A Review Paper

Traumatic Anterior Shoulder Instability: The US Military Experience

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Abstract

There is a long history of military surgeons who have made significant contributions that have advanced our understanding of traumatic anterior shoulder instability and its treatment and results. In this article, we describe the scope, treatment, and results of this pathology in the US military population.

Given its relatively young age, high activity level, and centralized medical care system, the US military population is ideal for studying traumatic anterior shoulder instability. There is a long history of military surgeons who have made significant contributions that have advanced our understanding of this pathology and its treatment and results. In this article, we describe the scope, treatment, and results of this pathology in the US military population.

Take-Home Points

- Arthroscopic stabilization performed early results in better outcomes in patients with Bankart lesions.
- A subcritical level of bone loss of 13.5% has been shown to have a significant effect on outcomes, in addition to the established "critical amount".
- Bone loss is a bipolar issue. Both sides must be considered in order to properly address shoulder instability.
- Off-track measurement has been shown to be even more positively predictive of outcomes than glenoid bone loss assessment.
- There are several bone loss management options including, the most common coracoid transfer, as well as distal tibial allograft and distal clavicular autograft.

Incidence and Pathology

At the United States Military Academy (USMA), Owens and colleagues[1] studied the incidence of shoulder instability, including dislocation and subluxation, and found anterior instability events were far more common than in civilian populations. The incidence of shoulder instability was 0.08 per 1000 person-years in the general US population vs 1.69 per 1000 person-years in US military personnel. The factors associated with increased risk of shoulder instability injury in the military population were male sex, white race, junior enlisted rank, and age under 30 years. Owens and colleagues[2] noted that subluxation accounted for almost 85% of the total anterior instability events. Owens and colleagues[3] found the pathology in subluxation events was similar to that in full dislocations, with a soft-tissue anterior Bankart lesion and a Hill-Sachs lesion detected on magnetic resonance imaging in more than 90% of patients. In another study at the USMA, DeBerardino and colleagues[4] noted that 97% of arthroscopically assessed shoulders in first-time dislocators involved complete detachment of the capsuloligamentous complex from the anterior glenoid rim and neck—a so-called Bankart lesion. Thus, in a military population, anterior instability resulting from subluxation or dislocation is a common finding that is often represented by a soft-tissue Bankart lesion and a Hill-Sachs defect.

Natural History of Traumatic Anterior Shoulder Instability in the Military

Several studies have evaluated the outcomes of nonoperative and operative treatment of shoulder instability. Although most have found better outcomes with operative intervention, Aronen and

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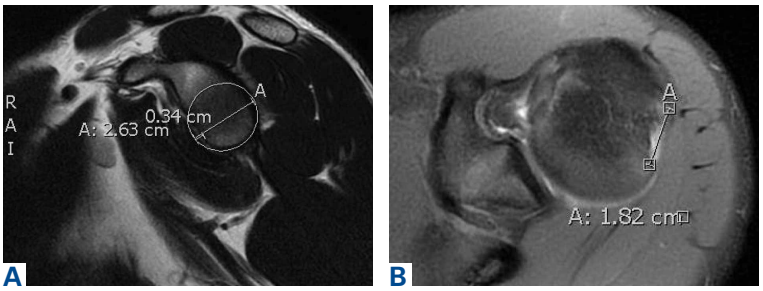

Figure 1. Example of application of the track concept shows "off-track" bipolar bone lesion from anterior instability. (A) Using the glenoid index method (circle diameter from inferior and posterior glenoid rim), the glenoid diameter is 26.3 mm. With bone loss of 3.4 mm, the track is (26.3 mm × 0.83 mm) – 3.4 mm = 18.4 mm. (B) Hill-Sachs interval measured on axial magnetic resonance imaging is 18.2 mm. These measurements indicate the patient has off-track lesion.

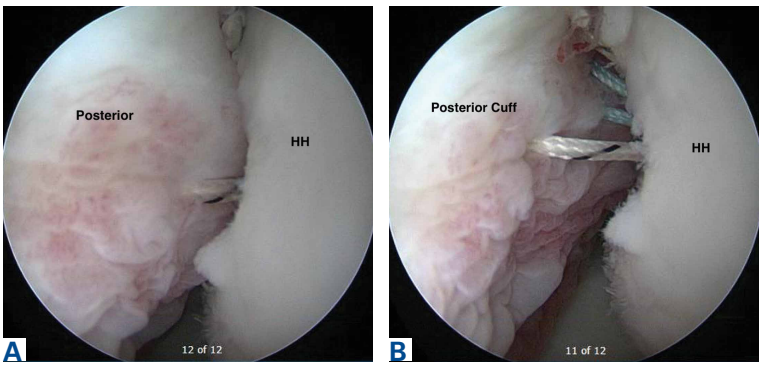

Figure 2. Remplissage technique for a large Hill-Sachs lesion. (A) After preparation of the lesion bed in the posterior humeral head (HH), 2 anchors are placed and tied over the posterior cuff tendon. (B) The posterior rotator cuff tendon undergoes tenodesis in order to place the Hill-Sachs lesion in an extra-articular position.

