Current Issues in Treatment of Anterior Shoulder Instability: A Review

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Abstract

Anterior shoulder instability can be problematic in the young, active population, particularly in athletes and military personnel. The shoulder joint is the most frequently dislocated joint, and there is a high rate of dislocation recurrence in younger patients. The stability of the glenohumeral joint is conferred through the bony anatomy and the static and dynamic stabilizers. Recognizing pathological features, identifying glenoid bone loss, and detecting Bankart and Hill-Sachs lesions are key to formulating an appropriate treatment strategy and improving surgical outcomes. Furthermore, the concept of critical bone loss has been refined by looking at subcritical loss. Recent evidence has shown that patients with glenoid bone loss at or above a subcritical level of 13.5% had higher re-dislocation rates, and those patients that did not re-dislocate experienced worse outcomes compared to those without subcritical bone loss. Intraoperative estimations of bone loss may not be always accurate, and advanced preoperative imaging using computed tomography or magnetic resonance imaging can be useful. To help assess successful treatment of anterior shoulder instability, I reviewed glenoid anatomy, injury workup, bone loss, the concept of glenoid track for engaging lesions, determination of bone loss, subcritical bone loss, and surgical treatment. Careful assessment of both types of lesions, the patient's preferred activity level, and postoperative goals allows surgeons to decide between procedures to restore anterior glenoid bone deficits and soft-tissue repair and determine any role for a Remplissage procedure.

Introduction

Anterior shoulder instability is a problem frequently encountered in young, athletic populations, with a high predominance in men.[1] It is the most frequently dislocated joint, and in this population there is a high risk of recurrence.[1] This frequently dictates operative treatment for stabilization of the shoulder.

Patients with anterior shoulder instability are often aged 15 to 40 years, although any age group can sustain the injury.[2] It has much higher incidence in military populations, ranging 1.69 to 4.35 per 1000 person-years compared to 0.08 to 0.24 per 1000 person-years in the civilian population.[2] In 1923, Bankart described the anteroinferior labral lesion that now bears his name.[2] Surgical treatment originally consisted of open repair, with debate often centering on whether any bony augmentation was needed.[3] Surgical stabilization generally produced favorable results and, with the advent of arthroscopy, this became the primary means of Bankart repair.[3] The efficacy of these repairs has been evaluated and may be affected by patient characteristics.[4] Results of recent studies have added to treatment strategies by determining which patients underwent successful treatment with a stand-alone arthroscopic Bankart repair and which need additional stabilization to reduce the risk of recurrent dislocation.

Estimates on the prevalence of engaging lesions varies widely. Engaging lesions are defined by a Hill-Sachs lesion that engages with the anterior glenoid rim and contributes to subluxation or dislocation (Figure 1).[4,5] Hill-Sachs lesions that are large or close enough to the articular margin may cause the humeral head to lever anteriorly with engagement of the lesion.[4,5] To help assess successful treatment of anterior shoulder instability, I reviewed glenoid anatomy, injury workup, bone loss, the concept of glenoid track, and surgical treatment.

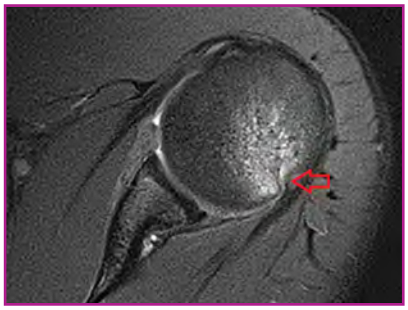

Figure 1. Magnetic resonance imaging of a Hill-Sachs lesion with subchondral edema (red arrow). This is classified as an "on-track" lesion and not expected to engage. Just 4 mm, or 17% anterior glenoid bone loss, would convert this to an engaging, "off-track" lesion that requires treatment.

Glenoid Anatomy

Glenoid anatomy also plays a role in anterior shoulder instability.[4] The shallow ball and socket anatomy of the glenohumeral joint is better described as a golf ball on a tee. Coupled with the degree of freedom of rotation, this joint is more susceptible to instability than others in the body. Normal anatomic stabilizers include both static stabilizers, including the morphological features of the glenoid, the labrum, glenohumeral ligaments and negative pressure of the joint, whereas dynamic stabilizers include the rotator cuff and long head of the biceps. Multiple glenohumeral ligaments resist translation at varying angles of shoulder abduction. Bankart tears of the labrum can result in loss of stability through loss of the bumper mechanism and detachment of the anterior-inferior glenohumeral ligament.

Glenohumeral joint congruence depends on the depth of the glenoid and the labrum, and the arc length.[4,6] The labrum and glenoid each contribute 50% of the depth. The effective glenoid arc is the available articular surface for humeral head compression. This concept was later advanced when describing the glenoid track. Shortening this arc leads to less available motion before instability occurs. The balance stability angle is defined as the angle from the center of the humeral head and the center of the glenoid to the edge of the glenoid, and is approximately 18° anteriorly. A total force vector on the humeral head greater than 18° can cause a loss of bony constraint of the humeral head and risk of anterior dislocation if the soft-tissue restraints fail.

