Open Shoulder Stabilization Procedure Using Bone Block Technique for Treatment of Chronic Glenohumeral Instability Associated With Bony Glenoid Deficiency

Michael Khazzam, MD, Steven M. Kane, MD, and Matthew J. Smith, MD

Abstract

We examined the early results of using an open bone block technique to stabilize the glenohumeral joint with chronic instability related to bony deficiency of the glenoid. Fifteen patients with anteroinferior glenoid bone loss on preoperative computed tomography underwent diagnostic shoulder arthroscopy (for evaluation of glenoid bony deficiency) and then open bone block augmentation of the anteroinferior glenoid rim.

Clinical follow-up of 10 patients at a mean of 25 months showed a mean postoperative Constant score of 94 (range, 32-100), a mean University of California Los Angeles score of 32 (range, 9-35), and a mean American Shoulder and Elbow Surgeons score of 83 (range, 47-100). Mean postoperative forward flexion was 172°, mean postoperative external rotation with the arm at the side was 60°, mean postoperative external rotation with the arm abducted 90° was 91°, and postoperative internal rotation ranged from the level of the anterosuperior iliac spine (minimal external rotation) to the T6 spinal level.

Bone block stabilization is an effective treatment in patients with chronic shoulder instability—a difficult population.

Glenohumeral joint stability is a complex equilibrium consisting of both static and dynamic stabilizers. There are 2 major static mechanisms of glenohumeral stability: glenoid concavity and ligamentous tension.[1] A third component of shoulder stability is found in the balanced forces of the musculature that surround the glenohumeral articulation.[2] The bony anatomy is analogous to a golf ball placed on a golf tee. With loss of a portion of the supporting tee surface rim, the golf ball no longer sees the concentric support of the entire rim of the "golf tee," and the ball more easily rolls off the tee at the area where there is structural loss of the golf tee rim. Similarly, with significant glenoid bone loss, the glenohumeral joint is predisposed to instability through an alteration in glenoid concavity. In the literature, it has been suggested

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that glenoid bony defects involving more than 30% of the articular surface area result in an increased risk for recurrent instability.[1,3-6] It is thought that, when a major bony glenoid deficiency reduces the stability of the glenohumeral joint, bony reconstruction of the glenoid rim is necessary. Traumatic glenohumeral dislocation commonly results in an avulsion of the anteroinferior glenohumeral ligament–labrum complex from the glenoid rim known as the Bankart lesion. At times, this injury entails

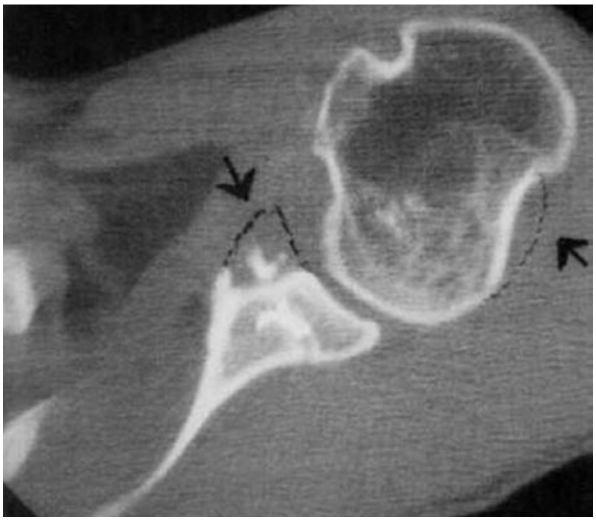

Figure 1. Computed tomography shows anteroinferior glenoid bone loss and Hill-Sachs lesion.

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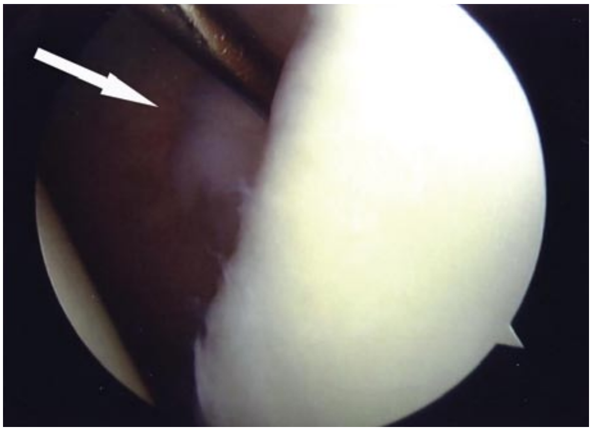


Figure 2. Arrow in arthroscopic photograph shows anterior glenoid bony deficiency.

an anteroinferior glenoid rim fracture, which then creates a bony Bankart lesion.

