Recurrent Shoulder Instability Associated with Bony Defects: A Current Review

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Expert Commentary
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The glenohumeral joint is one of great mobility facilitated through the complex interplay of soft tissue and osseous anatomy. Arthroscopic shoulder stabilization has become the standard of care in the surgical management of glenohumeral instability. However, the management of the unstable shoulder associated with a bony defect (glenoid, humeral or combined) can be challenging and preclude arthroscopic treatment. Adequate diagnosis of bony defects is paramount to successful treatment and entails a careful history, clinical exam, and specific radiographic imaging. In general, higher energy shoulder trauma leads to more significant glenoid and/or humeral head defects. In addition, the severity of these defects corresponds with the number and frequency of instability episodes. Non-operative methods of treatment are not sufficient for treating these cases. Although successful arthroscopic management of instability associated with osseous defects has been described, open reconstruction is often indicated.

The shoulder joint exhibits the greatest range of motion in the human body. This motion has developed through the interplay of osseous and soft-tissue shoulder anatomy providing for the increased kinematics and highly integrated biomechanics. However, alterations in the delicate balance between glenohumeral kinematics and the biomechanics of shoulder stability predispose the glenohumeral joint to a higher degree of instability than any other joint[1]. In the United States, shoulder dislocations occur at a rate of 11.2 per 100,000 per year[2], with the majority of dislocations occurring anteroinferiorly[3].

Recurrent glenohumeral instability after a traumatic dislocation can be a result of damage to the shoulder capsulolabral structures. This is well described in the literature with avulsion of the anterior inferior glenoid labrum (Bankart lesion) and plastic deformation of the associated capsuloligamentous structures. The anterior band of the inferior glenohumeral ligament, is considered the essential lesion after the majority of anterior shoulder dislocations[3-6].

In addition to capsular-labral damage, bony defects can occur in the setting of such trauma. These defects may involve the humeral head, the glenoid, or consist of combined lesions with a prevalence that is greater than appreciated with routine radiographs[7,8]. Avulsion of the anterior glenoid rim (Figure 1), the bony Bankart lesion, has been associated with recurrent shoulder instability[9-11] and has been noted to occur from 5% to 56% of the time[10,12-16]. Most frequently, these fractures occur in the anterior-inferior aspect of the glenoid rim[17]. Studies have reported a prevalence of bony glenoid deficiency as high as 90% in shoulders with recurrent instability[9] although not all of these are large enough to be of clinical significance [8]. Similarly, a high percentage of patients who failed soft tissue stabilization procedures have been noted to have osseous glenoid deficiencies[11,18,19]. Hill-Sachs lesions, impression fractures of the humeral head (Figure 2), occur in up to 65% to 71% of first time dislocators and also contribute to recurrent shoulder instability. In the case of recurrent instability, the incidence and size of Hill-Sachs lesions increases with a prevalence reported as high as 93%[3,16,20-22].

Despite the high rates of bony defects noted, not all are clinically relevant. Clinically significant glenoid and/or humeral head defects are large enough to cause or exacerbate shoulder instability. Biomechanical data from Itoi et al has shown that the force required to translate the humeral head in relation to the glenoid with the arm in abduction and external rotation was significantly smaller in the glenoid with a defect of equal to or greater than 21% of its length or 6.8 mm in width compared to in the presence of glenoid defects of smaller sizes[23]. Similarly, recent cadaveric data suggests glenohumeral instability in abduction and external rotation is significantly increased as the humeral head defect approaches 25% of the humeral head diameter[24].

This article reviews the anatomy and biomechanics pertinent to glenohumeral instability, the clinical evaluation of patients presenting with recurrent anterior shoulder instability, and the recommended treatment for addressing bony deficits associated with recurrent anterior shoulder instability.

Anatomy

The shoulder joint is composed of dynamic and passive stabilizers. The dynamic stabilizers confer stability during shoulder motion and include the rotator cuff muscles, long head of the biceps brachii, and scapular stabilizers. The passive stabilizers, responsible for shoulder stability at rest, include the glenoid labrum, glenohumeral ligaments, glenohumeral capsule,

