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Midterm Results of the Bony Bankart Bridge Technique for the Treatment of Bony Bankart Lesions

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Background: The arthroscopic ''bony Bankart bridge'' (BBB) repair technique was recently shown to successfully restore shoulder stability at short-term follow-up, but longer-term outcomes have not yet been described.

Purpose: To report the outcomes at minimum 5-year follow-up after BBB repair for anterior shoulder instability with a bony Bankart lesion.

Study Design: Case series; Level of evidence, 4.

Methods: Patients were included if they sustained a bony Bankart lesion, were treated with a BBB technique, and were at least 5 years postoperative. Patients were excluded if they underwent concomitant rotator cuff repair or an open bone fragment reduction. All patients were assessed with the following measures preoperatively and at final evaluation: QuickDASH (Quick Disabilities of the Arm, Shoulder and Hand), American Shoulder and Elbow Surgeons, Single Assessment Numeric Evaluation, and 12-Item Short Form Health Survey (SF-12) Physical Component Summary.

Results: From 2008 to 2012, 13 patients who underwent BBB met the inclusion criteria with a mean age of 39.6 years (range, 19.1-68.8 years) and a mean follow-up of 6.7 years (range, 5.1-9.0 years). Mean time from most recent injury to surgery was 6.3 months (range, 1 day–36 months). The mean glenoid bone loss was 22.5% (range, 9.1%-38.6%). Mean SF-12 scores demonstrated significant improvement from 45.8 (SD, 9.7) preoperatively to 55.1 (SD, 5.9) at a mean follow-up of 6.7 years. At final follow-up, the mean American Shoulder and Elbow Surgeons score was 93.1 (range, 68.3-100); the mean QuickDASH score, 6.2 (range, 0-25); and the mean Single Assessment Numeric Evaluation score, 92.8 (range, 69-99). None of the patients progressed to further shoulder surgery. Three of 13 patients (23%) reported subjective recurrent instability. At final follow-up, 9 of 12 (75%) patients indicated that their sports participation levels were equal to their preinjury levels. Median patient satisfaction at final follow-up was 10 of 10 points (range, 3-10).

Conclusion: The arthroscopic BBB technique for patients with anterior bony Bankart lesions can restore shoulder stability, yield durable improvements in clinical outcomes, and provide a high return-to-sport rate at a minimum 5-year follow-up. Three of 13 patients experienced postoperative symptoms of instability but did not undergo further stabilization surgery.

Keywords: bony Bankart; bridge technique; anterior instability; shoulder

A bony Bankart lesion is defined as a bony avulsion of the glenohumeral rim and is primarily associated with cases of traumatic glenohumeral instability.[1] The prevalence of bony Bankart lesions was reported to range from 7.9% to 50% in shoulders exhibiting traumatic instability.[26] Because a high percentage of these lesions undergo bony fragment resorption within a year of injury,[15] early recognition and appropriate treatment of a bony Bankart lesion are vital. If left untreated, bony fragment resorption can lead to glenoid bone loss—a major risk factor for recurrent instability[1] and functional disability.[3,23]

While a number of surgical techniques have been described to treat bony Bankart lesions, no single technique has emerged as the standard of care.[7,8,13,20,27] The typical treatment algorithm is to utilize cannulated screw fixation for large glenoid fractures[6] and capsulolabral soft tissue repair with suture anchors[10,18] for small lesions. Medium-sized lesions require some form of bony fixation, and numerous techniques have been described. However, to date, only short-term outcomes of these various techniques have been published, with mixed results.[9,10,16-18] Compared with an open approach, an all-arthroscopic approach for the treatment of bony Bankart lesions offers theoretical advantages of minimal invasiveness, low complication

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rates, improved cosmesis, and equal or superior patient-reported outcome scores. However, additional long-term outcome studies are necessary to further elucidate these potential advantages.

In 2009, the senior author (P.J.M.) described an all-arthroscopic technique for the treatment of bony Bankart lesions called the "bony Bankart bridge" (BBB).[13] Short-term outcomes for this technique were subsequently published.[14] The purpose of this article is to reevaluate the outcomes of this technique at midterm follow-up, including rates of return to sport and recurrent instability. We hypothesized that patients would continue to display significant improvements in patient-reported outcome scores, with a high rate of return to activity and a low rate of recurrent instability.