Several authors have addressed the underlying bony glenoid pathology in an attempt to provide a more stabile articulation for the humeral head.[7-15] In the study reported here, we examined the 1- to 2-year clinical results of patients who underwent open surgical treatment of chronic anteroinferior bony-deficient glenohumeral instability using a bone block stabilization technique.

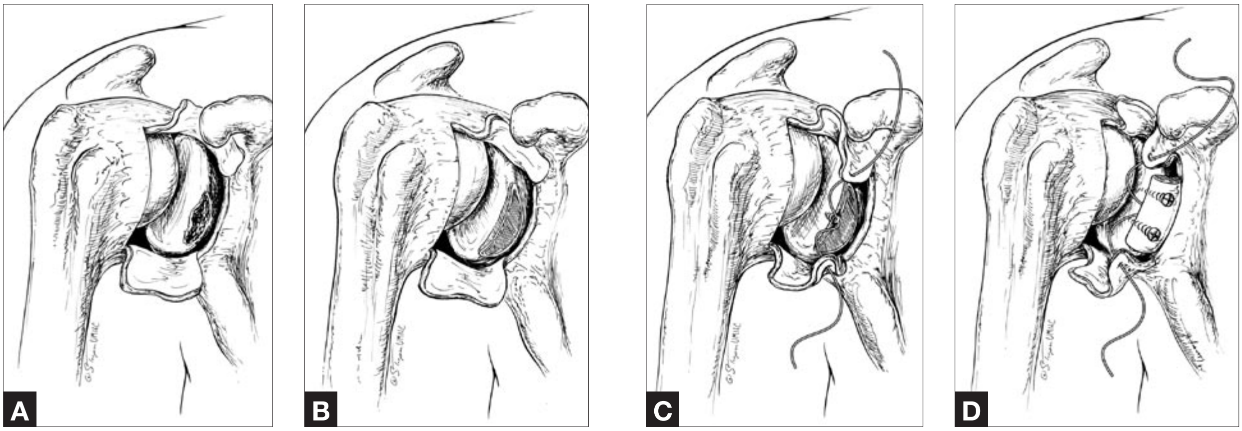
Materials and Methods

We reviewed operative records to identify patients who had undergone open shoulder stabilization using a bone block technique for the treatment of recurrent shoulder instability accompanied by bony deficiency of the glenoid. We identified 15 patients who fulfilled this inclusion criterion. Fifteen consecutive patients underwent anterior shoulder stabilization surgery between July 2004 and August 2006. Each patient underwent a preoperative radiographic evaluation to determine the presence of bony deficiency of the glenoid rim (Figure 1). Each patient subsequently underwent diagnostic shoulder arthroscopy to evaluate the status of the glenoid followed by an anterior open bone block stabilization/glenoid augmentation using either iliac crest autograft or allograft. All procedures were performed by Dr. Kane. Of the original 15 patients, 10 were available for follow-up study. Five patients were lost to follow-up. The operative reports were reviewed to identify pathoanatomical findings regarding glenoid bone loss and capsule status. We recorded demographic data, including age, sex, mechanism of initial dislocation, approximate number of previous dislocations or instability episodes, previous surgical procedures, and previous treatment (Table).

Follow-up clinical examination involved a patient outcomes questionnaire, which included Constant score, University of California Los Angeles (UCLA) score, and American Shoulder and Elbow Surgeons Shoulder Score (ASES). These outcomes measures assess function, pain, satisfaction, and residual instability perceived by the patient. In addition, a standard shoulder physical examination, involving range of motion (ROM), strength, and stability testing, was performed. ROM, measured by goniometer, included forward flexion, abduction, external rotation with arm at side, external rotation with arm at 90°, and internal rotation to highest spinal level. Muscle strength testing was assessed for deltoid and rotator cuff musculature. Stability testing included

