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SHOULDER

Off-track Hill–Sachs lesions do not increase postoperative recurrent instability after arthroscopic Bankart repair with selective Remplissage procedure

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Abstract

Purpose This study aimed to compare clinical outcomes and recurrence rates after arthroscopic Bankart repair with selective Remplissage procedure, between patients with off-track and on-track Hill–Sachs lesions.

Methods Patients who underwent arthroscopic Bankart repair with selective Remplissage procedure for recurrent anterior shoulder instability and were followed up for at least 2 years were included. Patients with a glenoid defect greater than 25% were excluded. According to the glenoid track concept, patients were divided into group I (off-track lesions) and group II (on-track lesions). After Bankart repair, an additional Remplissage procedure was performed selectively in patients who sustained engagement of the humeral head. The clinical outcomes and recurrence rates were evaluated.

Results A total of 193 patients (23 in group I and 170 in group II) were enrolled. No significant differences were found in clinical outcomes (n.s.) or recurrence rates (n.s.) between the two groups, despite larger glenoid defects in group I (group I:17.1 ± 6.1%, and group II:13.0 ± 6.4%, $P = 0.003$). In all patients, the incidence of off-track lesions was not significantly different according to the occurrence of postoperative recurrence (n.s.), whereas the glenoid defect size showed a significant difference (with recurrence: 17.9 ± 3.9%, and without recurrence: 13.2 ± 6.5%, $P = 0.002$).

Conclusions The presence of an off-track lesion did not alter the clinical outcomes and recurrence rates after arthroscopic Bankart repair with selective Remplissage procedure. The glenoid defect size rather than the presence of an off-track lesion can more reliably predict postoperative recurrence. Arthroscopic Bankart repair with selective Remplissage procedure is considered one surgical option for the treatment of off-track lesions.

Level of evidence III.

Keywords Shoulder · Recurrent instability · Glenoid track · Bipolar · Bone defect · Arthroscopy

Introduction

Humeral head and glenoid bone defects are important factors for determining surgical strategies and predicting the postoperative prognosis of patients with recurrent anterior shoulder instability [2, 5, 13, 15]. In these patients, bipolar bone defects have been reported in 44% of patients with less than 5 dislocations. The incidence of bipolar bone defects increases up to 82% with an increase in the number of dislocations [16]. To assess both bone defects simultaneously, a glenoid track concept has been widely described with three-dimensional computed tomography (3D-CT) or magnetic resonance imaging (MRI) [13, 17, 25]. Several studies have reported an off-track Hill–Sachs lesion as a contributing factor for postoperative recurrent instability [10, 14, 22]. Shaha et al. demonstrated a 75% recurrence rate in patients with an off-track lesion after arthroscopic Bankart repair, whereas patients with an on-track lesion only showed an 8% recurrence rate [22]. Based on these clinical outcomes, different surgical procedures have been recommended based on the glenoid track status to increase glenohumeral stability. Generally, the Remplissage procedure in addition to Bankart repair is recommended for patients with glenoid bone defects of less than 25% combined with an off-track lesion [5, 13].

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However, on- or off-track lesions are determined only by the bone defect size of the humeral head and glenoid, although soft-tissue conditions, such as capsulolabrum and glenohumeral ligaments, are also important factors for postoperative stability [18, 23]. Furthermore, usually, the humeral head is internally rotated after arthroscopic Bankart repair with capsular plication, and true engagement of the humeral head is not always sustained after Bankart repair even in patients with an off-track lesion [3, 9, 19]. Therefore, the effect of an off-track lesion on postoperative instability can be lowered by arthroscopic Bankart repair with selective application of the Remplissage procedure. Reevaluating the effects of off-track lesions on postoperative recurrences and clinical outcomes will be interesting.

This study aimed to compare clinical outcomes and recurrence rates after arthroscopic Bankart repair with selective Remplissage procedure between patients with off-track and on-track Hill–Sachs lesions. It was hypothesized that the clinical outcomes and recurrence rates of patients with off-track lesions would be comparable to those of patients with on-track lesions.

Materials and methods

From 2008 to 2015, 237 patients who underwent an arthroscopic stabilization procedure for recurrent anterior shoulder instability in one institute were evaluated retrospectively. The indications for operative treatment were a history of frank traumatic anterior shoulder dislocation or subluxation with MRI findings of anterior capsulolabral complex tears and symptomatic instability with a positive sign on the apprehension test. Patients included in this study had symptomatic recurrent anterior shoulder instability confirmed by preoperative MRI and physical examinations, underwent arthroscopic stabilization surgery, and had been followed for at least 2 years after the operation. Patients were excluded when they had a glenoid bone defect greater than 25%, a combined rotator cuff tear that required repair, combined bicep tendon-related pathologies, a history of ipsilateral shoulder surgery, combined shoulder fractures or brachial plexus injury, or an age greater than 35 years.

