Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology 34 (2023) 9–14

Contents lists available at ScienceDirect

Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology

journal homepage: www.ap-smart.com

original article

Arthroscopic repair with transosseous sling-suture technique for acute and chronic bony Bankart lesions

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ARTICLE INFO

Article history:
Received 29 December 2022
Accepted 14 August 2023

Keywords:
Arthroscopic repair
Bony Bankart lesion
Clinical outcome
Shoulder instability

ABSTRACT

Background: Failure to fix the fractured fragment can result in bony fragment resorption and consequent glenoid bone loss. Current arthroscopic repair techniques might lead to insecure fixation and refracture. The purpose of this study was to evaluate the effectiveness of the transosseous sling-suture technique for bony Bankart lesions, and to compare the clinical outcomes for acute and chronic bony Bankart lesions treated with this technique.
Methods: A retrospective case series consisting of 46 patients with bony fracture of the glenoid rim following traumatic injury was identified from May 2015 to August 2020. The patients were divided into the acute lesion group and the chronic lesion group according to the time from first injury to surgery. The size of bone fragment was used to group the patients into the small and the medium sized fragment groups. All the patients underwent arthroscopic repairs using the transosseous sling-suture technique. Preoperative and postoperative evaluations including Rowe score, West Ontario Shoulder Instability Index (WOSI), Visual Analogue Scale (VAS) for pain scores, ROMs and number of dislocations were recorded. No significant differences were found in the comparisons of postoperative ROMs ang functional outcomes regarding between the small and the medium sized fragment groups.
Results: No dislocations occurred for both groups postoperatively. At the last follow-up, all the ROMs (including anterior flexion, abduction, external rotation and internal rotation at the side), the Rowe score, the WOSI score and the VAS score for pain in the both groups were significantly improved compared to the preoperative evaluations (all Ps < 0.001). In the comparisons between the acute and the chronic lesion groups, significantly greater anterior flexion ($158.9 \pm 8.9^{\circ}$ vs. $153.0 \pm 6.4^{\circ}$, $P = 0.037$), abduction ($167.7 \pm 10.1^{\circ}$ vs. $161.0 \pm 7.0^{\circ}$, $P = 0.035$) and external rotation at the side ($88.3 \pm 6.4^{\circ}$ vs. $83.5 \pm 5.5^{\circ}$, $P = 0.024$) were found in the acute lesion group. The comparisons of the Rowe score (86.0 ± 7.5 vs. 87.5 ± 10.6, $P = 0.319$), the WOSI score (223.5 ± 56.3 vs. 185.0 ± 79.9, $P = 0.062$), the VAS score for pain (0.4 ± 0.2 vs. 0.3 ± 0.2, $P = 0.324$) and the internal rotation at the side ($74.6 \pm 13.2^{\circ}$ vs. $80.5 \pm 11.1^{\circ}$, $P = 0.116$) between these two groups did not demonstrate significant differences between the two groups.
Conclusion: This arthroscopic transosseous sling-suture repair technique for shoulder anterior instability with acute and chronic bony Bankart lesion can restore joint stability, improve clinical outcomes and range of motion postoperatively. The acute bony Bankart lesion using the current technique can produce better range of motion compared to the chronic lesion.

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https://doi.org/10.1016/j.asmart.2023.08.008

Study design: Retrospective case series; Level of evidence, 4.

1. Background

In patients who have undergone high-energy trauma with or without shoulder joint dislocations, the bony Bankart lesion is often present along with the glenohumeral joint instability.[1,2] The direct traumatic force against the glenoid via the humeral head is the main factor which leads to the fracture of the anterior-inferior glenoid rim.[3] Failure to fix the fractured fragment can result in bony fragment resorption and consequent glenoid bone loss, which is a major risk factor of recurrent shoulder instability and joint dysfunction.[1,4] In recent years, various arthroscopic managements have been reported to repair the fractured glenoid fragment.[5–8] The reduction and the fixation in arthroscopic repairs are under direct vision, which facilitates the anatomic and joint surface restoration.[9,10] The minimum invasive approach causes less soft tissue damage and faster post-operative recovery compared to the open surgery.[2,11]

