

Anterior shoulder instability with engaging Hill–Sachs defects: a comparison of arthroscopic Bankart repair with and without posterior capsulodesis

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Abstract

Purpose The purpose of this study was to compare the clinical results of isolated arthroscopic Bankart repair and those of arthroscopic Bankart repair with posterior capsulodesis for anterior shoulder instability with engaging Hill–Sachs lesions.

Methods Thirty-five shoulders that underwent isolated arthroscopic Bankart repair (Bankart group) and 37 shoulders that underwent arthroscopic Bankart repair with posterior capsulodesis (remplissage group) for anterior shoulder instability with engaging Hill–Sachs lesions were evaluated retrospectively. The mean age at the time of the surgery was 26.1 ± 7.0 years in the Bankart group and 24.8 ± 9.0 years in the remplissage group.

Results At the final follow-up, the Rowe and UCLA scores significantly improved in both the Bankart and remplissage groups ($P < 0.001$, in both groups). The post-operative mean deficit in external rotation at the side was $3^\circ \pm 10^\circ$ in the Bankart group and $8^\circ \pm 23^\circ$ in the remplissage group ($P = \text{n.s.}$ and $P = 0.044$, respectively). There was no decrease in muscle strength in either group. The recurrence rate was 25.7 % in the Bankart group and 5.4 % in the remplissage group ($P = 0.022$).

Conclusions Arthroscopic Bankart repair with posterior capsulodesis demonstrated good clinical outcomes with a low recurrence rate in the treatment for anterior shoulder instability with an engaging Hill–Sachs lesion. Although a limitation in external rotation was observed, there was no

significant limitation of any other motion and no decrease in muscle strength after the remplissage procedure. Posterior capsulodesis alone for remplissage should be considered as a surgical technique that can replace the conventional method.

Level of evidence Case–control study, Level III.

Keywords Shoulder · Anterior instability · Hill–Sachs lesion · Engaging · Arthroscopic Bankart repair · Remplissage · Posterior capsulodesis

Introduction

Several studies have investigated the effects of the Hill–Sachs lesion on recurrent glenohumeral instability and identified it as a contributor in the failure of anterior soft tissue stabilization [4, 6, 9, 21]. With recurrent episodes of glenohumeral instability, the lesion becomes larger and deeper, thereby increasing the risk of further instability [4]. Various surgical options for the management of recurrent anterior shoulder instability with an engaging Hill–Sachs lesion have been introduced.

Filling of the bony defect in the humeral head with a portion of the posterior capsule and infraspinatus tendon was first described by Connolly in 1972 [12]. Filling the humeral defect converts it to an extra-articular lesion and prevents the humeral head from engaging with the glenoid rim; posterior capsulodesis acts as a stabilizer, thereby preventing anterior translation of the humeral head. Purchase et al. [28] modified Connolly's procedure and were the first to use the term “remplissage” (“to fill” in French). They described the procedure as arthroscopic posterior capsulodesis and infraspinatus tenodesis to fill the Hill–Sachs lesion in addition to the arthroscopic Bankart procedure.

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Although several authors have reported the clinical outcomes of the arthroscopic remplissage procedure [2, 4, 5, 14–16, 20, 24, 26, 28, 29, 40], they performed both infraspinatus tenodesis and posterior capsulodesis to fill the humeral head defect. This “non-anatomic procedure” may induce changes in shoulder biomechanics including range of motion (ROM) and muscle strength, resulting from abnormal undue tension on the posterior structure. Accordingly, it is thought to produce more unexpected post-operative adverse effects than isolated Bankart repair. To minimize these adverse effects, one may consider enforcing only posterior capsulodesis without infraspinatus tenodesis to reduce abnormal undue tension on the posterior structure. To our knowledge, there is no information on the clinical outcomes of arthroscopic posterior capsulodesis alone for remplissage.

The purpose of this study was to compare the clinical results of isolated arthroscopic Bankart repair with those of arthroscopic Bankart repair with posterior capsulodesis for anterior shoulder instability with engaging Hill–Sachs lesions. It was hypothesized that the remplissage procedure would have a lower recurrence rate than isolated Bankart repair. It was also hypothesized that some limitation in shoulder motion and decrease in strength of external rotators would be inevitable in the remplissage group compared to the isolated Bankart repair group.