METHODS

Study Population

This was an institutional review board–approved level 4 retrospective study (approval 2017-05) with prospectively collected data from a single-surgeon series (P.J.M.). Demographic and surgical data were prospectively collected and retrospectively reviewed. Patients were included in this study if they (1) underwent a bridging technique for bony Bankart repair after traumatic anterior shoulder instability with type I or II bony lesions (according to Bigliani et al[2]) and (2) were at least 5 years postoperative. Patients were excluded if they (1) experienced posterior or multidirectional instability, including voluntary dislocation; (2) had glenoid erosion; (3) were <18 years of age; or (4) received concomitant reconstructive procedures at the time of surgery, such as rotator cuff repair or open fixation of the avulsed fragment.

Quantification of Bone Defects

Glenoid bone loss was evaluated with a 2-dimensional en face plain computed tomography (CT) or magnetic resonance imaging (MRI) view of the glenoid. As previously described, the percentage of bone loss was calculated as the ratio of the width of the defect to the diameter of the assumed outer-fitting circle based on the inferior portion of the glenoid contour.[5,11,27] In addition, the maximum depths of potential Hill-Sachs lesions were measured on the axial CT or MRI planes described by Saito et al.[25] The ratio of the depth of the lesion to the diameter of a best-fitting circle drawn around the humeral head was used for analysis to minimize any variability resulting from the location of the maximum depth on the humerus or the size of the humeral head.[14]

Surgical Technique

Patients were placed in the beach-chair position with the operative arm in a pneumatic arm holder. The surgical technique has been previously described.[13,14] After diagnostic arthroscopy, a high anterosuperior portal and an accessory anteroinferior portal were established. Typically, the labrum and inferior glenohumeral ligament (IGHL) complex remained attached to the bony fragment, and these attachments were preserved intraoperatively. After the fracture sites were prepared with a shaver or bur, a 3.0-mm bioabsorbable suture anchor loaded with nonabsorbable suture was inserted through the anteroinferior portal. The anchor was placed medially on the glenoid neck, thereby providing the medial fixation point for the Bankart bridge. Since correct medial anchor placement can be technically challenging, the anteroinferior portal was placed slightly more medial than usual to make this step easier. Next, medial visualization was improved with a 70° scope, and the capsule and labrum were freed with an elevator placed through the anterosuperior portal. One or 2 anchors were used medially, depending on the fragment size. If 1 anchor was used, it was placed medial (axial plane) to the fracture site on the glenoid neck and in the midportion (sagittal plane) of the fracture.

Both limbs of the suture were passed through the soft tissues, medial to the bony piece, with a shuttling device. An alternative method was to use a trocar tip guide for the anchor and to insert this through the capsule medial to the bone fragment. After the anchor was placed, the guide was then used to pass the sutures around the capsule-labral-bony fragment, thus obviating the need to use a shuttling device. Next, a suture anchor was placed inferior to the bony fragment on the glenoid rim to secure the labrum and IGHL complex inferior to the bony piece. The medial suture limb was passed through the IGHL complex, shifting the IGHL complex and labrum superiorly and medially, thereby tightening the axillary pouch. Sutures were then tied with a sliding-locking Weston knot backed up with 2 alternating half-hitches. Typically, 1 anchor was placed inferior to the bony fragment.

The bony Bankart lesion was then fixed with a bridging technique. The sutures from the medial anchor were

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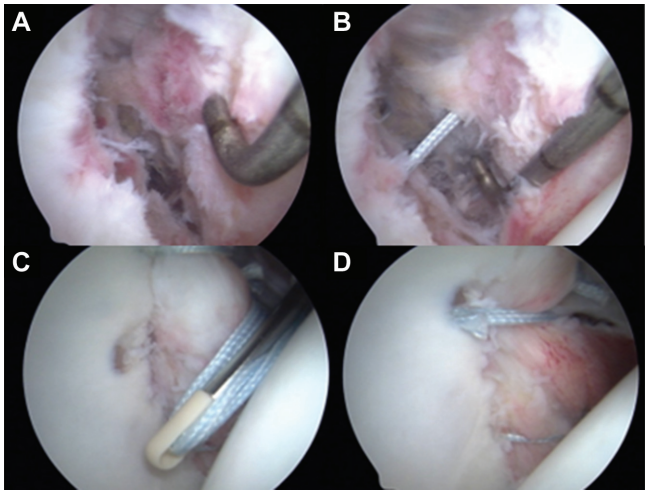