Table. Patient Data

Patient	Sex	Age (y)	Follow-Up Length (mo)	Side	Mechanism of Dislocation
1	M	20	33	R	Trauma, wrestling
2	M	47	23	L	Trauma, fall
3	M	46	16	L	Trauma, altercation
4	F	49	32	R	Trauma, water slide
5	M	21	22	L	Traumatic, fell off bicycle
6	M	37	24	R	Seizure disorder
7	M	28	27	R	No trauma, spontaneous, with arm over head while sleeping
8	F	30	14	R	Seizure disorder
9	M	51	12	R	Trauma, initially multidirectional instability
10	M	63	36	R	Trauma, fall on pipe



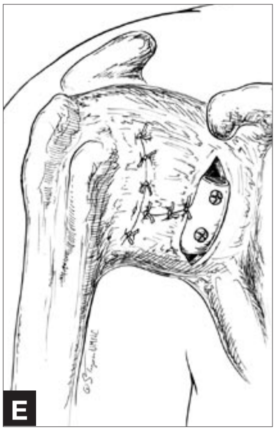


Figure 3. (A) "H" incised capsule of glenohumeral joint with anteroinferior glenoid bony deficiency. (B) Prepared glenoid. (C) Suture anchor in place. (D) Bone block in place. (E) Capsule closed over bone block. Illustrations by Stacy Turpin. Copyright 2009, the University of Missouri.

the load and shift test in the supine position for anterior and posterior translation and the sulcus sign for inferior translation. In addition, apprehension testing with the arm in abduction and external rotation and Jobe relocation testing were both performed to evaluate for recurrent symptomatic subluxation or dislocation.

Surgical Technique

Each patient was placed in the beach-chair position with all bony prominences well padded. After induction of general anesthesia, shoulder ROM and joint laxity were assessed on the affected shoulder and on the unaffected shoulder. Direction of instability was confirmed. Then a standard posterior superior portal was established, and the 4-mm arthroscope was introduced into the glenohumeral joint. A diagnostic arthroscopy was then performed for assessment of the rotator cuff, biceps tendon, capsule, and glenoid. In each patient, there was an identifiable bony deficiency of more than 25% at the anteroinferior glenoid, with loss of the pear-shaped anterior glenoid as measured from the central fovea of the glenoid[16] (Figure 2). In most of the patients, an engaging Hill-Sachs lesion also was noted. At this point, the arthroscope and cannula were withdrawn, and attention was turned to an open procedure.

A standard deltopectoral approach to the shoulder was performed, with careful preservation of the cephalic vein. After the clavipectoral fascia was incised and the conjoint tendon medially detracted, the subscapularis tendon was

Prior Surgery	Graft Type	Postoperative Complications
1 capsular shift	Autograft iliac crest	12 months after surgery, patient doing well (no issues); was in motor vehicle collision; redislocated and lost anterior bone block and bent screws; underwent revision anterior bone block with iliac crest 25 months after the first surgery (follow-up 20 months after second surgery)
None	Autograft iliac crest	None
None	Autograft iliac crest	None
None	Autograft iliac crest	None
None	Autograft iliac crest	None
1 anterior capsular/subscapularis shift	Allograft tricortical strut	None
1 diagnostic arthroscopy	Autograft iliac crest	None
None	Autograft iliac crest	2 weeks after iliac crest bone graft harvest, patient was ambulating and heard/felt pop (right anterior superior iliac spine avulsion); underwent open reduction and internal fixation; during approach, lateral femoral cutaneous nerve was lacerated, resulting in persistent numbness in anterolateral thigh
None	Allograft tricortical strut	None
None	Autograft iliac crest	None

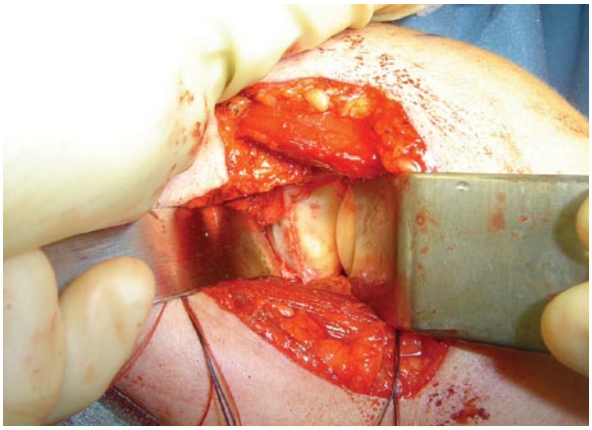


Figure 4. Interoperative photograph of prepared glenoid, before suture anchor and bone block placement.

