Short-Term Outcomes of Glenoid Bone Block Augmentation for Complex Anterior Shoulder Instability in a High-Risk Population

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Purpose: To describe the short-term clinical outcomes of glenoid bone block augmentation in a high-demand population, as well as to describe its clinical success and complications at greater than 2 years' follow-up in an at-risk military population. **Methods:** All patients undergoing anterior capsulorrhaphy with coracoid process transfer or anterior bone block augmentation (Current Procedural Terminology code 23662 or 23460) for shoulder instability between 2006 and 2012 were isolated from the Military Health System Management Analysis and Reporting Tool. Demographic and occupational parameters were identified, and multiple surgical factors and clinical outcomes were extracted from the medical record and US Defense Manpower Data Center. **Results:** A total of 64 service members (65 shoulders) underwent anterior bone block procedures, including coracoid transfer (n = 59, 90.8%), distal tibial allograft (n = 3, 4.6%), and autologous or allograft iliac crest bone graft (n = 3, 4.6%). This group was predominately comprised of men (n = 59), and the mean age was 25.9 years (range, 19 to 45 years). A total of 19 perioperative complications, including 8 neurologic injuries, 6 infections, and 4 hardware failures, occurred in 16 patients (25%). At a mean 2.4-year follow-up, 21 patients (32.8%) reported persistent shoulder pain and 15 patients (23.4%) disclosed subjective apprehension or recurrent instability. Secondary surgical procedures were performed in 12 patients (18.8%), including 4 revisions (6.3%). Ultimately, 20 patients (31.3%) underwent a medical discharge for persistent shoulder disability. Univariate analysis showed that the presence of a perioperative complication ($P = .049$) and tobacco use ($P = .038$) were associated with increased risk of subsequent surgical failure. **Conclusions:** Anterior glenoid bone block procedures for shoulder instability with concomitant bone loss enable a return to high-demand physical function. The short-term complication profile (25%), recurrence rate (23%), and persistence of shoulder pain (33%) should be emphasized during preoperative counseling, particularly in an active military population and revision setting. Although moderately successful in the military, anterior bone block procedures for complex shoulder instability can be associated with significant short-term complications and morbidity. **Level of Evidence:** Level IV, therapeutic case series.

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Recurrent anterior shoulder instability may frequently result in glenohumeral bone defects, with involvement of the anterior-inferior glenoid in up to 90% of cases.[1] Given the exceedingly high failure rate associated with isolated labral repair in the presence of bony defects,[2] anterior bone block procedures

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have been increasingly used for patients with complex anterior shoulder instability and significant glenoid or bipolar bone loss.[3-5]

Since the original description of the Bristow procedure by Helfet,[6] several authors have further modified the initial technique of coracoid transfer popularized by Latarjet.[7-9] In addition, the viability of free bone graft transfer, including both distal tibial allograft[10] and tricortical iliac crest graft[11] (i.e., Eden-Hybinette procedure[12,13]), has previously been established. However, although such techniques are effective at mitigating subsequent episodes of shoulder instability, few studies have evaluated the comprehensive short-term complications and clinical outcomes of these procedures using contemporary techniques,[5,14,15] particularly within a high-demand patient population.[16]

The purpose of this study was to evaluate the short-term clinical outcomes of glenoid bone block augmentation for bone loss with recurrent anterior shoulder instability, as well to describe its clinical success and complications at greater than 2 years' follow-up in an at-risk military demographic. We hypothesized that the anterior glenoid bone block procedures would be successful at preventing subsequent episodes of shoulder instability in military service members, despite the variable rates of postoperative complications.