Multiple clinical studies and technique notes have been published regarding the arthroscopic repair of the bony Bankart lesion.[2,8,12–14] The modified Bankart repair wraps the suture around the bone fragment with an anchor inserted in the glenoid.[7,9] The bony Bankart bridge technique uses two anchors placed at the glenoid and the glenoid neck to compress the fragment toward the glenoid.[6] Driscoll et al. reported a transosseous technique to fix the reduction of fracture fragment.[5] Voleti et al. used the screw fixation and the labral repair to manage the bony Bankart lesion.[10] However, insecure fixation, non-union or delayed bone union, the refracture of the bone fragment are still inevitable, which might cause post-operative shoulder instability or recurrence of dislocations.[15] In this study, the authors used a transosseous sling-suture repair technique. In this patient series, we compared the clinical outcomes for the acute and the chronic bony Bankart lesions. The hypothesis of the study is our arthroscopic transosseous technique can achieve satisfactory shoulder joint stability and functions for bony Bankart lesions in acute or chronic lesions.

2. Methods

This retrospective case series study was approved by the Health Science Institutional Review Board of the authors' hospital. The consent form was obtained from each patient agreeing to participate.

2.1. Patient selection

The inclusion criteria were (1) bony fracture of the glenoid rim following traumatic injury; (2) the size of the fragment was less than 25% measured on the preoperative computed tomography (CT) scans; (3) minimum 24-months follow-up. The exclusion criteria included: (1) concomitant humeral or scapular fracture; (2) neurological lesion of the affected arm; (3) previous surgical treatment on the affected shoulder; (4) patients with a Workers' Compensation claim. From May 2015 to August 2020, a total of 46 patients with bony Bankart lesions receiving arthroscopic procedures in the authors' institution met the above criteria (Fig. 1). The demographic data including age, sex, hand dominance, injury type, number of dislocations, time from injury to surgery were recorded from each patient.

2.2. Quantification of bone fragment

The size of bone fragment was evaluated according to previously published methods using the reconstructed glenohumeral joint.[13,16,17] The best-fitting circle for the inferior two-thirds of the glenoid on en face was drawn by selecting the outer cortex of the inferior glenoid.[7] The percentage of the bone fragment was calculated by the ratio of the width of the fragment to the diameter of the best-fitting circle.

2.3. Operative technique

The surgical treatment was performed under general anesthesia in the lateral decubitus position by the senior surgeons (YHH and XBZ) in the authors' hospital. The arthroscope was inserted for visualization and examination through a standard posterior portal into the glenohumeral joint. An anterior portal and an anterolateral portal were created using an inside-out technique under arthroscopy. Then the arthroscope was switched to the anterolateral portal to evaluate the fracture site, the size of the bone fragment and the integrity of labrum. The bone fragment and the labro-ligamentous complex were separated from the glenoid by removing scar tissue within the gap.

Afterwards, the transosseous tunnels through the bone fragment were drilled according to the size of fragment. As the size of bone fragment directly affected the number of anchors inserted and bone tunnels, we referred to a previously published classification, which divided the fragment into three types according to the percentage of the fragment: small (<12.5%), medium (12.5%–25%), large (>25%).[18] In the current study, the rate of small lesion was 67.4% (31/46), and the rate of medium lesion was 32.6% (15/46). To prepare the bone tunnels, a 3.0 mm Steinmann pin was drilled at the posterior-lateral site of the glenoid percutaneously. The fragment was held with an arthroscopic grasper from the anterior portal. For small bone fragment, one bone tunnel was drilled to avoid fragment breakage. For medium sized fragment, two tunnels were created according to the size and the quality of the bone fragment. The transosseous tunnels were made beneath the fragment's subchondral bone from posterosuperior to anterior-inferior direction. A No. 1 polydioxanone (PDS) suture (Ethicon, Somerville, NJ) was passed through each tunnel from anterior to posterior using the anterior portal. These sutures were placed at the anterior canula for future shuttling.