Materials and methods

Seventy-two patients with an Instability Severity Index Score (ISIS) [3] of ≥ 3 and an isolated large (Calandra [8] grade 3) or engaging Hill–Sachs lesion confirmed on dynamic arthroscopic examination and without significant glenoid bone loss (glenoid deficit $<25\%$) on

three-dimensional computed tomography (3D CT) were enrolled in this study. Thirty-five patients underwent isolated arthroscopic Bankart repair (Bankart group), and 37 patients underwent arthroscopic Bankart repair with posterior capsulodesis alone for the remplissage procedure (remplissage group). Patients with only soft tissue lesions, hyperlaxity (2+ or greater laxity on the sulcus sign) or voluntary instability, glenoid defects $>25\%$ of the inferior glenoid diameter, rotator cuff tears, severe pre-existing glenohumeral osteoarthritis, or epilepsy were excluded from the study. Patients who underwent the Latarjet procedure were also excluded. All patients underwent routine preoperative radiography and 3D CT scans to check for evidence of a substantial bony lesion of the glenoid and humerus. The glenoid bone deficit was calculated based on the AP distance using the bare area method [37] on the *en face* view of 3D CT [11, 18]; the depth of the Hill–Sachs lesion was measured directly on an axial CT image, in the area where the size of the lesion was the largest, with a digital measurement tool, and was defined as the longest length between the bottom of the lesion and the corresponding arc.

The mean patient age at the time of the surgery was 26.1 ± 7.0 years (range 14–46 years) in the Bankart group and 24.8 ± 9.0 years (range 14–52 years) in the remplissage group. The mean follow-up period was 22.9 ± 13.5 months (range 12–48 months) and 24.7 ± 9.5 months (range 19–31 months), respectively. Patient demographic details for both groups are summarized in Table 1. There were no significant differences in the demographic data between the two groups.

Surgical techniques

All surgeries were performed by the senior author, with the patient in a 70° beach chair position. With the arthroscope

Table 1 Patient demographics in the Bankart and remplissage groups

| Variables | Bankart group ($n = 35$) | Remplissage group ($n = 37$) | <i>P</i> value |
|---|-------------------------------|--------------------------------|----------------|
| Age at surgery (years) | 26.1 ± 7.0 (range 14–46) | 24.8 ± 9.0 (range 14–52) | n.s. |
| Age at primary dislocation (years) | 20.3 ± 5.7 (range 11–39) | 18.3 ± 6.3 (range 10–36) | n.s. |
| Gender (male/female) | 33/2 | 34/3 | n.s. |
| Mean follow-up (months) | 22.9 ± 13.5 (range 12–48) | 24.7 ± 9.5 (range 19–31) | n.s. |
| Dominant involvement | 28 (80 %) | 32 (86 %) | n.s. |
| Frequency of dislocation | 10.4 | 7.7 | n.s. |
| Glenoid bone deficit (%) | 9.9 ± 6.9 (range 0–21.8) | 8.5 ± 5.8 (range 0–20.3) | n.s. |
| Depth of Hill–Sachs lesion (mm) | 6.0 ± 1.5 (range 3.9–9.7) | 6.8 ± 1.7 (range 4–11) | n.s. |
| Instability Severity Index Score (ISIS) | 4.2 ± 1.3 (range 3–7) | 4.2 ± 1.0 (range 3–6) | n.s. |
| No. of anchors in Bankart repair | 3.8 ± 0.8 | 3.7 ± 0.6 | n.s. |
| No. of anchors in the remplissage procedure | – | 2.4 ± 0.8 | |

Mean \pm standard deviation, unless otherwise indicated

n.s. Not statistically significant

in the posterior portal, the arm was brought into abduction and external rotation (ER), and the humeral head was pushed anteriorly to confirm an engaging humeral defect over the anterior glenoid rim.

After completion of the anterior capsulolabral repair, the remplissage procedure was performed. Four limbs from the two single-loaded anchors were relayed by passage through the infraspinatus and the posterior joint capsule and pulled through the small skin incision. The knot pusher was pushed along the two limbs of each anchor to enable dissection of the muscular portion of the infraspinatus around the limb to the posterior capsule. Care was taken not to strip off the posterior capsule from the limb. Once all the muscular portions of the infraspinatus were stripped from the four limbs of both anchors, the limbs from each anchor were tied.