Methods

Protocol approval was obtained from our institutional review board. We performed a retrospective review of all tri-service US military service members undergoing isolated anterior capsulorrhaphy with coracoid process transfer (Current Procedural Terminology code 23662) or anterior bone block augmentation (Current Procedural Terminology code 23460) for anterior shoulder instability (*International Classification of Diseases, Ninth Revision* code 718.31, 718.81, or 831.00) from the Military Health System Management Analysis and Reporting Tool (M2) between January 1, 2006, and April 31, 2012. Patients of nonmilitary status and patients with multidirectional laxity or associated posterior glenohumeral instability (with or without concomitant posterior or superior labral repair) or with incomplete medical documentation or insufficient follow-up (i.e., <24 months' follow-up) were excluded. However, patients with early clinical failure and medical separation before 24 months were included in our comprehensive statistics to limit nonresponder bias. The M2 database is an established managed care tool that has been used for clinical outcomes research after the surgical treatment of a variety of orthopaedic conditions, including anterior shoulder stabilization.[17] It contains data primarily from the Medical Data Repository, which is operated by the Military Health System and populated by end users of the military electronic health record for all beneficiaries. The Military Health System offers worldwide coverage for all TRICARE beneficiaries, which includes over 9.5 million active-duty service members, activated National Guard and Reserve service members, retirees, and family members, through the direct care system at Department of Defense facilities or purchased care using civilian providers.

Demographic and occupational parameters were extracted from the M2 dataset, including age, military rank, branch of military service, military treatment facility, and operating surgeon. Patients were queried within the Armed Forces Health Longitudinal Technology Application electronic medical record, and line-by-line analysis was subsequently performed to confirm underlying diagnosis, surgical procedure, and date of surgery. Individual surgeon preference dictated surgical indications, operative technique, and source of bone graft. Further chart review yielded additional patient-based factors (e.g., military occupational specialty, laterality, limb dominance, prior shoulder surgery) and surgical factors (e.g., graft source, surgical technique, method of fixation, operation by a surgeon fellowship trained in sports medicine or shoulder surgery). The following clinical and functional outcomes were also abstracted: perioperative complications, postoperative range of motion (as measured during formal physical therapy sessions), secondary surgical interventions, recurrent shoulder instability or apprehension (e.g., patient-reported instability event with or without formal shoulder reduction, 2+ anterior load-shift examination with reproduction of symptoms, and subjective feelings of instability with abduction or external rotation), radiographic findings, activity limitations, and deployment history.

In addition, the US Defense Manpower Data Center and US Army Physical Disability Agency databases were queried to identify all individuals with postoperative combat deployments, as well as current military status, and those undergoing a medical discharge for persistent shoulder dysfunction after the index procedure. For the purposes of this study, the primary outcome measures were revision operations after the index procedure and military discharge for persistent shoulder-related disability.

Statistical Analysis

Statistical means with 95% confidence intervals and/or standard deviations were calculated for continuous variables. Categorical data were expressed as frequencies or percentages. Univariate and χ^2 analysis was performed to evaluate the association between potential risk factors and the primary outcome measures. $P < .05$ was considered statistically significant.

Results

A total of 64 service members with 65 shoulders undergoing anterior glenoid bone block procedures were identified during the study period (Table 1).

Table 1. Patient Demographic Data and Clinical Profile

Variable	Data
Total patients	64
Total shoulders	65
Laterality,* n	
Dominant extremity	32 (63%)
Left	28 (43%)
Right	37 (57%)
Sex (male/female), n	59 (92%)/5 (8%)
Mean age (range), yr	25.9 (19-45)
Military rank, n	
Junior enlisted	41 (64%)
Senior enlisted	13 (20%)
Officer/warrant officer	8 (13%)
Cadet	2 (3%)
Branch of military service, n	
Marines	18 (28%)
Army	13 (20%)
Navy	18 (28%)
Air Force	15 (24%)
Source of bone graft, n	
Coracoid transfer	59 (91%)
Distal tibia allograft	3 (5%)
Iliac crest autograft	2 (3%)
Iliac crest allograft	1 (1%)
Operating surgeon, n	
Subspecialty fellowship training	44 (68%)
None	21 (32%)
Tobacco use, n	19 (30%)

*One patient had bilateral involvement.

Table 2. Complications and Reoperation After Anterior Glenoid Bone Block Procedure

Complication*	Patients, n	Complications Requiring Operative Intervention
Infection	4 (6.1%)	3 (4.6%)
Deep	2 (3.0%)	2 (3.0%)
Superficial	2 (3.0%)	1 (1.5%)
Hardware failure or loss of fixation	4† (6.1%)	4 (6.1%)
Neurologic injury	8 (12.3%)	—
Chronicity		—
Transient	6 (10.8%)	
Permanent‡	2 (1.5%)	
Nerve		—
Axillary nerve	5 (7.6%)	
Musculocutaneous nerve	2 (3.0%)	
Suprascapular nerve	1 (1.5%)	
Subscapularis failure	1 (1.5%)	1 (1.5%)
Hematoma	2 (3.0%)	—
Total	19 (16 patients [24.6%])	8 (6 patients [12.3%])

*Complications do not include instability recurrence or positional apprehension.
†Two hardware failures were also infected.
‡Two permanent neurologic complications occurred in 1 patient.