Next, the suture anchors were placed in the glenoid in turn. The first Lupine anchor (Mitek, Norwood, MA) inserted was at the opposite site to the transosseous tunnels, at the osteochondral junction of the glenoid. Each bone tunnel needed an anchor in the corresponding side of fracture bed. The posterior limb of the placed PDS suture was used to shuttle one high-strength suture from the anchor through the tunnel (Fig. 2). A curved suture hook (ConMed Linvatec, Largo, Florida) was used to pass the previous suture through the anterior-inferior capsulolabral tissue as much as possible. The following Lupine anchors (Mitek, Norwood, MA) were placed at the inferior and superior margin of the fracture site, at the edge of the intact cartilage of glenoid. The sutures passed the

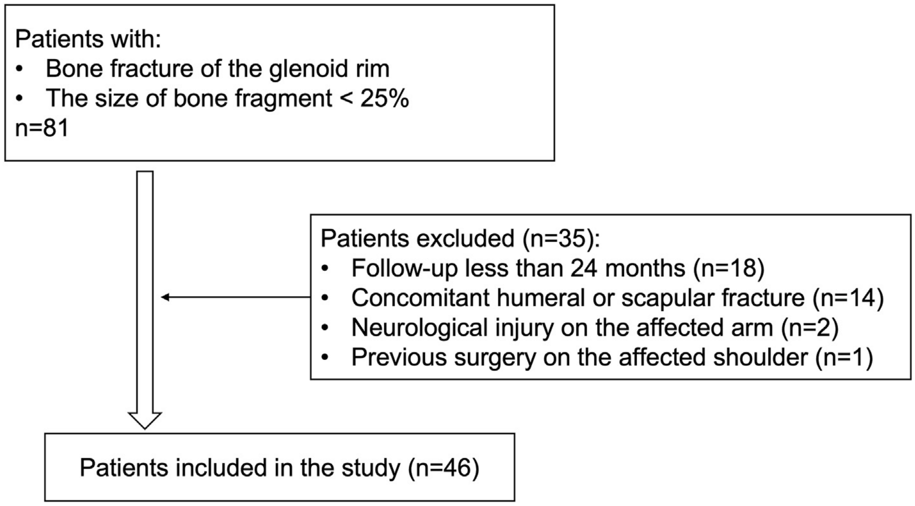

Fig. 1. The flowchart of patient inclusion and exclusion.

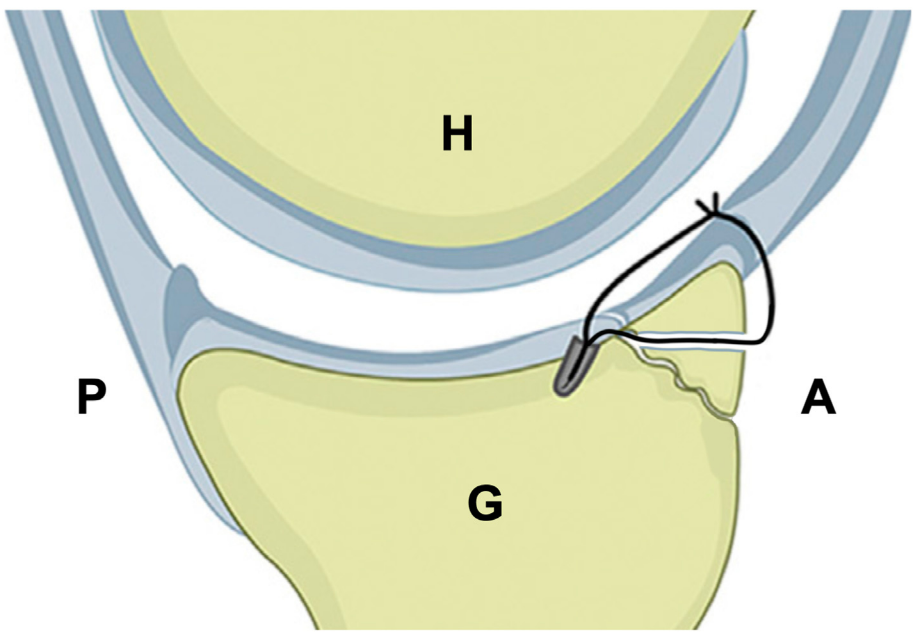

Fig. 2. The diagram of the transosseous sling-suture repair technique: The transosseous tunnels were made beneath the fragment's subchondral bone from posterosuperior to anterior-inferior direction. A limb of the suture from the anchor was passed through the tunnel and the capsulolabral tissue, and then secured with the other limb. G: glenoid; H: humeral head; A: anterior; P: posterior.

surrounding capsulolabral tissue. Then all the sutures of each anchor were tied with a sliding-locking knot with 3 alternating half-hitches, from inferior to superior. An arthroscopic grasper was used to hold the bone fragment for reduction during the knot tying (Fig. 3).