Loss of glenoid bone results in a shallower glenoid surface with less constraint and a shorter arc of motion before the Hill-Sachs lesion engages.[7] This often causes a sense of subluxation or a fulcrum for anterior dislocation. The chance of engagement and dislocation are increased when the shoulder is abducted 90° while flexed and with varying external rotation.[7] This athletic position is most often encountered in athletes who participate in overhead-throwing sports.[2]

Workup

Thorough workup begins with a detailed history about instability events, number of events, arm position or activity during instability, and type of physical activity or sports.[8] Findings of physical examinations help support the diagnosis of anterior instability. Standard examination protocols should include range of motion, apprehension and relocations tests, which specifically focus on anterior dislocation. The load-and-shift test estimates the degree of translation and lesions that will engage the posterior humeral head on the anterior glenoid and whether they are reducible. Additionally, the sulcus sign, an indicator of inferior laxity, and generalized ligamentous laxity with the Beighton Score may help with the diagnosis.

Glenoid Bone Loss

Estimates of the degree of glenoid bone loss have varied considerably. Sugaya et al[9] felt that glenoid bone loss was significant in patients with recurrent anterior dislocations. With 50% of the fragment type, and 40% erosion type, that left 10% without any glenoid bone loss.

Burkhart and De Beer[4] discussed the concept of "significant bone loss." They described traumatic glenoid bone loss of 25%, below the mid-glenoid notch, which has been noted as creating an inverted pear shape. This traumatic loss lead to greater instability than an isolated Bankart lesion (Figure 2). They determined that the key to arthroscopic Bankart repair was proper placement of the labrum on the glenoid. If fixed laterally on the glenoid rim, rather than medially, it was equivalent to an open repair.

Recurrence rates after arthroscopic stabilization are dependent on bone loss and type of activity. This is particularly true for athletes in contact-based sports. Contact athletes had a higher recurrence rate with a bony defect (up to 89%) than without (down to 6.5%).[4] For non-contact athletes, two-thirds with a bony defect had recurrence, whereas those with an intact glenoid had a 4% recurrence rate that was comparable to an open Bankart repair.[4] Burkhart and De Beer[4] also found that 100% of patients with an engaging Hill-Sachs had recurrence.[4] This statistic helped lead to the general consensus that patients with more than 25% glenoid bone loss might require an additional procedure to ensure stabilization.[4]

Quantifying the amount of glenoid bone loss helps determine whether Bankart repair may be successful or should be augmented or replaced by another procedure. Anteroinferior bone loss of 21% of the superior-inferior length has been shown to predict failure of Bankart repair alone.[10] Previously, the amount of significant bone loss was thought to be about one-third of the glenoid width.[10] Itoi et al[10] found this fraction was more likely to be as little as one-fifth of the width and theorized that glenoid bone loss may also lead to instability owing to internal rotation and laxity of the anterior ligamentous constraint. Yamamoto et al[11] defined this as 25% of the loss of width (19% loss of height), representing a 26% loss in surface area. Additionally, the length may be easier to measure because the width can be altered by bone loss.[11] Bankart repair can decrease terminal external rotation, losing about 25° for every centimeter of anterior capsular imbrication. This is important in throwing athletes, and consideration to bony treatment of the glenoid may be more important in these patients.[10]

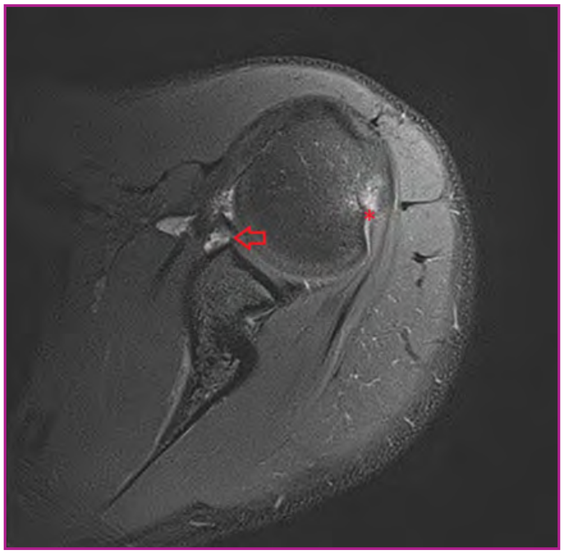

Figure 2. Axillary T2-weighted magnetic resonance imaging, showing the Bankart lesion, an anterior-inferior labrum tear (red arrow). A moderate Hill-Sachs lesion is also present (red asterisk).