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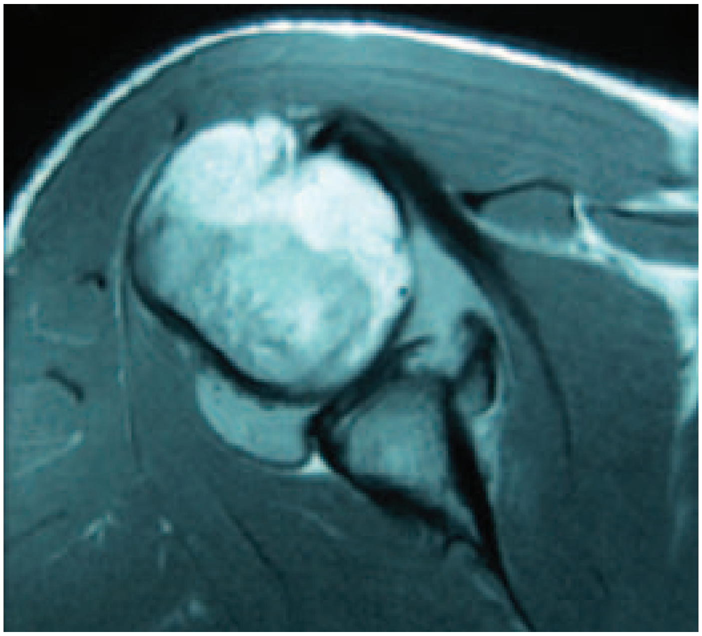

Figure 1. Magnetic resonance image (MRI) revealing a bony defect of the anterior glenoid rim.

and rotator interval[3,25]. At rest, negative intra-articular pressure provides primary glenohumeral stability. Through a functional range of motion, the rotator cuff and biceps brachii confers stability and at the extremes of motion, the capsuloligamentous structures provide primary constraint[26].

The anterior-inferior glenoid labrum and attached anterior band of the inferior glenohumeral ligament play a significant role in providing shoulder stability, especially when the arm is in abduction and external rotation[25]. When the labrum is damaged, the depth of the shoulder socket is decreased[27,28] and tension of the associated glenohumeral ligaments is lessened[25]. While the Bankart lesion is present in the majority of anterior shoulder instability cases, cadaveric studies clearly show that the Bankart lesion alone does not create instability[6]. Of significant importance is the role of the inferior-glenohumeral ligament (IGHL) complex in shoulder instability. The IGHL, attaching to the anterior-inferior labrum, acts as a hammock preventing anterior humeral head translation in the abducted arm[25]. Damage to the IGHL in the setting of Bankart lesion, whether at the labral attachment or as a result of plastic deformation in addition to capsular damage, leads to clinical shoulder instability[3,25,29]. The rotator interval[30,31], biceps tendon[32], and rotator cuff muscles[33-35] have also been shown to contribute to anterior shoulder stability. In addition to these dynamic stabilizers, concavity-compression relies on the convex head articulating with the concave glenoid and labrum[36]. Loss of this important mechanism as found in significant glenoid or humeral impression fractures can lead to shoulder instability[24].

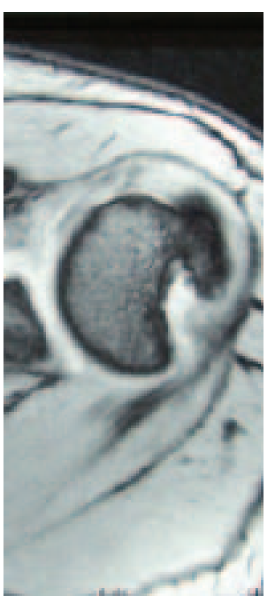

Figure 2. MRI revealing a large postero-lateral humeral head defect.

Diagnosis

Accurate characterization of bony shoulder instability relies on a combination of the patient's history of shoulder instability as well as the clinical and radiographic examination. The patient should be queried about the circumstances surrounding the initial dislocation episode and the position of their arm preceding dislocation. Similarly, the clinician should obtain a detailed history of subsequent dislocations, the force required to dislocate, the frequency of these episodes, and the length of time from the last dislocation. One should have an increased index of suspicion for bony deficiency in the presence of an initial high energy trauma with subsequent instability episodes occurring with minimal force or in the mid-range of shoulder motion[11]. Frequently these injuries are a result of sports activities or other high energy trauma[11]. Bigliani et al found a high incidence of shoulder injuries arising from competitive football in their series of patients with glenoid rim fractures[9].