2.4. Rehabilitation

Each patient was asked to wear an abduction sling after the arthroscopic surgery. Passive shoulder flexion, external rotation and isometric strengthening exercises started on the second day postoperatively. At the postoperative 6 weeks, the sling was removed, followed by active shoulder motion and strengthening exercises. Patients visit the clinic at postoperative 2 weeks, 6 weeks, 3 months, 12 months and 24 months. Evaluations including ROM and shoulder stability evaluations were performed at the last visit.

2.5. Clinical evaluations

All the evaluations of clinical outcomes were performed by one sports medicine resident to avoid the observer's bias. Preoperative joint stability and assessments and postoperative evaluations at last follow-up were performed including the Rowe score, the West Ontario Shoulder Instability Index (WOSI), and Visual Analogue Scale (VAS) for pain. In addition, a physical examination was conducted, including shoulder ROMs (forward flexion, abduction, external and internal rotations at the side) at these two time points. At the last visit, any recurrence of shoulder instability and its following treatments were recorded.

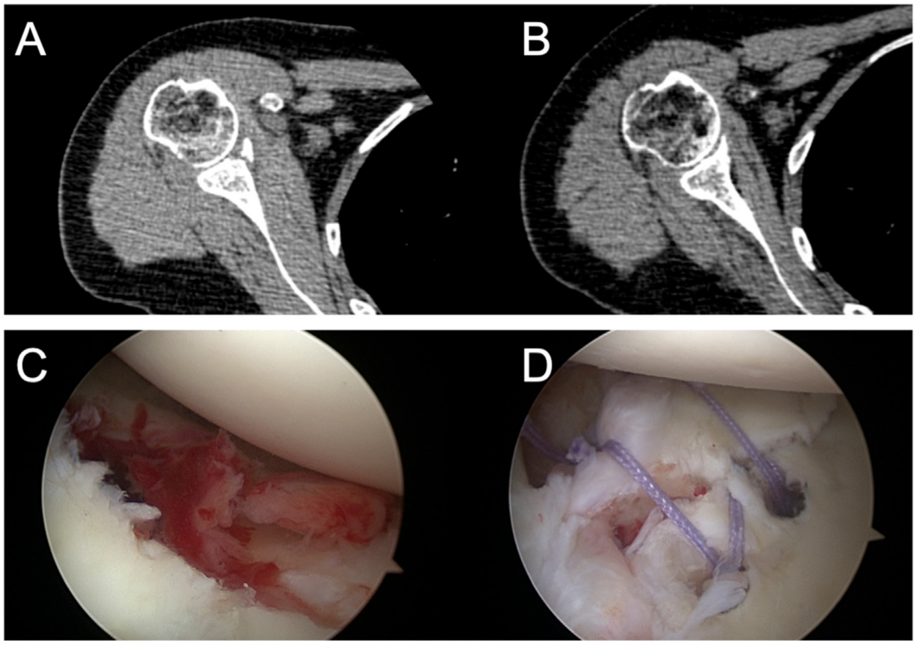

Fig. 3. The transosseous sling-suture repair technique was used to treat the bony Bankart lesion in a 57 years old female. (A) The preoperative MRI scan showed the small sized bone fragment of the glenoid. (B) The MRI scan at 19 months postoperatively demonstrated the bone fragment healing. (C) The bone fragment at the anterior-inferior rim of the glenoid. (D) Two anchors were inserted to repair the bone fragment by the transosseous sling-suture repair technique.

2.6. Data analysis

The sample size was justified on the basis of a previous investigation,[13] in which the major functional evaluation of preoperative and postoperative ASES scores were 78.8 ± 18.8 and 93.1 ± 16.4, respectively. A sample size of 19 in the clinical evaluation would be sufficient to detect a significant difference of one-half of a standard deviation with an 80% power at a level of significance of $P < 0.05$. This study expanded the sample size to 46 cases (26 cases in the acute group, 20 cases in the chronic group) to produce higher power.