Regan[5] reported good results (25% recurrence at nearly 3-year follow-up) with nonoperative treatment and adherence to a strict rehabilitation program. Most other comparative studies in this population have published contrary results. Wheeler and colleagues[6] studied the natural history of anterior shoulder dislocations in a USMA cadet cohort and found recurrent instability after shoulder dislocation in 92% of cadets who had nonoperative treatment. Similarly, DeBerardino and colleagues[4] found that, in the USMA, 90% of first-time traumatic anterior shoulder dislocations managed nonoperatively experienced recurrent instability. In a series of Army soldiers with shoulder instability, Bottoni and colleagues[7] reported that 75% of nonoperatively managed patients had recurrent instability, and, of these, 67% progressed to surgical intervention. Nonoperative treatment for a first-time dislocation is still reasonable if a cadet or soldier needs to quickly return to functional duties. Athletes who develop shoulder instability during their playing season have been studied in a military population as well. In a multicenter study of service academy athletes with anterior instability, Dickens and colleagues[8] found that, with conservative management and accelerated rehabilitation of in-season shoulder instability, 73% of athletes returned to sport by a mean of 5 days. However, the durability of this treatment should be questioned, as 64% later experienced recurrence.

Arthroscopic Stabilization of Acute Anterior Shoulder Dislocations

In an early series of cases of traumatic anterior shoulder instability in USMA cadets, Wheeler and colleagues[6] found that, at 14 months, 78% of arthroscopically stabilized cases and 92% of nonoperatively treated cases were successful. Then, in the 1990s, DeBerardino and colleagues[4] studied a series of young, active patients in the USMA and noted significantly better results with arthroscopic treatment, vs nonoperative treatment, at 2- to 5-year follow-up. Of the arthroscopically treated shoulders, 88% remained stable during the study and returned to preinjury activity levels, and 12% experienced recurrent instability (risk factors included 2+ sulcus sign, poor capsular labral tissue, and history of bilateral shoulder instability). In a long-term follow-up (mean, 11.7 years; range, 9.1-13.9 years) of the same cohort, Owens and colleagues[9] found that 14% of patients available for follow-up had undergone revision stabilization surgery, and, of these, 21% reported experiencing subluxation events. The authors concluded that, in first-time dislocators in this active military population, acute arthroscopic Bankart repair resulted in excellent return to athletics and subjective function, and had acceptable recurrence and reoperation rates. Bottoni and colleagues,[7] in a prospective, randomized evaluation of arthroscopic stabilization of acute, traumatic, first-time shoulder dislocations in the Army, noted an 89% success rate for arthroscopic treatment at an average follow-up of 36 months, with no recurrent instability. DeBerardino and colleagues[10] compared West Point patients treated nonoperatively with those arthroscopically treated with staples, transglenoid sutures, or bioabsorbable anchors. Recurrence rates were 85% for nonoperative treatment, 22% for staples, 14% for transglenoid sutures, and 10% for bioabsorbable anchors.

Arthroscopic Versus Open Stabilization of Anterior Shoulder Instability

In a prospective, randomized clinical trial comparing open and arthroscopic shoulder stabilization for recurrent anterior instability in active-duty Army personnel, Bottoni and colleagues[11] found compa-