The mean patient age was 25.9 years (range, 19 to 45 years), and the group was predominately comprised of men (n = 59, 92.2%) and patients of enlisted military rank (n = 54, 84.3%). The right side was the operative extremity in 56.9% of cases (n = 37). The dominant shoulder was involved in 62.7% of those with documentation (n = 32), whereas 14 patients had either unknown limb dominance or ambidexterity. Of the patients, 50 (78%) had undergone prior anterior stabilization procedures (arthroscopic Bankart procedures [n = 42], indeterminate arthroscopic or open Bankart procedures [n = 5], or open capsular shift/Bankart procedures [n = 3]), and 15 patients (23%) had undergone 2 or more previous stabilization procedures.

The surgical technique used coracoid transfer (n = 59, 90.7%), distal tibial allograft (n = 3, 4.6%), autologous iliac crest bone graft (ICBG) (n = 2, 3.1%), or allograft ICBG (n = 1, 1.5%). With 47 total operating surgeons, 67.7% of surgical procedures (n = 44) were performed by a surgeon fellowship trained in either sports medicine or upper extremity surgery. In addition, 58.5% of the operations (n = 38) were performed at a military treatment facility by a military surgeon, and 41.5% (n = 27) were performed at civilian institutions through purchased care.

Complications

A total of 19 perioperative complications occurred in 16 patients (25.0%) (Table 2), including 8 neurologic injuries (axillary in 5, musculocutaneous in 2, and suprascapular in 1), 4 infections (superficial in 2 and deep space in 2), 4 hardware failures (2 of which were also infected), 2 hematomas, and 1 case of subscapularis rupture. Of the total complications, only 2 occurred after treatment by a non–fellowship-trained surgeon, and one additional complication occurred after surgery by a hand and upper extremity surgeon. Major complications, defined as either a complication-associated reoperation or persistent neurologic deficits, occurred in 6 patients (9.3%), including one case performed by a non–fellowship-trained surgeon.

Clinical Outcomes

At a mean follow-up of 2.4 years, 15 patients (23.4%) disclosed recurrent subluxation (n = 14) or subjective feelings of apprehension (n = 1) and 21 patients (32.8%) reported some degree of persistent shoulder pain (Table 3). When complication-associated

Table 3. Clinical Outcomes After Anterior Glenoid Bone Block Procedure

Variable	Patients, n
Recurrent instability or apprehension	15 (23%)
Return to military duty	43 (67%)
Medical discharge	20 (31%)
Secondary procedures	12 (18%)
Revision surgery	4 (6.1%)
Deployed after procedure	17 (26.5%)

reoperations were also taken into consideration, 12 patients in total (18.8%) underwent secondary surgical procedures, including 4 revisions (6.2%) of prior Latarjet procedures (distal tibial allograft [n = 2], autograft ICBG [n = 1], and partial graft with capsulorrhaphy [n = 1]), 3 hardware removals, 3 wound debridements, 1 graft debridement, and 1 subscapularis repair. The mean postoperative range of motion was 163° of forward flexion (SD, 25°), 150° of abduction (SD, 42°), 54° of external rotation at the side (SD, 18°), 56° of internal rotation in the abducted position (SD, 22°) or a median between T12 and L1 with adduction, and 81° of external rotation at 90° of abduction (SD, 21°).

Failure

Ultimately, 43 service members (67.2%) returned to military duty, including 5 patients with recurrent instability and 1 patient with subsequent revision surgery. Furthermore, 17 patients (26.6%) participated in a postoperative combat deployment. However, a total of 20 patients (31.3%) underwent a medical discharge because of persistent shoulder disability and were unable to return to military function. After univariate analysis (Table 4), surgical failure was associated with the presence of a perioperative surgical complication ($P = .049$) and cigarette smoking ($P = .038$). Patient age (as a continuous variable), male sex, enlisted military rank, branch of military service, and surgery by a non–fellowship-trained surgeon were not associated with rates of surgical failure in this analysis.