Glenoid track evaluations

In all patients, the widths of the glenoid track and Hill–Sachs lesion were measured on preoperative MRI to determine whether the patient had on- or off-track lesions [6, 22]. The width of the glenoid track was calculated as 83% of the normalized glenoid width minus the glenoid bone defect width [17]. The normalized glenoid width was assessed by the diameter of the outer fitting circle based on the inferior portion of the glenoid contour on the sagittal T2-weighted image. The width of the Hill–Sachs lesion was calculated as the distance from the articular insertion of the rotator cuff tendon to the medial margin of the Hill–Sachs lesion on axial T2-weighted images. When the width of the Hill–Sachs lesion was greater than the width of the glenoid track, the patient was considered to have an off-track lesion, whereas on-track lesions were considered in cases, where the opposite was found. Patients with off-track lesions were placed in group I, and patients with on-track lesions were allocated to group II. The preoperative glenoid defect size was measured as the ratio of the glenoid bone defect width to the normalized glenoid width on a sagittal T2-weighted image. Two surgeons who were blinded to the clinical data independently assessed these measurements, and the averages of the two measurements were used in this study. The interobserver reliability was determined using intraclass correlation coefficients (ICCs). Four weeks after measurement by the 2 surgeons and 1 surgeon repeated the radiographic measurements to assess intraobserver reliability.

Clinical evaluations

All patients completed questionnaires to collect preoperative demographic data, such as age at the time of the first dislocation, operation, gender, and number of dislocations. The clinical outcomes were assessed using the Rowe score and the American Shoulder and Elbow Surgeons (ASES) score preoperatively, at 3, 6, and 12 months postoperatively and at the last visit. The return to sports activity level was assessed with four grades at the last visit as follows: grade I, no limitation in the previous sports activity; grade II, mild limitation in the previous sports activity; grade III, moderate limitation in the previous sports activity; and grade IV, severe limitation in the previous sports activity [4, 8]. Postoperative recurrence was defined as postoperative dislocation or subluxation events that required revision surgery.

Surgical procedures

All of the operations were performed by a single orthopedic surgeon with 18 years of experience. Under general anesthesia, the patients were placed in the lateral decubitus position with the arm in 40° abduction and slight forward flexion using a lateral traction device. Diagnostic arthroscopy was performed through the standard posterior portal. After moving the arthroscope to the anterosuperior portal, the Bankart lesion was repaired using at least four suture anchors, while the grasper was used to pull the capsuloligamentous complex upward to maintain the tension in the anterior labrum and to obtain the capsular plication effect [20]. After Bankart repair, the arm was brought into 90° abduction and 90° external rotation, while anterior pressure was placed on the humeral head to assess the engagement of

the Hill–Sachs lesion into the anterior glenoid margin under arthroscopic examination in the anterosuperior portal. This test was performed immediately before full engagement of the humeral head to avoid disrupting the repaired anterior labrum during testing for engagement. An additional Remplissage procedure was performed in patients with off-track lesions who sustained engagement of the humeral head even after Bankart repair. During the Remplissage procedure, two suture anchors were placed in the middle of the Hill–Sachs lesion. The sutures were passed over the infraspinatus tendon and the capsule in a mattress configuration and tied over the infraspinatus tendon in the subacromial space.

Postoperatively, shoulder joint immobilization was maintained for the first 4 weeks with an abduction brace. Passive range of motion exercises was begun after 4 weeks, and muscle-strengthening exercises were initiated at postoperative weeks 8–12. All sports activities were permitted after 6 months. The institutional review board of Ewha Womans University approved this study (IRB no: EUMC 2018-05-005), and informed consent was obtained from all participants.

Statistical analysis

The paired *T* test and Wilcoxon signed rank test were used to compare differences between the Rowe and ASES scores obtained preoperatively and at the final follow-up. The Mann–Whitney *U* test and Fisher's exact test were used to identify significant differences in clinical scores or recurrence rates between the two groups. Reliability was assessed using ICCs and a two-way mixed-effects model assuming a single measurement and absolute agreement. Significance was set at $P < 0.05$. All statistical analyses and tests were conducted using the SPSS program (SPSS version 21.0, Chicago, IL, USA).