Figure 1. The bony Bankart bridging technique. (A) The bony Bankart fragment is freed from the glenoid. (B) The medial suture anchor is placed, and both suture limbs are passed through the anterior capsule medially. (C) The 2 suture limbs are then loaded into another suture anchor, which is appropriately tensioned and placed at the chondral-fracture junction. (D) Final bony Bankart bridge repair construct with 2 medial and 2 lateral suture anchors.

retrieved out of the anteroinferior portal. Appropriate tension was assessed to test the fracture reduction and to determine the optimal position for the lateral fixation anchor before a hole was drilled on the glenoid face at the cartilage-
fracture margin. The 2 free limbs of the medial suture anchor were then fed into a knotless suture anchor, and the anchor was subsequently placed. The suture limbs were tensioned before final fixation of the anchor, thereby compressing the bony fragment back into its donor bed. Finally, additional repair of the labrum and middle glenohumeral ligament superior to the Bankart bridge with 1 or 2 anchors was performed to provide additional rotational stability (Figure 1).

Postoperative Rehabilitation

Postoperative rehabilitation consisted of sling immobilization for 3 weeks. The rehabilitation program was individualized by fracture and repair characteristics. The patients were encouraged to perform early passive range of motion exercises, with supervised active motion taking place within 2 weeks. Strengthening began 6 to 8 weeks postoperatively. At 3 to 4 months postoperatively, all patients were cleared to return to noncontact sports activities. Full return to contact or throwing sports was allowed after an average of 6 months.

Additionally, preoperative and 6-week postoperative range of motion recordings were extracted from the patients' records and analyzed. Pre- and postoperative (minimum, 5 years) patient-reported outcome measures included the American Shoulder and Elbow Surgeons (ASES), QuickDASH (Quick Disabilities of the Arm, Shoulder and Hand), Single Assessment Numeric Evaluation (SANE), and 12-Item Short Form Health Survey (SF-12) Physical Component Summary. Postoperative satisfaction was also recorded, as were pain levels on a visual analog scale (ie, pain with activities of daily living, sport, work, and rest). Finally, levels of return to sport or fitness were documented.

At a 5-year follow-up questionnaire, patients were asked whether they experienced subjective instability. Failure was defined as progression to a revision stabilization procedure. Subjective feelings of subluxation were excluded from failures, as patients may have had difficulty distinguishing between pain and instability and results could thus have been misleading.[19] Pre- and postoperative outcome scores were compared for all patients in the study population.

Statistical Analysis

All statistical analyses were performed with SPSS (v 11.0; IBM). A formal post hoc power analysis was not appropriate for this retrospective series, given that all eligible patients were included. In this data set, continuous variables were nonnormally distributed. The pre- and postoperative outcome scores of the study population were compared with a Wilcoxon signed rank test. The association between categorical variables and outcome scores was assessed with a Mann-Whitney U test. All results are presented as means and ranges unless otherwise stated. The level of significance was set at $P < .05$.

RESULTS

Between April 2008 and September 2012, the senior surgeon (P.J.M.) performed BBB repair on 24 patients (Figure 2). Eight patients were excluded because of additional concomitant procedures that could influence the outcome of the BBB procedure (Figure 2). The final study population of 16 patients had a mean age of 39.6 years (range, 19.1-68.8 years) at the time of index surgery. Minimum 5-year follow-up was obtained for 13 (81.2%) of 16 patients with a mean follow-up of 6.7 years (range, 5.1-9.0 years). None of the patients required revision surgery. Patient characteristics are listed in Table 1.

All patients were without pain or signs of instability before the initial trauma. Trauma was related to an accident during winter sports, such as skiing or snowboarding, for 9 (69.2%) patients, and 2 (15.4%) cases happened during other recreational activities. Two injuries (15.4%) were sustained after a fall while working. The dominant shoulder was involved in 5 (38.5%) of 13 cases. Six shoulders (46.2%) underwent surgical repair within 3 months (acute: mean, 14 days; range, 1-66 days) after initial trauma, while 5 shoulders (38.5%) were treated at a later time point (chronic: mean, 475 days; range, 120-1095 days). The other 2 patients were classified as acute-on-chronic injuries. One patient sustained a shoulder dislocation 1 year before surgery, which was treated nonoperatively. The patient fell again on the same shoulder while