Wilcoxon signed-rank test was used to compare the preoperative and postoperative stability outcomes and VAS scores. Wilcoxon rank sum test was used to compare the postoperative functional outcomes between the acute and the chronic bony Bankart lesions, and lesions with different sized bone fragments. The comparisons between preoperative and postoperative ROMs were performed with the paired *t*-test. A *P*-value <0.05 was considered to be statistically significant. Statistical analyses were processed with SPSS software (SPSS Inc., Chicago, Illinois).

3. Results

All the 46 patients (age 52.0 ± 13.0, ranging from 18 to 69) suffered from traumatic injuries, while 6 of them did not have shoulder dislocations. Twenty-six of the involved patients received the surgeries within 3 months from the first dislocation (0.7 ± 0.5 month, ranging from 0.1 to 3 months) after the injury (the acute lesion group), and the rest 20 patients (65.4 ± 43.3 months, ranging from 4 to 120 months) took longer intervals (the chronic lesion group). The acute lesion group had 1.08 ± 1.84 joint dislocations (ranging from 0 to 10), and the chronic group had 8.44 ± 13.40 dislocations (ranging from 1 to 45). The demographic data of the patients are presented in Table 1. The most common trauma type is the fall on arm, others included traffic accidents and sports injuries. The average follow-up was 41.47 ± 17.64 months (ranging from 25 to 92 months). No dislocation occurred after the arthroscopic surgery in both acute and chronic lesion groups.

3.1. Comparisons between the acute and the chronic bony Bankart lesions

In the arthroscopic procedure of the bony Bankart lesion, concomitant lesions including superior labrum anterior posterior (SLAP) lesions, rotator cuff tears and Hill-Sach's lesions were observed. These injuries were repaired with arthroscopic anchor-suture methods. The number of anchors used for the repair of bony Bankart lesion in the acute lesion group (2.92 ± 0.55) was not significantly different from that in the chronic lesion group (3.00 ± 0.00, $P = 0.335$).

Regarding the preoperative ROMs, the acute lesion group showed significantly lower anterior flexion (85.77 ± 27.86° vs.

Table 1
The demographic data of the acute and the chronic bony Bankart lesion groups.

	Acute lesion group	Chronic lesion group	P value
Age at surgery (yrs)	55.1 ± 11.8	52.0 ± 13.9	0.064
Sex (male: female)	10 : 16	14 : 6	0.090
Affected side (left: right)	4 : 22	4 : 16	0.739
Time from first injury to surgery (m)	0.7 ± 0.6	65.4 ± 43.2	0.002
No. of dislocations	1.8 ± 1.1	8.4 ± 5.7	0.006
Time of follow-up (m)	26.5 ± 13.7	29.5 ± 17.6	0.055

Table 2
The preoperative and the postoperative clinical outcomes of the acute and the chronic groups. P value*: between preoperative and the postoperative clinical outcomes of the acute group. P value#: between preoperative and the postoperative clinical outcomes of the chronic group. P valueα: between the clinical outcomes in the acute and the chronic groups preoperatively. P valueβ: between the clinical outcomes in the acute and the chronic groups postoperatively.

	Acute lesion group			Chronic lesion group			*P* value$^{\alpha}$	*P* value$^{\beta}$
	Preoperative	Postoperative	*P* value*	Preoperative	Postoperative	*P* value#		
ROM (°)								
Anterior flexion	85.8 ± 27.9	158.9 ± 8.9	<0.001	130.5 ± 17.8	153.0 ± 6.4	0.005	<0.001	0.107
Abduction	84.4 ± 27.1	167.7 ± 10.1	<0.001	130.5 ± 21.4	161.0 ± 7.0	0.005	<0.001	0.097
External rotation	41.0 ± 12.9	88.3 ± 6.4	<0.001	61.5 ± 18.3	83.5 ± 5.5	0.007	0.003	0.029
Internal rotation	31.9 ± 12.5	74.6 ± 13.2	<0.001	44.0 ± 10.9	80.5 ± 11.1	<0.001	0.016	0.211
Rowe score	37.7 ± 11.5	86.0 ± 7.5	<0.001	42.5 ± 15.5	87.5 ± 10.6	<0.001	0.407	0.631
WOSI score	1429.2 ± 150.1	223.5 ± 56.3	<0.001	1211.0 ± 147.5	185.0 ± 79.9	<0.001	0.002	0.280
VAS for pain	5.3 ± 0.9	0.4 ± 0.2	<0.001	3.8 ± 1.7	0.3 ± 0.2	<0.001	0.013	0.711