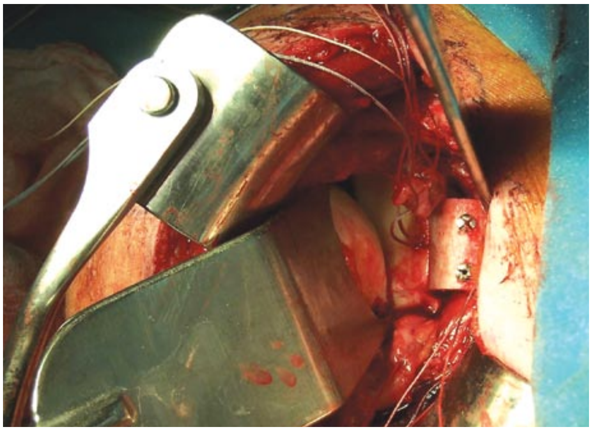


Figure 5. Intraoperative photograph shows bone block placement. Note position of suture anchor in glenoid.

identified, divided 1 cm medial to its humeral insertion, and retracted medially. Care was taken to identify and protect the axillary nerve using the finger-sweep technique as well as frequent visualization of the nerve when possible. The subscapularis was then dissected from the anterior capsule medially, and enough tissue (the most posterior 1 mm of the subscapularis tendon) was left on the anterior capsule so it would be available for the repair. This dissection was carried medially to the glenoid rim. The capsule was then divided in a lateral T-type fashion from its humeral attachment. The capsule at the glenoid was then dissected free from the glenoid down to the 6-o'clock position as well as superiorly to the 1-o'clock position (in a right shoulder). This medially based capsular tissue along the glenoid was then incised superiorly and inferiorly so that in essence the *T* became an *H,* enabling the medial capsular flaps to be brought anterior to the bone block once the bone block had been placed (Figure 3A). Once the capsule was open and the glenohumeral articulation exposed, digital palpation of the anterior glenoid demonstrated a significant bony deficiency, as noted on arthroscopy. A periosteal elevator was then used on the bony-deficient portion of the glenoid, which was prepared down to cancellous bleeding bone with a burr for acceptance of an iliac crest bone graft (Figures 3B, 4).

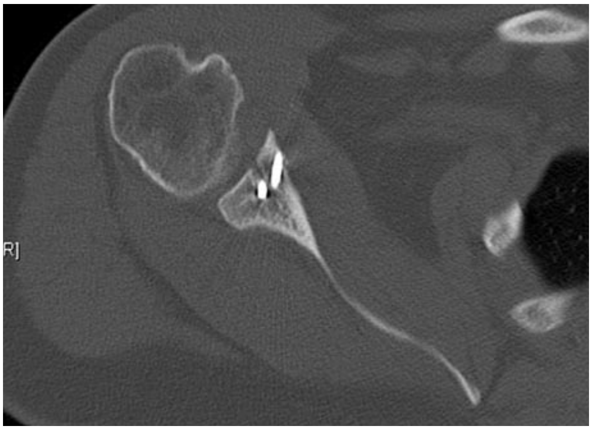


Figure 6. Computed tomography shows placement of bone block and its reproduction of anterior glenoid rim.

At this point, attention was turned to the iliac crest or to preparation of a tricortical allograft bone block. An incision was made along the iliac crest approximately 5 cm posterior to the anterior superior iliac spine (ASIS), and dissection was carried down to the periosteum, which was divided sagittally. The inner muscular table was retracted medially and the lateral table laterally. A microsagittal saw was used to harvest a 2×2.5-cm tricortical bone graft, which was taken to the back table and shaped to match the glenoid deficiency and concavity. The iliac crest wound was copiously irrigated, closed in layers, and sterilely dressed. Meticulous hemostasis was used throughout the entire iliac crest harvest procedure.

