적으로 의미있는 차이를 보였다(p<0.001). medial overhang은 내회전시에 81%가 양성 반면 외회전시에는 86%가 음성이었으며 이는 통계학적으로 유의하였다(p<0.001).

결론: 관절경적 Bankart 수술로 관절낭-순을 복원한 후 관절경적 내회전 고정시 관절낭-순의 buttress가 소실되는 것으로 보인다. 이를 방지하기 위해 수술 후 외회전 상태로 고정하는 것이 권장될 것으로 사료된다.

색인 단어: 관절경적 Bankart 수술, 관절 조영 자기공명영상, 수술 후 관절 고정