Post-operative rehabilitation

Patients of both groups underwent rehabilitation according to the same general protocol for each group. In the Bankart group, the shoulders were immobilized for 3 weeks post-operatively. In the meantime, only pendulum exercises were allowed. Three weeks after the surgery, passive elevation and ER were performed to achieve full ROM at 6 weeks post-operatively. Muscle strengthening exercises followed. Patients were allowed to participate in sport activities only after they had gained full range of shoulder motion without pain and near-normal muscle strength. In the remplissage group, use of a shoulder sling for inhibition of abduction and ER was recommended for 6 weeks. After 6 weeks, patients were allowed to remove the sling for active movements. Contact sports or “at-risk” work-related activities were not allowed for 6 months.

Preoperative and post-operative evaluations

A retrospective analysis of the prospectively collected patient data was performed. A thorough patient history regarding the cause of initial dislocation, type of dislocation, interval between the first and second dislocations, and frequency of dislocation was obtained before the surgery. The load-and-shift test and sulcus sign test were performed in both shoulders to check anterior, posterior, and inferior translations and general laxities.

Preoperative and post-operative pain and instability were assessed with the visual analogue scale (VAS), with 0 indicating a painless stable shoulder and 10 indicating a severely painful unstable shoulder. Active and passive shoulder ROM in forward flexion (FF), ER at the side (ERs), external and internal rotations at 90° of abduction (ERa and IRa), and internal rotation to the posterior (IRp) were assessed, with the patient in the seated position.

Quantitative muscle strength measurements were assessed with the use of a portable, hand-held Nottingham Mecmesin Myometer (Mecmesin Co, Nottingham, UK). The Rowe score [32] and the Shoulder Rating Scale of the University of California at Los Angeles (UCLA) score [13] were used for clinical assessment. In the remplissage group, all patients underwent preoperative magnetic resonance imaging (MRI), and magnetic resonance arthrography (MRA) was performed at least 6 months post-operatively to evaluate the integrity of the humeral defect filling as a structural outcome. The grade of the “filling” from the posterior joint capsule to the humeral head defect was assessed on the axial plane in the region where the size of the lesion was the largest on the MRA images. All values were measured directly using digital imaging software. The post-operative filling was classified into five categories based on the axial views of T2-weighted images [31]: grade 4, complete filling with no fluid equivalent signal; grade 3, partial filling with a minor defect (<50 % of the whole length of the lesion); grade 2, partial filling with a major defect (≥50 % of the whole length of the lesion); grade 1, minimal filling with a significant free fluid level; and grade 0, filling failure with dehiscence.

Final approval of exemption from review by the IRB was obtained for this study because of its retrospective nature (KHNMC IRB 2012-136).

Statistical analysis

The paired *t* test was performed to evaluate the differences in preoperative and post-operative values. For a comparison of results between the two groups, the Student’s *t* test was used, and the χ^2 test was used for comparing proportions between groups. The level of significance was set at 0.05 with associated 95 % confidence intervals. The SPSS software package (version 18.0; SPSS, Inc., an IBM Company, Chicago, Illinois) was used for all statistical analyses. For a power analysis, we additionally adopted a stringent approach of a conditional power analysis of two proportions using the Power and Sample Size Calculation Program (version 3.1.2, 2014).

Results

A detailed comparison of the preoperative variables in both groups is presented in Table 2. There was no significant difference between the two groups.

At the final follow-up, there were statistically significant discrepancies in IRp compared with the contralateral shoulder in the Bankart group ($P = 0.009$) and in ERs and IRp in the remplissage group ($P < 0.001$ and $P = 0.002$, respectively) (Table 3). Preoperative ROM and post-operative

ROM in both groups are summarized in Table 4. At the final follow-up, there was a statistically significant restriction in ERs in the remplissage group ($P = 0.044$). However, there was no significant difference in post-operative ROM between the Bankart and remplissage groups.