Attention was then turned to the shoulder and to preparation of the bone graft. After a single 3-mm bioabsorbable suture anchor (Arthrex, Naples, Fla) was placed in the 4- to 5-o'clock position (right shoulder) of the glenoid bone/articular surface interface (Figure 3C), the bone graft was positioned in the anterior glenoid bony-deficient area. Two 3.5-mm cannulated screw guide pins were then drilled through the bone block and into the anterior glenoid neck holding the bone block in a position of anatomical glenoid bone restoration. Digital palpation was used to ensure that the graft was not lateral to the natural surface and concavity of the glenoid (Figure 5). The pins were then overdrilled and measured, and the screws placed, to hold an anatomical bone reconstruction anteriorly. The screws were placed with sounding of the drill holes to determine bone quality in each drill hole, and the screws, approximately 30 mm in length, were placed (Figure 3D). Next, the bioabsorbable suture anchor limbs were tied to the medial capsular flaps, which had been dissected, thereby closing the capsule inside the bone block. The patient then underwent a capsular closure and a minimal capsular shift in a standard pants-over-vest method, creating a reanastomosis laterally, superiorly, and inferiorly (Figure 3E). In each case, the subscapularis was then repaired back to its anatomical footprint with 6 figure-of-8 No. 1 Ethibond (Ethicon, Somerville, NJ) sutures with the arm held in 30° of external rotation at the patient's side.

After surgery, the shoulder was immobilized in a standard shoulder immobilizer, with physical therapy beginning within 5 days for the parameters of external rotation to 40° and forward elevation to 120° in the first 3 weeks. Progression up to full forward flexion was gradual over the next 3 weeks of postoperative care. Active motion of the subscapularis was withheld until 6 weeks after surgery.

Results

Ten of 15 patients were available for follow-up and completed the study. There were 8 men and 2 women. Mean age at time of follow-up was 39 years (range, 20-63 years).

Of the 10 patients, 7 had an initial dislocation involving a traumatic event (they subsequently developed chronic instability), 2 had an initial dislocation resulting from a seizure (these seizures continued, and the patients developed chronic instability with dislocations beyond an identifiable number), and 1 patient reported an atraumatic dislocation (he had woken up with his affected arm locked in abduction; this dislocation required closed reduction in the emergency department, and the patient continued to have laxity and recurrent subluxations and dislocations, though the source of the bony deficiency in the anteroinferior glenoid could not be determined).

Three of the 10 patients had undergone surgical procedures that failed. One procedure was diagnostic arthroscopy for evaluation of glenoid bone loss and confirmation of an engaging Hill-Sachs lesion on the humeral head; the other 2 procedures were capsular shifts, 1 of which included subscapularis advancement. In 8 patients, tricortical iliac crest autograft was used for the bone block; in the other 2 patients, allograft was used.

Mean postoperative Constant score was 94 (range, 72-100), mean postoperative UCLA score was 32 (range, 24-35), and mean postoperative ASES score was 83 (range, 47-100).

Mean active ROM of the operative shoulder was 172° of forward flexion (range, 130°-180°), 60° of external rotation (range, 10°-80°), and 91° of external rotation with the arm in 90° of abduction (range, 60°-100°). Internal rotation of the operative shoulder ranged from the level of the ASIS to as high as the level of T6.

On manual muscle strength testing, all patients had 4/5 to 5/5 strength in the planes of forward flexion, external rotation, abduction, and internal rotation. Only 1 patient complained of pain during manual muscle testing, particularly with internal rotation, but still had 5/5 muscle strength on resisted forward flexion, external rotation, and abduction and 4/5 strength with resisted internal rotation. On physical examination, no patients had any evidence of anterior, posterior, or inferior glenohumeral translation. No patients experienced any recurrent episodes of subluxations. One patient had a mild amount of apprehension, but no instability or positive relocation test was found on physical examination. Nine of the 10 patients were very satisfied with their surgical outcomes. The 1 patient who was not satisfied continued to have seizures and pain. Repeat computed tomography (CT) of the shoulder (Figure 6) showed the bone block healed in anatomical position and recreating the anterior rim of the glenoid. This patient was one of those with a postsurgical complication (described in the next section).