Discussion

This study establishes that nearly 67% of service members returned to military duty after glenoid bone block augmentation for complex anterior shoulder instability. Furthermore, approximately 1 in 4 patients had a perioperative complication after a bone block procedure, and an additional 1 in 4 individuals disclosed recurrent symptoms of shoulder instability in this investigation.

Table 4. Univariate Logistic Regression Analyses of Surgical Failure

Variable	Odds Ratio	95% Confidence Interval	*P* Value
Age*	0.94	0.84-1.05	.248
Male sex	0.77	0.12-4.98	.783
Enlisted military rank	4.45	0.51-38.80	.176
Branch of service			
Army	1.0	—	—
Navy	0.45	0.10-2.01	.658
Air Force	0.18	0.03-1.14	.066
Marines	1.17	0.28-4.87	.094
Dominant extremity	0.90	0.28-2.93	.859
Tobacco use	3.20	1.07-9.58	.038†
Civilian medical facility	1.04	0.37-2.95	.941
Non–fellowship-trained surgeon	0.73	0.22-2.45	.609
Complication	3.26	1.01-10.60	.049†

*Age was analyzed as a continuous variable.
†Statistically significant.

The current rate of perioperative surgical complications (25.0%) after open anterior glenoid augmentation in this active military population mirrors that previously reported in the literature. Furthermore, the presence of a perioperative complication and tobacco use were the only variables associated with an increased rate of surgical failure after index surgery. In a recent systematic review of surgical outcomes after the Bristow-Latarjet procedure, Griesser et al.[14] described an overall complication rate of 30% among 1,904 shoulders, with nonunion or fibrous union (9.4%) and neurovascular injury (1.8%) the most commonly identified. In another short-term analysis, Shah et al.[15] reported a complication profile of 25% in 45 shoulders undergoing the Latarjet procedure at a single center over a 5-year period, including neurovascular injury in 10%, recurrent instability in 8%, and infection in 6%. When procedures were separately analyzed, more recent data have suggested a lower complication rate with the open Bristow-Latarjet procedure (15%) than with the arthroscopic Latarjet (17.2%) or Eden-Hybinette procedure (17.6%).[5]

Neurologic injury occurred in 8 patients in our study; however, only 1 patient had both persistent axillary nerve and suprascapular nerve deficits, whereas the remaining patients recovered uneventfully after transient sensory disturbance. Prior studies have attributed neurologic injury to prolonged patient malpositioning (e.g., abduction and external rotation), aggressive manipulation or traction during glenoid exposure and graft placement, or inadvertent suture or retractor entrapment,[18-20] typically with transient neurapraxia of the axillary, musculocutaneous, and radial nerves. Maquieira et al.[21] described suprascapular nerve injury due to prominent screw fixation at the spinoglenoid notch during the Latarjet procedure, with resolution after screw removal. Shishido and Kikuchi[22] and Lädermann et al.[23] advised against drilling at greater than 10° to 28° from the face of the glenoid to limit iatrogenic injury to the suprascapular nerve. Care must also be exercised in the revision setting after a prior arthroscopic or open stabilization procedure and coracoid transfer because these prior operations may contribute to changes in the relative position and course of the musculocutaneous and axillary nerves.[24] Surgical efficiency, limitation of time spent in "at-risk" positions, and periodic relaxation of retractors may also mitigate rates of neurapraxia during coracoid transfer or anterior bone block procedures.