The VAS score for pain during motion and instability and the Rowe and UCLA scores showed statistically

significant improvement after the surgery in both groups (Table 5). When the two groups were compared, the remplissage group had better post-operative results for some of the variables. There was a significant difference in the VAS score for instability and in the Rowe score between the two groups ($P = 0.004$ and 0.011 , respectively). At the final follow-up, there was a significant increase in the muscle strength of forward flexors in the Bankart group ($P = 0.047$) and of external rotators, internal rotators, and abductors in the remplissage group ($P = 0.006, 0.009$, and <0.001 , respectively).

In the remplissage group, 20 of 37 patients underwent MRA at least 6 months post-operatively. The post-operative MRA examination of the fillings revealed grade 4 in 13 patients (65 %), grade 3 in three patients (15 %), grade 2 in two patients (10 %), grade 1 in one patient (5 %), and grade 0 in one patient (5 %).

The overall recurrence rate (positive apprehension sign, subluxation, or dislocation) in the Bankart group (25.7 %, nine of 35 patients) was significantly higher than that in the remplissage group (5.4 %, two of 37 patients) ($P = 0.022$), and the frank redislocation rates were 14.3 % (five patients) and 0 %, respectively ($P = 0.023$).

Among nine patients who had recurrent instability in the Bankart group, five patients who experienced a frank dislocation required additional surgery. Two patients underwent open Bankart repair as a revision surgery (at 12 and 25 months post-operatively, respectively); two patients underwent the Latarjet procedure (at 11 and 33 months post-operatively, respectively); and 1 patient underwent revision arthroscopic Bankart repair with the remplissage

Table 2 Comparison of preoperative data in the Bankart and remplissage groups

| Preoperative variables | Bankart group | Remplissage group | P value |
|--------------------------|---------------|-------------------|---------|
| VAS (pain at rest) | 0.4 ± 0.8 | 0.3 ± 0.9 | n.s. |
| VAS (pain during motion) | 2.2 ± 2.3 | 2.0 ± 1.9 | n.s. |
| VAS (instability) | 5.3 ± 1.5 | 4.6 ± 2.0 | n.s. |
| ROM | | | |
| FF | 165° ± 8° | 162° ± 9° | n.s. |
| ERs | 65° ± 14° | 66° ± 11° | n.s. |
| ERa | 83° ± 14° | 84° ± 10° | n.s. |
| IRa | 72° ± 11° | 71° ± 10° | n.s. |
| IRp | T7.4 ± 2.5 | T7.3 ± 2.6 | n.s. |
| Rowe score | 42 ± 13 | 46 ± 18 | n.s. |
| UCLA score | 24 ± 3 | 25 ± 3 | n.s. |

Mean ± standard deviation, unless otherwise indicated

VAS Visual analogue scale, ROM range of motion, FF forward flexion, ERs external rotation at the side, ERa external rotation at 90° of abduction, IRa internal rotation at 90° of abduction, IRp internal rotation to the posterior, UCLA University of California at Los Angeles, n.s. not statistically significant

Table 3 Discrepancies in range of motion compared with the contralateral shoulder

| | FF | ERs | ERa | IRa | IRp |
|-------------------|---------|----------|---------|---------|-----------|
| Bankart group | | | | | |
| Preoperative | | | | | |
| Difference | 3° ± 2° | 4° ± 3° | 3° ± 3° | 0° ± 3° | 1.0 ± 0.6 |
| P value | n.s. | n.s. | n.s. | n.s. | n.s. |
| Final follow-up | | | | | |
| Difference | 3° ± 2° | 5° ± 3° | 4° ± 3° | 0° ± 3° | 1.3 ± 0.5 |
| P value | n.s. | n.s. | n.s. | n.s. | 0.009 |
| Remplissage group | | | | | |
| Preoperative | | | | | |
| Difference | 2° ± 2° | 6° ± 2° | 2° ± 3° | 0° ± 2° | 1.8 ± 0.5 |
| P value | n.s. | 0.014 | n.s. | n.s. | 0.001 |
| Final follow-up | | | | | |
| Difference | 3° ± 2° | 14° ± 3° | 3° ± 4° | 3° ± 3° | 2.4 ± 0.7 |
| P value | n.s. | <0.001 | n.s. | n.s. | 0.002 |

Mean ± standard deviation, unless otherwise indicated

FF forward flexion, ERs external rotation at the side, ERa external rotation at 90° of abduction, IRa internal rotation at 90° of abduction, IRp internal rotation to the posterior, n.s. not statistically significant