Only 1 of the 10 patients available for follow-up had a redislocation. This patient had an uneventful postoperative course for 12 months—a stable glenohumeral joint, full ROM, and 5/5 strength of the rotator cuff muscle group—but then was involved in a motor vehicle collision that caused a traumatic shoulder redislocation and facial trauma. Radiographic evaluation showed bent screws and medial displacement of the bone block. After failure of conservative treatment and recurrent instability of the affected shoulder, the patient underwent revision anterior bone block stabilization with iliac crest autograft. This patient has since done exceptionally well—full shoulder ROM, muscle strength, and no evidence of instability. None of the 5 patients unavailable at the most recent follow-up had reported any episodes or symptoms of redislocation in the first 4 to 6 months after surgery.

“There were successful outcomes regardless of the graft material (autograft or allograft iliac crest) used for the bone block.”

Complications

The only complication occurred after iliac crest bone block harvest. The patient showed no evidence of complication during surgery or immediately after surgery. Two weeks later, the patient was ambulating and felt a pop in the left groin region, near the ASIS. After this incident, the patient was unable to bear weight and had difficulty ambulating. An avulsion fracture of the left ASIS was discovered. The patient underwent open reduction and internal fixation (ORIF) by another physician. During the surgical approach, the patient sustained a laceration of the lateral femoral cutaneous nerve. Although the patient had a successful outcome in terms of no further episodes of instability at last follow-up, there continued to be decreased sensation and dysesthesia in the left anterolateral thigh.

Discussion

Glenoid bone loss has been shown to be a significant risk factor for recurrent glenohumeral instability after shoulder dislocation. It is held that the larger the bony defect, the less stable the shoulder.[1,4-6,16-18] Several anatomical studies[1,5,6,16] have attempted to quantify glenoid bone loss and its relationship to shoulder instability. Lo and colleagues[5] found that large osseous defects (>25% of entire width of widest portion of inferior glenoid) result in symptoms of shoulder instability and described the inverted pear-shaped glenoid that results from either an osseous Bankart lesion or an impression/compression-type lesion at the anteroinferior margin of the glenoid. To eliminate the instability, they suggested a bone-grafting procedure that restores the normal articular arc and reestablishes glenohumeral stability. In a cadaveric study, Itoi and colleagues[1] found that progressively larger osseous defects of the glenoid were associated with decreased glenohumeral stability. These authors found that the critical amount of bone loss for glenohumeral instability, not amenable to isolated soft-tissue procedures alone and requiring bone-graft augmentation, was at least 21% of the anteroinferior glenoid. In another cadaveric study, Montgomery and colleagues[6] found that glenoid bony deficiency of 20% diminished glenohumeral stability by almost 50% (P = .006). They also demonstrated that placing a bone graft into the glenoid defect significantly increased stability, particularly when the graft was contoured to match the native glenoid articular surface (P<.001). The purpose of our study was to examine 1- to 2-year results after bone restoration for stabilization of a chronically unstable shoulder with a significant (>25% articular surface) glenoid bone loss.

Quantifying glenoid bone loss is clinically difficult. Several methods have been used, including imaging studies (radiographs, CT scans) and estimates made at time of surgery through an open or arthroscopic procedure. Burkhart and colleagues[16] arthroscopically evaluated normal glenoid anatomy in an attempt to determine a reliable anatomical landmark (bare spot) that could then be used as a consistent reference point to objectively quantify glenoid bone loss. Lo and colleagues,[5] using the techniques described by Burkhart and colleagues,[16] evaluated bony morphology arthroscopically and subsequently were able to classify glenoid shape as either an inverted pear in bony-deficient shoulders or a noninverted pear in normal shoulders. In our study, patients underwent diagnostic arthroscopic evaluation of glenoid morphology, and routine preoperative radiographs and CT scans of the shoulder were obtained. All patients had more than 20% anteroinferior bony glenoid deficiency as determined through preoperative CT/magnetic resonance imaging or as measured at time of surgery.

Several surgical techniques have been used to treat chronic glenohumeral instability, but few have addressed glenoid bony deficiency. Stabilizing procedures that have addressed glenoid bone loss include the Bristow procedure,[19-22] the Eden-Hybbinette procedure, and the Trillat-Latarjet procedure.[23] Most of these procedures were described more than 30 years ago, and few outcome studies have been reported within the past 5 years.