Results

Of the 237 patients, 9 were excluded due to a concomitant rotator cuff tear requiring repair, 11 patients were excluded because of the age limitation, and three patients were excluded due to combined shoulder fractures. A total of 214 patients met the inclusion criteria, but 21 patients were lost to follow-up. Finally, 193 patients (23 in group I and 170 in group II) were enrolled in this study. The mean follow-up period was 36.5 ± 12.3 months in group I and 36.9 ± 12.8 months in group II. Group I showed significantly greater glenoid defects than group II ($P = 0.003$). The demographic data for the two groups are summarized in Table 1.

The clinical outcomes improved significantly after arthroscopic surgery regardless of the glenoid track type (in group I: $P < 0.001$ for the ASES and Rowe scores; in group II: $P < 0.001$ for the ASES and Rowe scores). Group I showed slightly poorer clinical outcomes than group II, although the differences did not reach statistical significance (Table 2). The average number of suture anchors used during Bankart

Table 2 Postoperative clinical outcomes and recurrence rates

	Group I ($n = 23$)	Group II ($n = 170$)	*P* value
ASES score			
Preoperative	51.7 ± 15.3	54.6 ± 15.0	n.s
At the final visit	89.3 ± 13.2	91.9 ± 10.8	n.s
Rowe score			
Preoperative	47.7 ± 16.2	49.1 ± 13.1	n.s
At the final visit	87.7 ± 12.2	90.6 ± 10.8	n.s
Recurrence (%)	8.7	6.5	n.s

ASES and Rowe scores were described as mean ± standard deviation

ASES American Shoulder and Elbow Surgeons

Table 1 Patient demographics

	Group I ($n = 23$)	Group II ($n = 170$)	*P* value
Gender (male:female)	20:3	157:13	
Age at the first dislocation (years)	20.5 ± 3.5	21.4 ± 6.0	n.s
Age at the operation (years)	22.9 ± 4.3	23.6 ± 6.4	n.s
Symptom duration (months)	28.1 ± 27.4	25.8 ± 23.1	n.s
Number of dislocations	4.7 ± 3.3	5.6 ± 3.4	n.s
Dominant arm	16 (69.6%)	116 (68.2%)	n.s
Generalized laxity	3 (13.0%)	41 (24.1%)	n.s
Glenoid defect size (%)	17.1 ± 6.1	13.0 ± 6.4	0.003*
High levels of sports activity	7 (30.4)	33 (19.4)	n.s
Non-collision athlete	1	7	
Collision athlete	4	14	
Soldier	2	12	

All values except gender and dominant arm were described as mean ± standard deviation

*Statistically significant

repair was 4.7 ± 1.1 in group I and 4.7 ± 1.5 in group II (n.s.). In group I, the width of the Hill–Sachs lesions averaged 20.2 ± 2.4 mm, and the width of the glenoid track was 17.9 ± 1.9 mm. In group I, six patients underwent an additional Remplissage procedure. Among these six patients, the width of the Hill–Sachs lesions averaged 20.2 ± 3.2 mm, and the width of the glenoid track was 16.8 ± 2.1 mm. The interobserver intraclass reliability was 0.88 and 0.84 and the intraobserver reliability was 0.91 and 0.88 for measurements of the Hill–Sachs lesion and glenoid track widths, respectively.

Postoperative recurrent instability occurred in 13 patients (6.7%), two (8.7%) of whom were in group I and 11 (6.5%) in group II. Of these patients, 11 were treated by arthroscopic revision Bankart repair with the Remplissage procedure (1 in group I) or without the Remplissage procedure (10 in group II). The other 2 patients (1 patient in each group) underwent an open Latarjet procedure as the revision surgery. Although the recurrence rate was slightly higher in group I than in group II, no significant difference was observed (n.s.). Of the 13 patients who had postoperative recurrence, the preoperative glenoid defect size was significantly greater than that of the 180 patients without recurrence (17.9 ± 3.9% in patients with recurrence and 13.2 ± 6.5% in patients without recurrence, $P = 0.002$). However, no significant difference was noted in the incidence of off-track lesions between the patients with and without recurrence (15.4% in patients with recurrence and 11.7% in patients without recurrence, n.s.) (Table 3). Among the six patients who underwent the additional Remplissage procedure, one patient experienced postoperative recurrence. Six patients (1 in group I and 5 in group II) experienced a single subluxation event after the operation. All of these patients were treated by shoulder muscle-strengthening exercises, and stability was restored at the final follow-up visit.