Table 4 Preoperative and post-operative range of motion in the Bankart and remplissage groups

| ROM | Bankart group | | | | Remplissage group | | | | P value ^a |
|-----|---------------|----------------|------------|---------|-------------------|----------------|------------|---------|----------------------|
| | Preoperative | Post-operative | Difference | P value | Preoperative | Post-operative | Difference | P value | |
| FF | 165° ± 8° | 163° ± 9° | 2° ± 10° | n.s. | 162° ± 9° | 160° ± 10° | 3° ± 10° | n.s. | n.s. |
| ERs | 65° ± 14° | 62° ± 14° | 3° ± 10° | n.s. | 66° ± 11° | 58° ± 19° | 8° ± 23° | 0.044 | n.s. |
| ERa | 83° ± 14° | 81° ± 16° | 2° ± 15° | n.s. | 84° ± 10° | 80° ± 9° | 4° ± 13° | n.s. | n.s. |
| IRa | 72° ± 11° | 68° ± 12° | 4° ± 16° | n.s. | 71° ± 10° | 65° ± 15° | 6° ± 17° | n.s. | n.s. |
| IRp | T7.4 ± 2.5 | T8.1 ± 2.4 | 0.7 ± 2.3 | n.s. | T7.3 ± 2.6 | T8.2 ± 3.6 | 0.8 ± 4.4 | n.s. | n.s. |

Mean ± standard deviation, unless otherwise indicated

ROM Range of motion, FF forward flexion, ERs external rotation at the side, ERa external rotation at 90° of abduction, IRa internal rotation at 90° of abduction, IRp internal rotation to the posterior, n.s. not statistically significant

^a Comparisons between post-operative values in the two groups

Table 5 Clinical outcomes in the Bankart and remplissage groups

| Variables | Bankart group | | | | Remplissage group | | | | P value ^a |
|--------------------------|---------------|----------------|------------|---------|-------------------|----------------|------------|---------|----------------------|
| | Preoperative | Post-operative | Difference | P value | Preoperative | Post-operative | Difference | P value | |
| VAS (pain at rest) | 0.3 ± 0.8 | 0.3 ± 0.5 | 0 ± 0.8 | n.s. | 0.3 ± 0.9 | 0.1 ± 0.4 | -0.1 ± 1.0 | n.s. | n.s. |
| VAS (pain during motion) | 2.2 ± 2.3 | 0.8 ± 1.0 | 1.3 ± 2.1 | 0.001 | 2.0 ± 1.9 | 1.2 ± 1.1 | -0.7 ± 1.8 | 0.019 | n.s. |
| VAS (instability) | 5.3 ± 1.5 | 1.3 ± 2.1 | 4.1 ± 2.2 | <0.001 | 4.6 ± 2.0 | 0.1 ± 0.5 | 4.4 ± 1.8 | <0.001 | 0.004 |
| Rowe score | 42 ± 13 | 84 ± 19 | 42 ± 24 | <0.001 | 46 ± 18 | 93 ± 6 | 47 ± 19 | <0.001 | 0.011 |
| Stability | 15 ± 9 | 40 ± 18 | 25 ± 21 | <0.001 | 19 ± 10 | 49 ± 4 | 30 ± 11 | <0.001 | 0.004 |
| Motion | 14 ± 4 | 16 ± 5 | 2 ± 5 | n.s. | 16 ± 5 | 17 ± 3 | 1 ± 6 | n.s. | n.s. |
| Function | 13 ± 7 | 28 ± 3 | 15 ± 7 | <0.001 | 12 ± 8 | 26 ± 3 | 14 ± 8 | <0.001 | n.s. |
| UCLA score | 24 ± 3 | 32 ± 3 | 8 ± 3 | <0.001 | 25 ± 3 | 33 ± 4 | 8 ± 5 | <0.001 | n.s. |
| Muscle strength (kg) | | | | | | | | | |
| FF | 8.4 ± 3.1 | 9.3 ± 2.8 | 0.9 ± 2.7 | 0.047 | 8.9 ± 2.0 | 9.0 ± 2.5 | 0.1 ± 2.6 | n.s. | n.s. |
| ER | 8.9 ± 2.5 | 9.3 ± 2.6 | 0.4 ± 2.4 | n.s. | 8.4 ± 1.6 | 9.3 ± 2.3 | 1.0 ± 2.0 | 0.006 | n.s. |
| IR | 9.0 ± 2.6 | 9.6 ± 2.4 | 0.7 ± 2.6 | n.s. | 8.4 ± 2.0 | 9.7 ± 2.6 | 1.3 ± 2.8 | 0.009 | n.s. |
| Abd | 8.1 ± 3.0 | 8.9 ± 2.9 | 0.8 ± 2.8 | n.s. | 8.5 ± 1.5 | 9.3 ± 1.8 | 1.4 ± 1.5 | <0.001 | n.s. |