On clinical examination, Jobe's relocation, anterior apprehension, and the load and shift tests are effective means of evaluating anterior instability. In the setting of significant bony deficiency, the apprehension test will be positive with minimal amounts of abduction and external rotation. Similarly, the relocation test may create grade 3 instability with locking or appreciable crepitus [16]. The load and shift test reproduces the inherent shoulder instability. With a compressive load applied to the glenohumeral joint, an anterior translational force is applied. In the intact shoulder, increased external rotation will increase tension on the anterior band of the IGHL and decrease anterior translation. In the presence of anterior shoulder instability, excessive translation of the humeral head is noted even with external rotation of the shoulder. For this reason, patients with significant bony deficiency and a history of instability with minimal effort do not often tolerate these tests while awake, and these findings are best noted during an examination under anesthesia.

Radiographic imaging is critical in detecting osseous lesions. All patients with shoulder instability should have at least three plain radiographs including a true anterior-posterior, scapula lateral, and axillary views[37]. The Styker notch and the internal rotation views are the most accurate radiographic imaging techniques for diagnosing Hill-Sachs lesions[37-40]. The West Point and Bernageua glenoid profile views[41] are useful in detecting glenoid rim lesions not identified on standard radiographic images[7,37,41]. However, these views may not be sensitive enough to detect small glenoid defects[9]. Computed tomography (CT) is the imaging modality of choice in patients with suspected osseous deficiency and should also be included in the work-up of patients with recurrent shoulder instability or those that fail arthroscopic shoulder stabilization[9,37]. In addition, CT scans are helpful for pre-operative assessment and planning, as it allows quantification and positional mapping of osseous lesions. Magnetic resonance imaging (MRI) is also useful for identifying humeral avulsion of the glenohumeral ligaments (HAGL lesion)[42] and is useful in evaluating glenoid rim deficits, rotator cuff integrity, and for sizing humeral impaction fractures[43,44].

Diagnostic arthroscopy is very effective in the diagnosis of bony defects about the shoulder joint [4,45,46]. Dynamic instability with the shoulder in positions at risk can also be fully assessed when patients are placed in the beach chair position; however, this is more difficult in the lateral decubitus position.

Treatment

Success following arthroscopic treatment of Bankart lesions in the absence of bony deficits is very high. However, failure rates for arthroscopic treatment in the presence of large bony glenoid and/or humeral head impaction fractures that engage with the glenoid are unacceptably high[3,19,47]. Cadaveric models have demonstrated that bony glenoid lesions in which the width measures up to 20% of the glenoid leads to shoulder instability[23]. A Hill-Sachs lesion may contribute to recurrent instability when it "engages" the anteroinferior glenoid rim during abduction and external rotation[19,46]. Such a defect may be present as the size of the impaction fracture approaches 25%, which has been shown to coincide with significant loss of stability at 60 degrees of abduction[24]. The ease of engagement also depends on the amount of laxity from capsuloligatmentous injury and the presence of glenoid bone loss. Stage III instability, or a locked dislocation from engagement of the Hill-Sachs lesion, occurs when the humeral impaction fracture involves 30% or more of the humeral head diameter.

There is level I and II evidence that arthroscopic stabilization of acute, traumatic first-time dislocations produces a lower rate of recurrent instability than does immobilization and rehabilitation[1,48]. However, in the absence of a HAGL lesion, bony humeral or glenoid defects, or a rotator cuff avulsion injury, operative stabilization of first-time shoulder dislocations remains controversial.

Glenoid Defects

Arthroscopic Techniques

Arthroscopic Bankart repair performed in the presence of significant osseous defects have increased failure rates compared to those shoulders without bony defects[9,16,19,49]. Sugaya and others have reported on the successful arthroscopic treatment of both acute and chronic bony Bankart lesions[10,15,50-52]. In most instances, however, open approaches are used with greater success and lower recurrence rates in the presence of large glenoid defects[9,16,19,49].

Open Techniques

In the presence of glenoid rim fractures greater than 20-25% of the width of the glenoid, as measured at the bare area of the glenoid, open as opposed to arthroscopic approaches are recommended[16]. Historically, tricortical iliac crest bone grafting[53,54] or coracoid process transfers[55-57 56-58] have been described in the treatment of glenoid bone loss[16,59]. Recently, more "anatomic" means of restoring deficient glenoid bone stock through the use of fresh frozen osteo-articular glenoid allografts have been described with good outcomes[60]. While this seems promising, the prohibitive cost of fresh osteoarticular allografts and the surgeon's inability to truly restore the soft tissue anatomy of the glenoid labrum and capsuloligamentous structures to the reconstructed glenoid rim may preclude this technique from being widely used.