In group I, seven patients (30.4%) had high levels of sports activity, including professional athletes and soldiers. Among them, one rugby player experienced a postoperative recurrent dislocation during a rugby game. Another patient who participated in recreational judo play experienced recurrent subluxation during daily activity. In group II, 33 patients (19.4%) had high levels of sports activity. Competent recovery (level I or II) to the previous sports activity was achieved in 91.3% of the group I and 89.4% of the group II patients (n.s.).

Discussion

The most important finding of the present study was that arthroscopic Bankart repair with selective Remplissage procedure showed satisfactory clinical outcomes and low recurrence rates in patients with off-track as well as on-track lesions. The incidence of off-track lesions was not significantly different between the patients with and without postoperative recurrence, whereas the preoperative glenoid defect sizes showed a significant difference.

A biomechanical study proved that combined glenoid and humeral head defects had an additive and negative effect on glenohumeral stability compared to that of isolated glenoid or humeral head defects [1]. Itoi and Yamamoto introduced the glenoid track concept to allow simultaneous evaluation of bipolar bone defects; this concept is known to predict clinical engagement with an accuracy of 85% [11, 13, 26]. Surgeons should fully evaluate glenoid tracks before surgical procedures, because this area is frequently correlated with postoperative clinical outcomes [7, 25]. The glenoid track concept is determined by the size of the bipolar bone defect. Glenoid bone defects can be easily assessed on sagittal images of MRI or en-face views of 3D-CT [6, 24]. However, quantification of Hill–Sachs lesions is relatively difficult, because not only the width but also the depth, location, or direction of the Hill–Sachs lesions can affect their clinical importance [3, 9]. When Hill–Sachs lesions are shallow and

Table 3 Comparison of clinical outcomes, preoperative glenoid defect size and incidence of off-track lesions between patients with and without postoperative recurrence

	Patients with recurrence ($n = 13$)	Patients without recurrence ($n = 180$)	P value
ASES score			
Preoperative	51.5 ± 12.6	54.5 ± 15.3	n.s
At the final visit	69.7 ± 19.2	93.2 ± 8.4	< 0.001*
Rowe score			
Preoperative	51.9 ± 7.8	48.8 ± 13.8	n.s
At the final visit	65.2 ± 19.0	92.1 ± 7.5	< 0.001*
Glenoid defect size (%)	17.9 ± 3.9	13.2 ± 6.5	0.002*
Incidence of off-track lesions	2 (15.4%)	21 (11.7%)	n.s

ASES and Rowe scores were described as mean ± standard deviation

ASES American Shoulder and Elbow Surgeons

*Statistically significant

flat, true engagement cannot occur even when the lesion is wide enough to reach the glenoid anterior margin. In the present study, patients with off-track lesions showed satisfactory clinical outcomes and recurrence rates that were comparable to those of patients with on-track lesions despite the large size of the Hill–Sachs lesions. These results could be explained by changes in the location of the Hill–Sachs lesions and the possibility of nonengagement after Bankart repair with capsular plication. The humeral head usually rotated internally after repair and tightening of the anteroinferior capsulolabral tissue, and the locations of the Hill–Sachs lesions were altered far from the articular surface compared to their preoperative state. Furthermore, 10–15 degrees of external rotation limitation is frequently combined after Bankart repair with capsular plication, especially for patients with large bone defects [12, 27]. Therefore, there is little chance that the glenoid anterior margin will engage into the Hill–Sachs lesion even when the additional Remplissage procedure is not performed. Many clinical studies support the disappearance of engagement of the Hill–Sachs lesion after Bankart repair. During arthroscopic surveys, the incidence of engaging Hill–Sachs lesions was usually reported as 27–34% for patients with recurrent shoulder instability [3, 19]. However, that percentage decreased to 7% after Bankart repair [9]. Wide but shallow Hill–Sachs lesions are another reason for the satisfactory clinical outcomes of patients with off-track lesions [9].

Two studies have evaluated the clinical outcomes of patients with off-track lesions after arthroscopic surgery [10, 22]. These previous studies reported poor clinical outcomes and high recurrence rates for patients with off-track lesions compared to those of patients with on-track lesions, with recurrence rates of up to 75% for off-track lesions [22]. These recurrence rates were considerably higher than those of the patients with off-track lesions in the present study because of the different surgical procedures, such as the Remplissage procedure or capsular plication in addition to Bankart repair. In the present study, the authors made a conscious effort to restore the proper tension of the inferior glenohumeral ligament by capsular plication during Bankart repair. Moreover, patients who sustained engagement of the humeral head after Bankart repair with capsular plication underwent the additional Remplissage procedure. Six patients underwent the additional Remplissage procedure in the present study, which could have affected the lower overall recurrence rate of the patients with off-track lesions, because only one patient had postoperative recurrence among these six patients. Burkhart and Giacomo recommended arthroscopic Bankart repair with the Remplissage procedure in patients with glenoid bone defects of less than 25% combined with off-track lesions [5]. Following their recommendation, patients with off-track lesions had satisfactory clinical outcomes and low recurrence rates compared with those of the patients with on-track lesions in the present study. However, the Remplissage procedure was performed only in patients with clinical engagement even after Bankart repair, because the authors thought that the additional Remplissage procedure was not necessary in patients who did not sustain engagement of the humeral head. Different sample sizes could be another reason for the different recurrence rates. The two previous studies reported clinical outcomes and recurrence rates in only 8 and 12 patients with off-track lesions, respectively. These sample sizes were relatively small for evaluation of the clinical outcomes and recurrence rates.