Mean ± standard deviation, unless otherwise indicated

VAS Visual analogue scale, UCLA University of California at Los Angeles, FF forward flexion, ER external rotation, IR internal rotation, Abd abduction, n.s. not statistically significant

^a Comparisons between post-operative values in the two groups

procedure (at 12 months post-operatively). Four patients who had positive apprehension sign or subluxation post-operatively did not require additional stabilization surgery. They recovered with conservative treatment, which included muscle strengthening exercises.

Among the two patients who had recurrent instability in the remplissage group, one had persistent pain and subjective apprehension sign without frank dislocation at 18 months post-operatively. As the MRA demonstrated a 100 % filling of the humeral defect, conservative treatment was adopted. The other patient also had subjective apprehension sign without frank dislocation at 6 months post-operatively when playing basketball at a competitive level,

but underwent conservative treatment with no other event of recurrence.

At the final follow-up, in the Bankart group, 19 (57.6 %) of the 33 active patients showed complete return to pre-injury activity levels (grade 1); 12 (36.4 %) showed near return to preinjury activity levels (≥ 90 % recovery) (grade 2); and 2 (6.0 %) showed return to preinjury activity levels with moderate limitations (≥ 70 % recovery) (grade 3). In the remplissage group, the post-operative filling was classified as grade 1 in 22 (68.8 %) of the 32 active patients, grade 2 in seven (21.9 %), and grade 3 in three (9.3 %). There was no significant difference in the return to sport activities between the two groups (n.s.).

Discussion

The most important finding of the present study was that arthroscopic Bankart repair with posterior capsulodesis was associated with a significantly lower recurrence rate than isolated Bankart repair. In addition, even though a limitation in ERs was observed, there was no significant limitation of any other motion and no decrease in muscle strength after the remplissage procedure.

Despite the advances of the arthroscopic Bankart repair technique, in some cases, it has been associated with a disappointing result. In 2000, Burkhart and De Beer [7] refocused attention on the role of the engaging Hill–Sachs lesion in recurrent anterior shoulder instability. They reported an unacceptable high failure rate of 67 % after arthroscopic Bankart repair in patients with glenohumeral bone deficiency and recurrence in all of the three cases with engaging Hill–Sachs lesions. Patel et al. [27] attributed most failures of prior surgeries for correction of instability to an unidentified Hill–Sachs lesion. Similarly, Lynch et al. [23] attributed up to 93 % of recurrent instability cases to large engaging Hill–Sachs lesions.

Although there are several studies on the treatment for glenoid bone loss [23, 25, 33–38], bone defects of the humeral head have not been thoroughly evaluated. There is little consensus regarding surgical indications or standard treatments to reconstruct defects of the humeral head [22]. Surgical procedures to correct bony defects of the humeral head include the remplissage procedure [5, 28, 29], osteoarticular humeral head allograft [10, 36], resurfacing arthroplasty [23], rotational osteotomy of humerus [39], transhumeral head plasty [30], and percutaneous humero-plasty [19].

Currently, the arthroscopic technique, which helps avoid complications frequently associated with open, non-physiologic procedures such as the Latarjet procedure, is of great interest in the field of shoulder surgery [17]. The remplissage procedure, initially described as an open technique, was re-described by Purchase et al. [28] as an arthroscopic technique in 2008. This is partially related to patient selection in this study, because the authors have performed the remplissage procedure since 2008.