Bristow-Latarjet

The Bristow and Latarjet procedures involve a non-anatomic transfer of a coronal plane osteotomy of the coracoid process to the glenoid (Figure 3). The Bristow procedure, described by Helfet in 1958, involves transfer of the tip of the coracoid to the glenohumeral capsule and to the tip of the anterior glenoid periosteum[55]. In 1964, it was modified by Mead and Sweeney to include rigid internal fixation[61]. Attached to the tip of the coracoid, the biceps and coracobrachialis provide dynamic restraint to inferior and anterior instability, especially in abduction and external rotation. Further additional restraint is provided by transferring the coracoid bone block and conjoined tendon between the inferior 1/3 and superior 2/3

Figure 3. Postoperative x-ray after successful Latarjet procedure.

of the subscapularis muscle to prevent it from riding superior to the inferior humeral head during at-risk activities.

The Latarjet approach was described in 1954 by Latarjet[58] and involves transfer of the entire coracoid process to the anterior glenoid neck. The coracoclavicular ligaments and base of the coracoid process are left intact. A remnant of the coracoacromial ligament remains attached to the transferred coracoid process and is imbricated into the anteroinferior glenohumeral capsule for further stability.

A triple-blocking effect has been ascribed to the success of the Latarjet procedure in which the three stabilizing components include: 1) the structural bone graft that the coracoid process provides effectively increases the osseous diameter of the glenoid and precludes humeral head engagement on the glenoid rim; 2) the hammock effect of the inferior subscapularis prevents excessive humeral translation in the abducted and externally rotated position; and 3) the ligamentous augmentation of the anterior band of the inferior glenohumeral ligament by the coracoacromial ligament transfer.

Many surgeons prefer the Latarjet over the Bristow, as it provides a larger piece of structural bone for superior fixation of the coracoid with two screws rather than one and allows for augmentation of the capsule with the coracoacromial ligament. An advantage of both procedures over non-local structural bone grafting is that the transferred coracoid process remains vascularized and may therefore more reliably achieve osseous union with the glenoid neck.

Long term studies have reported a long-term satisfaction rate of up to 98%[62]. However, overhang of the coracoid process may lead to early arthrosis and excessive medialization, and superior placement of the fragment may lead to higher rates of arthrosis[63].

Non-Local Structural Bone Grafting

These techniques involve the use of structural bone graft, harvested from the iliac crest, or allograft (cortical tibial allograft, calcaneal allograft, and fresh-frozen glenoid allograft have been described) to augment large glenoid defects[16,53,54,64]. Good outcomes were reported by Warner et al on 11 patients treated with these techniques with an average follow-up of 33 months. They noted significant improvement using multiple outcomes measurements and a return to pre-injury sporting activities after surgery. However, they did note some loss of flexion (mean, 7 degrees) and external rotation (mean, 14 degrees)[54]. The use of tendo-Achilles allografts have been described to provide bony augmentation and capsular reconstruction. Additionally, recent biomechanical data suggests a role for the use of fresh frozen glenoid allografts in the appropriate patients[60].

Humeral Head Defects

Arthroscopic Techniques

Large humeral head defects complicating anterior shoulder instability are difficult to manage through arthroscopic means. This is proportionate to the size of the lesion and exacerbated by the posterosuperior position of the defects on the humeral head[65]. Despite this, the use of osteoarticular transfer systems (OATS) plugs and osteobiologic implant (OBI) plugs performed arthroscopically has been described[50]. The arthroscopic advancement of the infraspinatous tendon and associated posterosuperior glenohumeral capsule into the Hill-Sachs lesion (i.e., the Remplissage technique) has also been described.[66]

Remplissage

The "Remplissage" technique has recently gained popularity as an arthroscopic means of addressing engaging Hill-Sachs lesions. Remplissage means "to fill" in French and involves imbrication of the posterior capsule and infraspinatus tendon into the humeral head defect[66]. While similar to the open McLaughlin procedure for engaging reverse Hill-Sachs lesions, the Remplissage technique decreases the joint space, may limit glenohumeral external rotation, and non-anatomically places the humeral head defect into an extra-articular location[16]. Technically, this may be performed through an accessory posterior portal with one or two rotator cuff anchors placed, depending upon the size of the defect. While case series have shown promising results, biomechanical and kinematic data is lacking. Similarly, long-term studies are needed to document the outcomes and complications of this approach.