May[20] reported successful outcomes and no complications for 16 patients a minimum of 13 months after a modified Bristow procedure for treatment of posttraumatic recurrent shoulder instability. Lombardo and colleagues,[21] who retrospectively examined 51 patients at a mean of 17 months after a modified Bristow procedure for treatment of recurrent shoulder instability, reported positive results in their short-term follow-up case series, and there was only 1 case of redislocation, caused by a fall on an outstretched arm. Two other patients had postoperative, surgery-related complications—1 pulmonary embolus and 1 hematoma. Wredmark and colleagues[22] reported successful outcomes of Bristow procedure surgery in 44 patients at a mean follow-up of 6 years. Only 2 patients had recurrent dislocation, and all patients returned to full shoulder girdle muscle strength and full ROM.

However, an expanding body of literature has identified the problems associated with the Bristow procedure. Specifically, Young and Rockwood[24] examined the complications associated with the Bristow procedure as well as the difficulty encountered in revising these shoulders. Complications included chronic painful anterior shoulder instability, degenerative changes of the glenohumeral joint, complications related to the coracoid transfer (nonunion), hardware failure, neurovascular injury (axillary or musculocutaneous nerve palsy), and posterior instability. Given these results, the authors indicated that the Bristow procedure should not be the primary treatment for symptomatic anterior shoulder instability. Most recently, Hovelius and colleagues[12] reported long-term results (mean follow-up, 15 years) in 118 patients with chronic anterior shoulder dislocation treated with the Bristow-Latarjet procedure. The authors found a 98% satisfaction rate at time of follow-up. Only 4 of the 118 patients had recurrent dislocations: One patient had 2 redislocations (9 and 12 years after surgery); 1 patient had 3 redislocations (3 years after surgery); and 1 patient had 1 redislocation (during the follow-up period). Recurrent subluxation had been reported only once during the follow-up period for 4 patients and several times for 7 patients. One patient had undergone revision surgery for recurrent instability.

Haaker and colleagues[10] reported outcomes for 24 patients (22 anterior and 2 posterior dislocations) after intra-articular autogenous bone grafting of the glenoid for the treatment of recurrent shoulder dislocation. The authors described a bone block technique similar to the technique used in our study. Postoperative follow-up ranged from 6 months to 4 years. Their study examined only postoperative ROM and satisfaction (all patients were satisfied) and did not provide any objective or subjective outcome measures for comparison but is one of the few studies on the outcomes of this bone augmentation procedure.

Gerber and colleagues[23] reviewed the results of 52 cases of Trillat-Latarjet procedure with a mean follow-up of 69 months and reported 83% good to excellent results. There was a 4% incidence of redislocation, and 10 patients continued to have a positive apprehension sign. Although this study had a high success rate, similar to ours, their patients continued to have positive apprehension signs, which may indicate that, with longer follow-up, these patients may experience recurrent instability.

An advantage of the bone block procedure is that it does not overtighten the capsule. Several of the anterior instability reconstruction procedures involve an anterior capsular shift, which may result in excessive anterior capsular tightness, internal rotation contracture, and posterior glenoid wear (capsulorrhaphy arthropathy).[25-27]

Our study had 1 complication involving iliac crest bone graft harvest. The result was an ASIS avulsion fracture that required ORIF. Iliac crest is the most common donor site for the harvest of autogenous bone graft. Although common, this procedure is not without complication.[28] Reynolds and colleagues[29] described the first case of ASIS avulsion fracture occurring 2 weeks after monocortical bone graft harvest from the right anterior iliac crest. This case was successfully treated with bed rest. Several authors[30-35] have since reported ASIS avulsion fractures after iliac crest bone graft harvests treated either conservatively or with ORIF—similar to what was done for our patient. These cases highlight the importance of recognizing this fracture as a possible complication of this common procedure.

Our 1- to 2-year follow-up showed that the bone block stabilization procedure had successful outcomes and can be recommended for use in patients with recurrent shoulder instability and a significant glenoid bony defect. With restoration of the supporting structure of the glenoid, and the glenoid concavity, this procedure demonstrated a high success rate. There were successful outcomes regardless of the graft material (autograft or allograft iliac crest) used for the bone block. No difference in outcome measurement parameters was identified when either allograft or autogenous bone block grafts were used, but, given our small sample size, we were unable to formally compare these groups statistically. Further studies and larger samples would help determine the long-term outcome of this procedure.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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This paper will be judged for the Resident Writer's Award.