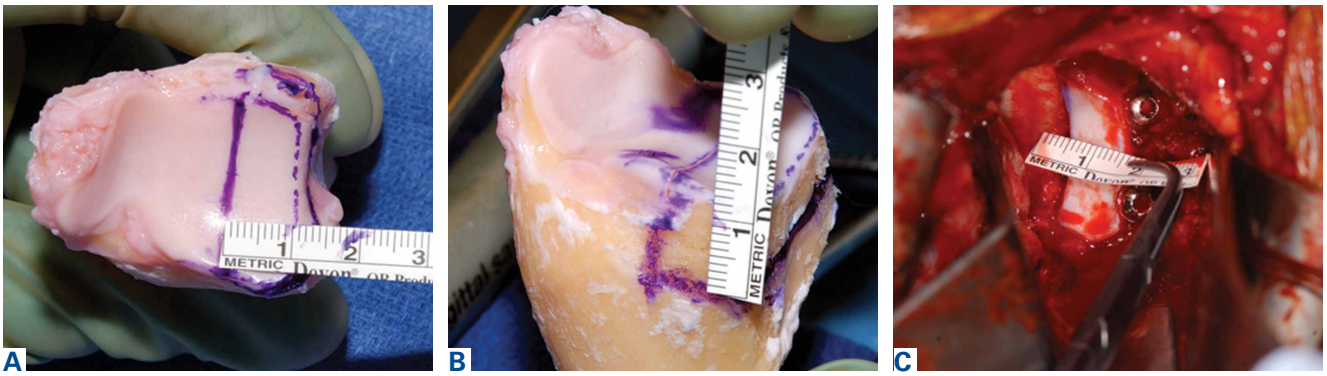

Figure 3. Distal tibial allograft (DTA) is described to address anterior glenoid bone loss in instability. (A) Axial and (B) coronal views of DTA with graft size templated. (C) From the deltopectoral approach, DTA is seen in place and secured to the anterior glenoid with 2 screws.

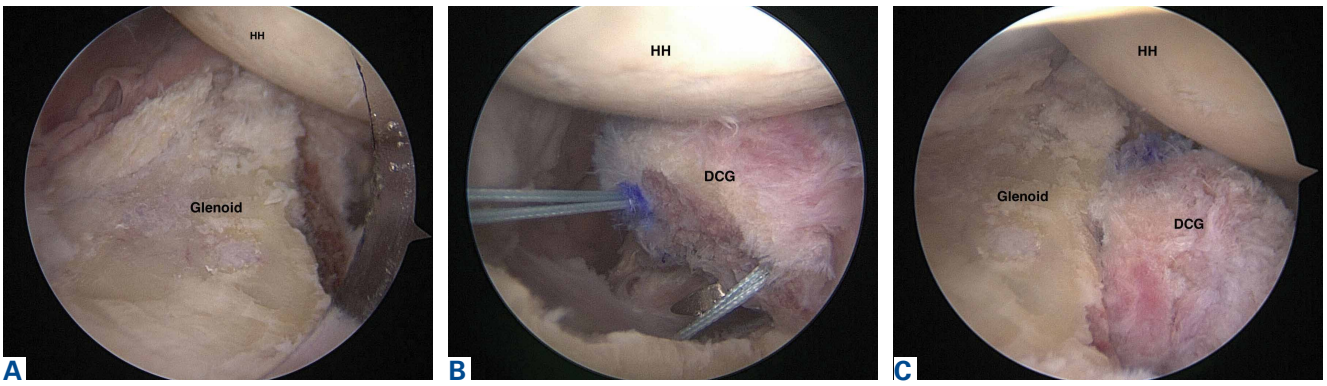

Figure 4. Placement of the distal clavicle autograft (DCG) used to augment anterior bone loss in the setting of instability. (A) Assessment of anterior bone loss. (B) DCG deployed into defect with 2 anchors into the glenoid. (C) Final view of the graft after it is tied in place.
Abbreviation: HH, humeral head.

rable clinical outcomes. Stabilization surgery failed clinically in only 3 cases, 2 open and 1 arthroscopic. The authors concluded that arthroscopic stabilization can be safely performed for recurrent shoulder instability and that arthroscopic outcomes are similar to open outcomes. In a series of anterior shoulder subluxations in young athletes with Bankart lesions, Owens and colleagues[12] found that open and arthroscopic stabilization performed early resulted in better outcomes, regardless of technique used. Recurrent subluxation occurred at a mean of 17 months in 3 of the 10 patients in the open group and 3 of the 9 patients in the arthroscopic group, for an overall recurrence rate of 31%. The authors concluded that, in this patient population with Bankart lesions caused by anterior subluxation events, surgery should be performed early.

Bone Lesions

Burkhart and De Beer[13] first noted that bone loss has emerged as one of the most important considerations in the setting of shoulder instability in active patients. Other authors have found this to be true in military populations.[14,15]

The diagnosis of bone loss may include historical findings, such as increased number and ease of dislocations, as well as dislocation in lower positions of abduction. Physical examination findings may include apprehension in the midrange of motion. Advanced imaging, such as magnetic resonance arthrography, has since been validated as equivalent to 3-dimensional computed tomography (3-D CT) in determining glenoid bone loss.[16] In 2007, Mologne and colleagues[15] studied the amount of glenoid bone loss and the presence of fragmented bone or attritional bone loss and its effect on outcomes. They evaluated 21 patients who had arthroscopic treatment for anterior instability with anteroinferior glenoid bone loss between 20% and 30%. Average follow-up was 34 months. All patients received 3 or 4 anterior anchors. No patient with a bone fragment incorporated into the repair experienced recurrence or subluxation, whereas 30% of patients with attritional bone loss had recurrent instability.[15]