Open Techniques

Open approaches are favored for management of large humeral head defects. Accepted techniques include humeral head derotational osteotomies[67], structural grafting[68], and humeral head resurfacing or traditional hemiarthroplasty in cases in which the defect exceeds 40% of the humeral head diameter with associated arthrosis.

Derotational Osteotomies

Historically, derotational humeral osteotomies have been described to treat recurrent instability exacerbated by engaging Hill-Sachs lesions. The goal of this technique is to increase the retroversion of the proximal humerus so that the defect no longer engages on the glenoid rim during a functional arc of motion. In the original description by Weber et al, they reported on 180 shoulders over an average follow-up period of 14 years. They noted a redislocation rate of 5.7% and average of loss of external rotation of 5 degrees. One hundred and seven shoulders underwent plate removal. However, 90% of the patients reported good to excellent results[69]. Despite these positive results this technique is rarely performed today.

Structural Bone Grafting

Fresh frozen osteochondral allograft to fill in humeral head defects allows for restoration of the humeral head anatomy and elimination of osseous engagement on the anterior glenoid rim (Figure 4). Studies have reported good outcomes using this approach. Miniaci et al reported their results using this approach on 18 patients at 2 years[70]. There was no recurrent instability and all patients had return to near normal activity. This surgical approach entails an open surgery through the deltopectoral interval with takedown of the subscapularis

Figure 4. Postoperative x-ray after successful structural bone grafting of humeral head defect.

and dislocation of the humeral head for adequate visualization and anatomic restoration. In cases in which the articular cartilage of the glenohumeral joint is well-preserved, the use of fresh frozen osteochondral allograft affords a joint-sparing procedure eliminating the need for shoulder replacement. Reports of using OBI plugs or OATS has also been described with success[71,72].

Reconstruction

Finally, in cases in which the humeral impaction fracture exceeds 40% of the humeral diameter, hemicap resurfacing or traditional hemiarthroplasty is the treatment of choice if fresh allograft is not available or the joint shows signs of post-instability arthropathy.

Conclusion

The management of the unstable shoulder with bony defects is challenging and differs depending on the individual case. Diagnosis relies on a thorough clinical and radiographic evaluation. Of significant importance is the size and location of the defect encountered. Treatment strategies are emerging, and our ability to create successful outcomes is improving. However, biomechanical data and longitudinal outcomes research will help us elucidate the most appropriate treatment.

Ask the Expert

William N. Levine, MD
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How do you approach the new patient with evidence of shoulder instability with bony defects?

The critical aspects of the work-up include the history as these patients will often relate that their instability events occur with little to no trauma or energy. This should always raise the red flag that there may be a bony component to the instability pattern. Next, once a bone deficit is suspected a CT scan must be ordered preferably with 3-D reconstruction. The critical images are the sagittal images with the humeral head subtracted. These views are the most reliable in determining the amount of bone loss, if present.

How do you decide whether to treat these patients through arthroscopic and/or open techniques?

The paradigm has truly shifted from consideration of "scope vs open" to soft tissue vs bone procedures. Since I perform all soft tissue procedures arthroscopically there are few indications for open instability surgery in my practice today. Therefore, I perform open procedures (i.e. Latarjet coracoid transfer) only when significant bone defects are present.

Do you have any preferences in terms of surgical techniques for glenoid or humeral head defects?

Almost all bone defects (glenoid or humeral head) can be managed with a glenoid-based procedure. My preferred procedure is the Latarjet procedure where the coracoid process is osteotomized at the base of the coracoid and is then transferred through a subscapularis split to the anteroinferior glenoid defect and affixed with 2 screws. In rare cases where the humeral head defect is so large (30-40%) and an arthroplasty is not appropriate due to patient's age, for example, I will perform a humeral head osteochondral allograft procedure. This is a technically demanding operation and some surgeons feel that even in the face of large humeral head defects a Latarjet will suffice.

What is your post-operative protocol with these patients?

Post-operatively, patients are placed in a sling with abdominal support to keep the shoulder in the desired position (arm at side in neutral to slight external rotation) to decrease stress on the reconstruction. Supervised physical therapy typically begins 10-14 days after surgery and continues for 3-6 months depending on the patient. Our goals are to have the patient regain full passive range of motion by 8 weeks and then begin light strengthening for the next several months. Progressive activities and strengthening are allowed as the shoulder recovers and return to sports is typically held off for at least 6 months post-operatively.

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