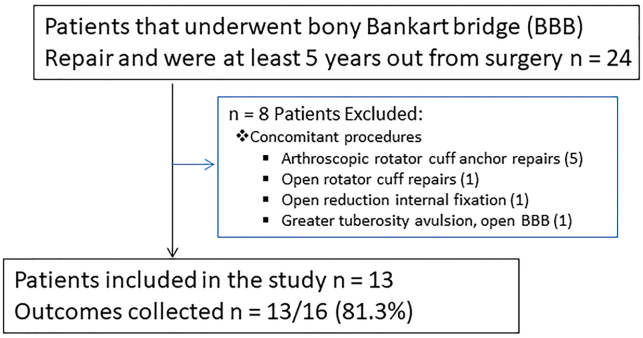

Figure 2. Flowchart visualizing the patient population for this study after accounting for inclusions, exclusions, and clinical failures. Patients progressing to a revision stabilization procedure were defined as clinical failures.

snowboarding a day before surgery. The second patient had recurrent instability for 51 years before suffering acute trauma 46 days preoperatively.

In the acute group, the mean number of dislocations was 2 (range, 1-7). Of the 5 patients with chronic injuries, 2 (40%) reported <10 dislocations, while 3 (60%) reported ≥10 dislocations. The remaining 2 cases with acute-on-chronic injuries reported a mean 5 dislocations (range, 2-8) before surgery. The bony Bankart lesion along the anteroinferior glenoid rim was confirmed for all patients during diagnostic arthroscopy (Figure 2). Ten patients (76.9%) had concomitant superior labral anterior and posterior lesions (4 type 1, 5 type 2, and 1 type 4). Of the 13 patients, 12 (92.3%) underwent the BBB repair as their primary stabilization procedure. One patient (7.7%) underwent a single prior arthroscopic soft tissue Bankart repair for anterior instability before BBB repair. In addition, 1 patient had a concomitant posterior labrum repair at the time of anterior BBB repair.

Quantification of glenoid bone loss and Hill-Sachs lesions was performed for all patients. The mean glenoid bone loss was 22.5% (range, 9.1%-38.6%) of the inferior glenoid diameter. Four patients (30.8%) had Hill-Sachs lesions with a depth >10%, whereas the mean maximum depth was 9.5% (range, 4.6%-13.6%) of the humeral head diameter. Nine patients (69.2%) had lesions <10% of the humeral head diameter.

Preoperatively, the mean active forward elevation and abduction were 152° (SD, 35°) and 133° (SD, 67°), respectively. Preoperative active external rotation was 69° (SD, 20°), and external rotation at 90° of abduction was 92° (SD, 23°). Although not statistically significant, there were slight improvements in postoperative averages at a mean of 5.4 months (range, 1.5-14.7 months) for the following: forward elevation, 162° (SD, 15°; P = .296); abduction, 153° (SD, 29°; P = .805); and external rotation, 63° (SD, 19°; P = .819).

Assessment of Outcomes

The mean subjective follow-up was 6.7 years (range, 5.1-9.0 years). At final evaluation, the mean ASES score improved from 78.8 (range, 45-98.3) preoperatively to 93.1 (range, 50-100) postoperatively (P = .686). Although not statistically significant, the amount of improvement was almost 3 times the minimal clinically important difference of 6.4 points as reported by Michener et al.[12] The mean SF-12 Physical Component Summary significantly improved from 45.8 (range, 32.2-57.6) to 55.1 (range, 38.6-61.8; P = .028). The mean QuickDASH score at final follow-up was 6.2 (range, 0-25), and the mean SANE score was 92.8 (range, 69-99) at final follow-up. Overall, median patient satisfaction at final follow-up was 10 of 10 points (range, 3-10) (Table 2). Patient-reported outcomes preoperatively, at 2 years postoperatively,[14] and at 5 years postoperatively are depicted in Figure 3.

One patient reported a reinjury at 2 years postoperatively and reported instability, including self-reduced dislocations with sports. The second patient did not report a reinjury but cited increased instability with self-reduced dislocations with sports. The third patient did not sustain a reinjury but noted subsequent subluxations without dislocations; however, no revision surgery was needed because of minimal symptoms.

There was a significant correlation between age and glenoid bone loss (r = 0.788, P = .001). No correlation was found between Hill-Sachs depth percentage and glenoid bone loss percentage ($r = -0.317, P = .292$). There was a significant association between number of dislocations and preoperative external rotation (r = 0.769, P = .009).

TABLE 1
Population Demographics and Surgical Information[a]

	n (%)
Male:female	13:0 (100:0)
Dominant:nondominant shoulders	5:8 (38.5:61.5)
Workers' compensation cases	2 (15.4)
Biceps tenodesis:SLAP repair	2:6 (15.4:38.5)
Patients failed	0 (0)

[a]SLAP, superior labral anterior and posterior.