Recurrence of anterior shoulder instability may occur at rates between 0% and 14% after open or

arthroscopic Latarjet procedures,[3-5,7,15,24-29] whereas limited data evaluating iliac bone block techniques have shown a rate of 9.8%.[5] Griesser et al.[14] reported a cumulative recurrent instability rate of 8.7% (anterior subluxation and dislocation rates of 5.8% and 2.9%, respectively), with most instability events occurring within the first year postoperatively.[3,14] In our study, no patient sustained a postoperative dislocation, but 23% disclosed subjective reports of apprehension and/or recurrent anterior subluxation without dislocation or formal reduction. Although higher than previously reported, this increased rate of subjective instability may reflect a greater preponderance of failed prior anterior stabilization procedures and heightened, at-risk occupational demands than those represented in other clinical series. Despite this finding, 67% of service members successfully returned to military service and the revision rate was only 6.1%, with only 2 patients (3.1%) undergoing revision for recurrent instability. By comparison, other authors have also identified that 2.5% to 7.5% of patients required revision surgery for instability.[3,14] Our results may reflect the salvage nature of this procedure in our high-demand patient population with recurrent instability and/or failed prior anterior stabilization (78%), as well as the increased vocational demands associated with military service.

As has been previously suggested in the literature, advanced training and greater surgical volume have been associated with improved clinical outcomes and lower rates of complications after shoulder reconstruction.[30,31] However, in our study a lack of subspecialty training in sports medicine or shoulder surgery was not associated with a higher rate of failure (odds ratio, 0.73; 95% confidence interval, 0.22 to 2.45; $P = .609$). In fact, non–fellowship-trained surgeons actually showed lower rates of surgical failure, total complications, and major complications. Because of the relatively higher incidence of shoulder instability among military patients[32] vis-à-vis civilian populations,[33] military orthopaedic surgeons traditionally have greater exposure to the surgical management of recurrent shoulder instability during residency training and clinical practice, even among non–fellowship-trained surgeons. This may serve as a confounding variable in our study. Furthermore, fellowship-trained surgeons at a tertiary referral center are more likely to treat patients with more complex anterior shoulder instability and multiple prior revision procedures, which may introduce selection bias. Despite these nuances, we believe that greater statistical power would allow a more substantive comparison that better controls for surgical volume and/or operative experience.

The strengths of this study include its closed health care system, the high-risk and homogeneous patient composition, and the intense physical and occupational demands of the patients. Further investigations should seek to ascertain the mid- and long-term clinical outcomes in a high-demand military population with recurrent anterior shoulder instability, as well as more robustly describe the rates of radiographic incorporation[25] and secondary osteoarthritis[34,35] after anterior bone block procedures.

Limitations

Although this study sought to describe the clinical and occupational outcomes and identify risk factors for surgical failure after anterior bone block procedures, there are certain limitations to acknowledge. Foremost, this patient population is subjected to unique upper extremity occupational demands that may limit external validity to a general demographic. The presence of a perioperative complication was associated with a significantly increased risk of military discharge or surgical revision in our military population. However, this analysis may be underpowered to elucidate other relevant factors predictive of failure (e.g., fellowship training, surgical volume, clinical experience), as noted in other studies evaluating variables associated with increased complications after the Latarjet procedure.[15] Because this study primarily comprised coracoid transfers, it may also be inadequate to discern relative differences in the complication profiles and rates of recurrence by graft type. As well, operative indications and surgical technique were not standardized, particularly source of the bone graft, technique of coracoid transfer, management of the capsule (i.e., intracapsular or extracapsular graft placement) and/or subscapularis (i.e., horizontal split *v* partial or complete takedown),[36,37] and type of fixation,[15] which may introduce confounding. Preoperative and postoperative radiographic imaging was also incompletely available to quantify the degree of bone loss and graft resorption. Validated clinical and patient-reported outcome measures were not obtained as a part of this retrospective analysis. In addition, although shoulder-related medical discharges and surgical revisions were primary outcomes of interest in this study, these endpoints may reflect multifactorial decision making rather than strict shoulder function. Lastly, given the transient nature of this military population, the current patient subset does not account for those individuals excluded for insufficient follow-up and those of non–active-duty (e.g., inactive National Guard or Reserve component) or civilian beneficiary status. Moreover, other patients may be inadvertently excluded because of procedure miscoding within this dataset.

Conclusions

Anterior glenoid bone block procedures for shoulder instability with concomitant bone loss enable a return to high-demand physical function. The short-term

complication profile (25%), recurrence rate (23%), and persistence of shoulder pain (33%) should be emphasized during preoperative counseling, particularly in an active military population and revision setting. Although moderately successful in the military, anterior bone block procedures for complex shoulder instability can be associated with significant short-term complications and morbidity.

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