130.50 ± 17.81°, *P* < 0.001), abduction (84.42 ± 27.12° vs. 131.52 ± 21.38°, *P* < 0.001), external rotation at the side (40.96 ± 12.86° vs. 61.50 ± 18.31°, *P* = 0.003), the internal rotation at the side (31.92 ± 12.49° vs. 44.00 ± 10.91°, *P* = 0.016), compared to the chronic lesion group (Table 2). The preoperative WOSI score of the acute lesion group was significantly higher than the chronic lesion group (1429.23 vs. 1211.00, *P* = 0.002). No significant difference was found between the Rowe scores of the two groups (*P* = 0.407).

At the last follow-up, all the ROMs (including anterior flexion, abduction, external rotation and internal rotation at the side), the Rowe score, the WOSI score and the VAS score for pain in the both groups were significantly improved compared to the preoperative evaluations (all *P*s < 0.001) (Table 2). In the comparisons between the acute and the chronic lesion groups, significantly greater external rotation at the side (88.3 ± 6.4° vs. 83.5 ± 5.5°, *P* = 0.029) was found in the acute lesion group. The comparisons of the Rowe score (86.0 ± 7.5 vs. 87.5 ± 10.6, *P* = 0.631), the WOSI score (223.5 ± 56.3 vs. 185.0 ± 79.9, *P* = 0.280), the VAS score for pain (0.4 ± 0.2 vs. 0.3 ± 0.2, *P* = 0.711), anterior flexion (158.9 ± 8.9° vs. 153.0 ± 6.4°, *P* = 0.107), abduction (167.7 ± 10.1° vs. 161.0 ± 7.0°, *P* = 0.097) and the internal rotation at the side (74.6 ± 13.2° vs. 80.5 ± 11.1°, *P* = 0.211) did not demonstrate significant differences between the two groups.

4. Discussions

This study employed a transosseous sling-suture repair technique to restore the glenohumeral joint stability for shoulder anterior instability with acute and chronic bony Bankart lesions. The results showed improved clinical outcomes and range of motion after surgery. Patients with acute lesions reached better range of motion compared patients with chronic lesions.

The bony fractures of the glenoid rim were found in 8.6% of first-time anterior shoulder dislocations.[19] The rate of bony Bankart lesion raised to 22.2%–26.1% in repeated joint dislocations.[20] The open procedure of bony Bankart lesion was challenging as it demanded extensive exposure and delicate fixation on the bone fragment. High risks of neurovascular injuries, infection, post-traumatic osteoarthritis and joint stiffness also confined the post-operative outcomes of open surgeries.[21] After the first arthroscopic approach for the treatment of bony Bankart lesions by Cameron, various studies have been performed to validate its clinical significance and biomechanical strength.[2,7,8,10,11,22] Spiegl et al. found the double-row repair technique could achieve improved fracture reduction and mechanical stability compared to the single-row technique at time zero in a cadaveric model.[22] In a biomechanical study by Greenstein et al., the double-row arthroscopic fixation technique resulted in superior stability and decreased displacement during simulated rehabilitation compared with the single-row technique.[23]