In the present study, patients with off-track lesions showed significantly greater glenoid bone defect sizes than patients with on-track lesions. This result is inevitable, because the glenoid bone defect should be large enough to decrease the width of the glenoid track to less than that of the Hill–Sachs lesion in patients with off-track lesions. A large glenoid bone defect is well known as an important risk factor for postoperative recurrence and poor clinical outcomes [2, 15]. According to the previous studies, postoperative recurrence rates increase up to 67% in patients with a glenoid bone defect greater than 20% [2, 12]. The poor clinical outcomes and high recurrence rates may be caused mainly by large glenoid bone defects rather than off-track lesions. That possibility might also be supported by our finding that the incidence of off-track lesions was not significantly different between patients with or without postoperative recurrence, whereas the glenoid defect size showed a significant difference. However, further analysis is necessary to fully evaluate the effects of risk factors on postoperative recurrence.

This study has several limitations. First, the authors used MRI to evaluate off-track lesions, although the glenoid track concept was originally designed using 3D-CT [5, 7]. Several measurement differences exist between 3D-CT and MRI, because MRI is composed of only two-dimensional images. Recently, MRI has been used to evaluate off-track lesions more frequently than 3D-CT, because 3D-CT has poor interobserver reliability for off-track evaluation, whereas MRI shows moderate-to-strong agreement [6, 21]. Second, the sample size of patients with off-track lesions was relatively small. Moreover, only 2 and 11 patients experienced postoperative recurrence in the two groups, respectively. The lack of significant differences in the recurrence rates between the patients with on- and off-track lesions could be caused by the small sample size. However, enrolling a sufficient number of patients with off-track lesions was difficult because of their low incidence rate. Third, postoperative instability events that did not require revision surgery were not considered surgery failure. Therefore, an evaluation of the patients' dysfunctions after surgery would be limited. However,

in this study, postoperative instability events that did not require revision surgery only included a single subluxation event. Because patients' subjective impressions of single subluxation could be biased, the authors considered a single postoperative subluxation event as not indicative of postoperative recurrence. Fourth, the test for engagement of Hill–Sachs lesions under arthroscopic examination was conducted only in patients with off-track lesions. We used this test to decide whether an additional Remplissage procedure was needed after Bankart repair in patients with off-track lesions. Therefore, we did not consider performing this test in patients with on-track lesions necessary. Moreover, because this test carries some risk of disrupting the repaired labrum, we performed this test only in selective patients who truly needed the test. Finally, the additional Remplissage procedure was applied to only 26% of patients with off-track lesions. The different surgical modalities in patients with off-track lesions might be a bias for the functional results. However, the authors intended to show that the effect of off-track lesions on postoperative instability could be lowered by arthroscopic Bankart repair with selective application of the Remplissage procedure. Surgeons could consider arthroscopic Bankart repair with the selective Remplissage procedure as one surgical option for treatment of off-track lesions.

Conclusion

Arthroscopic Bankart repair with selective Remplissage procedure for patients with off-track lesions showed comparable clinical outcomes and recurrence rates to those of patients with on-track lesions. The presence of off-track lesions did not alter the clinical outcomes and recurrence rates after arthroscopic Bankart repair with selective Remplissage procedure. The glenoid defect size rather than the presence of an off-track lesion more reliably predicts postoperative recurrence. However, a future study with a sufficient sample size is needed to fully clarify the effects of off-track lesions on postoperative instability.

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Compliance with ethical standards

Conflict of interest Sang-Jin Shin has received research grants from the National Research Foundation of Korea (NRF) grant funded by the Korea government. In Park, Jun-Seok Kang, Yoon-Geol Jo, and Sang-Woo Kim declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The Institutional Review Board of Ewha Womans University approved this study (IRB no: EUMC 2018-05-005).

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