In the present study, the first hypothesis was that the remplissage procedure provides more stability to the shoulder joint in the presence of an engaging Hill–Sachs lesion. Up until the final follow-up, the remplissage group had an overall recurrence rate of 5.4 % and a frank redislocation rate of 0 %, whereas the Bankart group had a significantly higher recurrence rate of 25.7 % and redislocation rate of 14.3 %. The Rowe score also showed a significantly higher improvement in the remplissage group than in the Bankart group. These results confirm that filling humeral

head defects using a remplissage procedure can prevent engaging of the Hill–Sachs lesion with the glenoid rim and support Bankart repair. The overall recurrence rate in this study was lower than the 8 % recurrence rate following the combined procedure reported by Purchase et al. [28], but slightly higher than the 2 % recurrence rate reported by Boileau et al. [4] and 0 % recurrence rate reported by Franceschi et al. [14].

The second hypothesis was that some limitation in shoulder motion and decrease in strength of external rotators were inevitable after the remplissage procedure. As remplissage is a non-anatomic procedure, there have been concerns regarding a theoretical adverse effect on post-operative shoulder motion, particularly the loss of ER [1, 4, 14, 24, 40]. In the current study, tightness of the posterior capsule, which was secondary to undue tension during the remplissage procedure, resulted in a limitation of 8° in ER. Although ER was significantly limited in the remplissage group, there was no significant difference in post-operative ER between the Bankart and remplissage groups. Our results are in agreement with those reported by Boileau et al. [4], who also found an 8° restriction in ER and a 9° restriction in ERa. Nourissat et al. [24] presented a series of 15 arthroscopic Bankart repairs with remplissage, with a limitation of 4° in ERs and 3° in ERa. Franceschi et al. [14] also reported a 2° loss in ERs in 25 cases of arthroscopic Bankart repair with remplissage. In the current study, muscle strength was not decreased, and the strength of external rotators, internal rotators, and abductors was, in fact, significantly increased after remplissage. The infraspinatus muscle was split less than 1 cm in length, parallel with the muscle fibres, for posterior capsulodesis, and the tendon portion was not captured with the suture material. The key for yielding better muscle strength is to minimize injury to the infraspinatus muscle.

In this study, arthroscopic Bankart repair with the remplissage procedure differed from the original technique described by Purchase et al. [28] in that the Bankart lesion was repaired first, and the trans-cuff lateral portal was used as the main viewing portal. Since a Bankart repair is considered to have priority over a remplissage procedure, remplissage has been performed after completion of Bankart repair. Several authors have described different sequential steps. Most authors complete remplissage first and then repair Bankart lesions [4, 26, 28]. Koo et al. [20] described the so-called double pulley technique, in which, after both sides were prepared, they repaired the Bankart lesion first and then tied the remplissage sutures. Other authors performed the remplissage through the anterosuperior portal as the main viewing portal. However, the trans-cuff lateral portal in the present study enabled the surgeons to secure a better view of the Hill–Sachs lesion. Further, a small

additional incision was made to dissect the infraspinatus muscle so that posterior capsulodesis could be performed into the Hill–Sachs lesion. Infraspinatus tenodesis is considered to possibly lead to strangulation of the tendon and entanglement of the multiple sutures in the subacromial space. Posterior capsulodesis, therefore, may reduce the possibility of infraspinatus tendon strangulation.

This study has several limitations. First, this study was a retrospective analysis and therefore has limitations similar to those seen in other retrospective studies. However, we conducted a retrospective analysis of prospectively collected patient data. Second, the mean follow-up period was relatively short. Post-operative complications after remplissage might occur during long-term follow-up. However, the arthroscopic remplissage procedure was introduced only recently, and the pros and cons of the procedure are still not clearly known. Lastly, posterior capsulodesis alone for remplissage was not compared directly with the conventional remplissage technique. However, this study is important for improving the technique of the remplissage procedure for anterior shoulder instability with an engaging Hill–Sachs lesion.

Conclusions

Arthroscopic Bankart repair with posterior capsulodesis demonstrated good clinical outcomes with a low recurrence rate in the treatment for anterior shoulder instability with an engaging Hill–Sachs lesion. Although a limitation in ER was observed, there was no significant limitation of any other motion and no decrease in muscle strength after the remplissage procedure. Posterior capsulodesis alone for remplissage should be considered as a surgical technique that can replace the conventional method.

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