Porcellini et al. described an arthroscopic technique to repair the bony Bankart lesion involving less than 25% of the glenoid using a single-row fashion.[7] 92% of the 25-patient series gained shoulder stability, minimally reduced ROM, and same level of activities as before surgery. In the previous authors' another four-year follow-up, they compared the clinical outcomes of acute and chronic bony Bankart lesions treated with arthroscopic approach.[9] The results indicated that the arthroscopic repair of the bone fragment was more favorable to the acute bony Bankart lesions compared to the chronic lesions. Plath et al. reported satisfactory outcomes of the shoulder stability, osseous integration and signs of osteoarthritis in 45 cases repaired by single-row technique at a midterm follow-up (mean, 82 months).[14] The radiological results showed that the arthroscopic repair of the bony Bankart lesion could reach anatomic reductions with no or only minimal articular steps. Compared to the acute lesions, the chronic lesions had an inferior potential for the bone fragment healing. In a similar study by Kim et al., significant improvements in patient-reported outcomes were achieved in 34 patients with minimum follow-up of 2 years. While the rate of anatomic reduction was 77.8%, which was associated to the difficulty of manipulation of relatively large bone fragment.[18] Our technique used two bone tunnels in the bone fragment to pass the sutures, which facilitated the anatomic reduction and solid fixation.

In a 13-patient series, Godin et al. evaluated the shoulder functions and stability with bony Bankart bridge technique in a minimum 5-year follow-up. They reported improved functions and a high return-to-sports rate.[13] However, 3 out of 13 (23%) patients experienced postoperative symptoms of instability but did not progress to further surgery. In a minimum of 2-year follow-up, Nakagawa et al. found higher complete bone union rate in patients with relatively large bone fragments (bone fragment ≥7.5%, union rate 78.9%) compared to those with relatively small fragments (bone fragment ≤7.5%, union rate 42.9%).[24] In the current study, none of the 46 patients, regardless the duration from first dislocation to surgery or size of the bone fragment, had post-operative instability, which was consistent with the improvements of the evaluations of the WOSI and the Rowe scores.

In Porcellini's study, a 3-month interval from the first dislocation to surgery was used to define the acute and the chronic bony Bankart lesions.[9] Plath et al. allocated the patients into acute or chronic group based on the arthroscopic documentations, i.e., the hemarthrosis, bleeding at the fracture site and fresh spongy edges of the fragment indicated an acute lesion.[14] In a consecutive series of chronic recurrent traumatic glenohumeral instability, Sugaya et al. selected six months before surgery as the criteria of chronic lesion.[2] In the current study, we used the same manner with Porcellini's study, a 3-month interval from the first dislocation to surgery. Based on our findings, the arthroscopic repair using the transosseous sling-suture repair technique, could achieve greater ROMs for acute bony Bankart lesions compared to acute lesions, which was consistent with previous publications.[2,9,14]

While this study reported a repair technique and its clinically significant outcomes, it is not without limitations. First, the comparisons between the acute and chronic lesions were compromised due to the relatively small sample size of each group. Although there might not be a large quantity of bony Bankart lesions, a control group of other techniques to compare would definitely provide more concrete conclusions. Second, postoperative CT or MRI scans were not available, which would provide more detailed outcomes of possible malunions, non-unions, labral retears and osteoarthritis. Third, due to the relatively old age of the patient series, we did not record the rate of return to sports and the level of activities. Third, due to the limited patient number, lesions with large bone fragments were not recorded in this study. Larger patient population is required to evaluate the outcomes of different fragment sizes with our transosseous sling-suture repair technique. Moreover, longer observations are needed to evaluate the mid-term and long-term functional outcomes and shoulder stability.

5. Conclusions

This arthroscopic transosseous sling-suture repair technique for shoulder anterior instability with acute and chronic bony Bankart lesion can restore joint stability, provide improvements in clinical outcomes and range of motion after surgery. The acute lesion using the current technique can produce better range of motion compared to the chronic lesion. Larger patient populations and longer follow-ups are necessary to provide more definitive conclusions.

Authorship

Category 1.

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Acquisition of data: L.C. Ye, X.X. Ji

Analysis and/or interpretation of data: X.X. Ji, L.C. Ye.

Category 2.

Drafting the manuscript: X.X. Ji

Revising the manuscript critically for important intellectual content: Y.H. Hua, L.C. Ye, X.B. Zhou.

Category 3.

Approval of the version of the manuscript to be published (the names of all authors must be listed): X.B. Zhou, Y.H. Hua, X.X. Ji, L.C. Ye.

Acknowledgement

This study was funded by National Natural Science Foundation of China, Grant Number 81702145.

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