TABLE 2
Postoperative Outcomes Scores[a]

	Preoperative	Postoperative	P Value
SF-12 PCS	45.8 ± 9.8	55.1 ± 5.9	.028
ASES			
Score	78.8 ± 18.8	93.1 ± 16.4	.686
Pain	40.6 ± 13	46.2 ± 8.9	.600
Function	32.8 ± 12	48.6 ± 4.9	.068
SANE	NA	92.8 ± 9.7	
QuickDASH	NA	6.2 ± 9.4	
Satisfaction	NA	10 (3-10)[b]	

[a]Continuous data presented as mean ± SD. ASES, American Shoulder and Elbow Surgeons; NA, not available; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS = 12-Item Short Form Health Survey Physical Component Summary.
[b]Median (range).

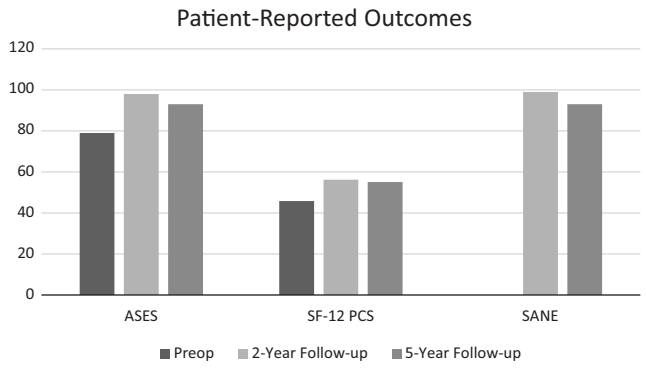

Figure 3. Preoperative, 2-year postoperative, and 5-year postoperative patient-reported outcomes. ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, 12-Item Short Form Health Survey Physical Component Summary. Note that the 2-year postoperative outcome scores are from previously published data with a similar cohort.[14] The preoperative and 5-year outcomes scores are from the current study.

Younger patients did not have an increased number of dislocations ($r = -0.402$, $P = .173$).

Return to Sports

Among the 12 patients who actively participated in sports preoperatively, 9 (75%) had returned to their sport at a level equal to or higher than their preinjury level, and 2 (17%) had returned with minimal restrictions. Specifically, there were 10 skiers/snowboarders, 2 kayakers, 1 mountain biker, and 1 weightlifter in the study population. The remaining patient returned to sports with significant restrictions. Eleven of 11 patients indicated that they had normal shoulder function throwing a softball overhand for 20 yards. The overall rate of return to a full fitness program was 9 of 12 (75%). Three (25%) of 12 patients modified their recreational activity postoperatively: 1 because of pain and weakness and the other 2 for fear of reinjury or further surgery.

DISCUSSION

The most important finding of this study is that the arthroscopic BBB technique can successfully restore shoulder stability in patients with bony Bankart lesions at midterm follow-up, including successful clinical outcomes, high patient satisfaction, and low failure rates. In a recent article, fractures of the anteroinferior glenoid rim, termed bony Bankart lesions, were reported to occur in 8.6% of first-time anterior shoulder dislocations.[22] The prevalence increases to >20% with increased number of dislocations.[24] Since the first successful arthroscopic reduction and fixation of an anterior glenoid fracture was described by Cameron,[6] an arthroscopic approach for treating bony Bankart lesions was reported to have results comparable to those of an open stabilization procedure. Several biomechanical studies reported on a variety of fixation methods. Spiegl et al[26] performed a biomechanical study comparing single- and double-row fixation techniques for acute bony Bankart lesions. The authors noted that the double-row fixation technique resulted in improved fracture reduction and superior stability.

Millett and Braun[13] and Millett et al[14] described this technique, as well as minimum 2-year outcomes after this procedure, for 15 patients with an average age of 44 years and an average glenoid bone loss of 29%. The final mean ASES (98), QuickDASH (2.8), SF-12 (56.2), and SANE (99) scores were all excellent, and there was a 7% failure rate.[14] The results of the current study report the minimum 5-year follow-up scores of the same cohort. The SF-12 Physical Component Summary score remained at a similar level at 55.1. The ASES score decreased to 93.1, while the QuickDASH and SANE showed a similar trend with 6.2 and 92.8, respectively. Despite the marginal decreases in outcomes scores from two years to five years, the results of this study demonstrate preservation of patient-reported outcomes at midterm follow-up.