Classifying Bone Loss and Recognizing Its Effects

Burkhart and De Beer[13] helped define the role and significance of bone loss in the setting of shoul-

der instability. They defined *significant bone loss* as an engaging Hill-Sachs lesion of the humerus in an abducted and externally rotated position or an "inverted pear" lesion of the glenoid. Overall analysis revealed recurrence in 4% of cases without significant bone loss and 65% of cases with significant bone loss. In a subanalysis of contact-sport athletes in the setting of bone loss, the failure rate increased to 89%, from 6.5%. Aiding in the quantitative assessment of glenoid bone loss, Itoi and colleagues[17] showed that 21% glenoid bone loss resulted in instability that would not be corrected by a soft-tissue procedure alone. Bone loss of 20% to 25% has since been considered a "critical amount," above which an arthroscopic Bankart has been questioned. More recently, several authors have shown that even less bone loss can have a significant effect on outcomes. Shaha and colleagues[18] established that a subcritical level of bone loss (13.5%) on the anteroinferior glenoid resulted in clinical failure (as determined with the Western Ontario Shoulder Instability Index) even in cases in which frank recurrence or subluxation was avoided. It is thought that, in recurrent instability, glenoid bone loss incident rate is as high as 90%, and the corresponding percentage of patients with Hill-Sachs lesions is almost 100%.[19,20] Thus, it is increasingly understood that bone loss is a bipolar issue and that both sides must be considered in order to properly address shoulder instability in this setting. In 2007, Yamamoto and colleagues[21] introduced the glenoid track, a method for predicting whether a Hill-Sachs lesion will engage. Di Giacomo and colleagues[22] refined the track concept to quantitatively determine which lesions will engage in the setting of both glenoid and humeral bone loss. Metzger and colleagues,[23] confirming the track concept arthroscopically, found that manipulation with anesthesia and arthroscopic visualization was well predicted by preoperative track measurements, and thus these measurements can be a good guide for surgical management (**Figures 1A, 1B**). At Tripler Army Medical Center, Shaha and colleagues[14] clinically validated the concept in a series of arthroscopic stabilization cases. They found that the recurrence rate was 8% for "on-track" patients' and 75% for "off-track" patients treated with the same intervention. In addition, positive predictive value was 75% for the off-track measurement and 44% for the glenoid bone loss assessment alone. The authors recommended the preoperative off-track measurement over the glenoid bone loss assessment. In an analysis of computer modeling of 3-D CT of patients who underwent Bankart repair, Arciero and colleagues[24] found that bipolar bone defects (glenoid bone loss combined with humeral head Hill-Sachs lesion) had an additive and combined negative effect on soft-tissue Bankart repair. In particular, soft-tissue Bankart repair could be compromised by a 2-mm glenoid defect combined with a medium-size Hill-Sachs lesion or, conversely, by a 4-mm glenoid defect combined with a small Hill-Sachs lesion (**Figures 2A, 2B**).

Strategies for Addressing Bone Loss in Anterior Shoulder Instability

Several approaches for managing bone loss in shoulder instability have been described—the most common being coracoid transfer (Latarjet procedure). Waterman and colleagues[25] recently studied the effects of coracoid transfer, distal tibial allograft, and iliac crest augmentation on anterior shoulder instability in US military patients treated between 2006 and 2012. Of 64 patients who underwent a bone block procedure, 16 (25%) had a complication during short-term follow-up. Complications included neurologic injury, pain, infection, hardware failure, and recurrent instability. After undergoing 1 of the 3 procedures, 33% of patients had persistent pain, and 23% had recurrent instability. In an older, long-term study of Naval Academy midshipmen, patients who underwent a modified Bristow procedure between 1975 and 1979 demonstrated 70% good to excellent results at an average follow-up of 26.4 years.[26] The recurrent instability rate was 15%, with 9% of the cohort dislocating again and 6% of the cohort experiencing recurrent subluxation. Direct bone grafting to the glenoid has also been described. Provencher and colleagues[27] introduced use of distal tibial allograft in addressing bony deficiency, and clinical results were promising (**Figures 3A-3C**). Tokish and colleagues[28] introduced use of distal clavicular autograft in addressing these deficiencies but did not report clinical outcomes (**Figures 4A-4C**).

Conclusion

Traumatic anterior shoulder instability is a common pathology that continues to significantly challenge the readiness of the US military. Military surgeon-researchers have a long history of investigating approaches to the treatment of this pathology—applying good science to a large controlled population, using a single medical record, and demon-

strating a commitment to return service members to the ready defense of the nation.

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