Plath et al[18] reported the midterm results (mean, 82 months) of 45 patients who underwent bony Bankart repair. Of note, the authors employed multiple techniques, including arthroscopic suture anchor repair, arthroscopic screw fixation, and open repair. Postoperatively, all patient-reported outcome scores improved significantly, with only a 6.6% recurrent instability rate. While 95% of patients returned to sport, the level of sporting activity was significantly worse than that before the initial instability event. In our cohort, 75% of patients were able to return to sport at a similar level, while 17% did so with slight restrictions. Three of 13 patients reported subjective instability on postoperative electronic assessment. Since these patients did not present for in-office evaluation postoperatively and there was no follow-up imaging, it is difficult to delineate the cause.

Similarly, Kim et al[10] showed significant improvements in patient-reported outcomes after arthroscopic bony Bankart repair of 34 patients at a minimum follow-up of 2 years. In their study, small bony Bankart lesions (<12.5% of glenoid width) were treated with capsulolabral repair without bone fragment excision, while medium bony Bankart lesions (12.5%-25% of glenoid width) were anatomically reduced and repaired with suture anchors. Their overall recurrent dislocation rate of approximately 6% was similar to that reported by Plath et al.[18] Subanalysis revealed similar results between the groups, leading the authors to conclude that restoration of capsulolabral soft tissue tension alone may be enough, whereas the osseous architecture of the glenoid in medium lesions should be reconstructed for more functional improvement and less pain.[10] Moreover, the depth of the Hill-Sachs lesion is important, as engaging lesions can cause problems with overhead activities.[4] The off-track lesions may especially predispose to recurrent instability.[22]

Porcellini et al[20] described 25 patients with acute (<3 months) bony Bankart lesions with a size <25% of the glenoid. The authors arthroscopically fixed the avulsed fragment anatomically and noted a return to the previous

level of function and stability for 92% at 2 years postoperatively. In a longer follow-up study, the authors noted 2.4% and 4.2% rates of traumatic redislocations in the acute (<3 months) and chronic (>3 months) groups, respectively.[21] They stressed that arthroscopic repair should be the preferred treatment for acute bony Bankart lesions. On the contrary, Sugaya et al[27] mentioned that even in the chronic stage, every osseous fragment was firmly attached to the labroligamentous complex, was displaced, and had malunited to the glenoid neck. Therefore, a blood supply to the fragment through the surrounding soft tissue can be expected. In contrast to Sugaya et al, Porcellini et al[20] found that patients with chronic lesions had significantly less favorable outcomes. In our cohort, the patients with acute injuries showed higher clinical outcome scores as compared with the patients with chronic ones, although the former showed larger glenoid bone loss and Hill-Sachs lesion size. However, only the ASES score showed a statistically significant difference. Of note, satisfaction was significantly higher in the acute group. Despite the small sample sizes, these results underline the importance of early arthroscopic treatment of these lesions. While good clinical outcomes have been reported, other studies investigated union after bony Bankart fixation. In a study of 113 patients, Nakagawa et al[15] showed bony union in 30.5% within 6 months of surgery and an 84.6% union rate after 1 year. The recurrence rate for postoperative instability was only 6.1% for shoulders with complete union, while it was 50% for shoulders with partial union, nonunion, and no fragment on CT.

Limitations

While this study demonstrates interesting, clinically useful findings, it is not without limitations. First, all patients were treated by an experienced single surgeon in a referral clinic; thus, the results may not be generalizable given the small patient numbers, the lack of a control group, and the large variation in anatomic defects. In addition, this is a retrospective study with no description of "off-track" lesions or the activities to which patients are returning postoperatively. We did not collect postoperative MRI or CT, which would provide advanced imaging data to support our clinical outcomes and to investigate bone healing and possible resorption of bone, labral retear, nonunions, and malunions. Moreover, a small sample size with variable anatomic defects and glenoid bone defects is an additional limitation of the study.

CONCLUSION

The arthroscopic BBB technique for anterior instability with glenoid bone loss can restore shoulder stability, yield durable improvements in clinical outcomes, and provide high patient satisfaction at midterm follow-up. Three of 13 patients experienced postoperative symptoms of instability but did not undergo further stabilization surgery. Acute operative intervention may reduce the risk of subjective instability postoperatively. Larger patient populations are needed to draw more definitive conclusions.

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