Glenoid Track Concept

The concept of the glenoid track is a continuation of the idea of an engaging lesion. It defines the articular contact of the humeral head on the glenoid. An intact glenoid track often indicates a stable glenohumeral joint. The glenoid track is 84% of the glenoid width, which is equivalent to the medial margin of the humeral head contact area to the medial margin of the rotator cuff attachment at 90° of abduction.[12]

The area of contact between the glenoid and the humeral head changes with motion of the joint. As the humeral head abducts the posterior humeral contact area shifts from inferomedial to superolateral.[12] If the Hill-Sachs lesion is within the track, or "on-track," it will not override the anterior glenoid rim and engage.[12] An "off track" lesion risks overriding and engagement.[12] Thus, the depth of the Hill-Sachs lesion is not as important as its medial-most margin.

Likewise, glenoid bone loss directly narrows the glenoid track and risks engagement and dislocation.[12] The humeral portion of the track should be measured from the lateral margin (medial footprint of rotator cuff) because the posterolateral cartilage may not be a reliable marker.[12] This concept has been used to unify the issue of bipolar lesions and how to address them.[12] Although studies with computed tomography (CT) have helped demonstrate glenoid bone loss and Hill-Sachs lesions, Omori et al[13] used magnetic resonance imaging (MRI) with similar findings and noted that the glenoid track was 83% of the glenoid width.

Giacomo et al[5] noted that arthroscopic evaluation could be problematic. Evaluation of engaging lesions before soft-tissue labral repair would not indicate true stability because of lack of capsular, labral, and ligamentous stability. Evaluation post-repair risked damage to the repair. They advocated for more rigorous classification and preoperative measurement with CT scan and arthroscopic measurement. By calculating the diameter of the glenoid (D) minus the amount of bone loss (d), the width of the glenoid track (GT) is determined (GT = 0.83[D-d]). The Hill-Sachs Interval (HSI) is then determined, which is the width of the Hill-Sachs lesion (HS) plus the width of the bone bridge (BB) between the rotator cuff attachments and the lateral aspect of the Hill-Sachs lesion. (HSI = HS + BB). If the HSI value is greater than that of GT, the Hill-Sachs lesion is off-track or engaging; if less, the Hill-Sachs lesion is on-track or non-engaging.[5] This can be confirmed arthroscopically by measuring the anterior and posterior rims of the glenoid from the center of the bare spot and measuring the medial edge of the Hill-Sachs lesion.

To clarify the presence of engaging lesions that needed to be treated, Kurokawa et al[14] reviewed 100 consecutive patients with primary dislocation, unilateral disease, and CT scans. About 86% of patients had glenoid bone loss of 9% (SD, 6%) and 94% had a Hill-Sachs lesion, with a medial margin of 69% (SD, 20%) of the glenoid track. The study noted that 7% of patients had engaging lesions and all had glenoid bone loss, without which there would not have been engagement. In these seven patients, the Hill-Sachs lesions were either wide and large or narrow and medial; additionally, the Hill-Sachs lesion was noted to be 114% (SD, 7%; range, 100%-121%) of the glenoid track width and the glenoid bone defect was 20% (SD, 6%; range, 12%-27%).

Determination of Bone Loss

Gyftopoulos et al[15] correlated MRI measurements with arthroscopic findings. Glenoid bone loss on MRI was measured with a best fit circle. Thirteen of 18 lesions on MRI were classified as off-track, with a sensitivity of 72.2%. Fifty-one lesions were classified as on-track on MRI, for a specificity of 87.9%. Positive predictive value was 61.1% and negative predictive value was 87.9%. In comparing CT measurements to MRI measurements, Huijsmans et al[16] found no difference between CT or MRI and digital-photograph measurements; however, MRI measurements tended to be larger and had a larger standard deviation.[16]

Chuang et al[17] retrospectively viewed CT scans of shoulders to correlate the arthroscopic findings compared to the injured and uninjured sides. They calculated the glenoid index (1.0 minus the percent loss) and found that patients treated arthroscopically had a glenoid index of 0.85 to 0.95. Of those repaired with the Latarjet procedure, a total of 92% were correctly identified by CT, with a glenoid index of 0.58 to 0.74. Glenoid index was determined by the measured glenoid compared to the predicted width, and a glenoid index > 0.75 could be treated arthroscopically.

Determining the location of the bone loss is also important to guide treatment, especially when using arthroscopic measurement. One study[18] retrospectively reviewed CT scans and noted that the defects were at 3:01 on a clock face from the superior glenoid, which correlated to 4:17 in relation to the body. Ji et al[19] reported similar findings with defects at 3:20 on the glenoid. Altan et al[20] questioned the accuracy of a single linear CT measurement. The measurement of the diameter at 4:00, referenced from the superior glenoid, was the most accurate for smaller overall loss (6%). There was difficulty in measuring increasing values. As the loss grew greater than 14%, it showed no correlation, potentially owing to biconcave-shaped bone loss. Averaging multiple measurements of diameter improved the correlation, but the results also revealed that use of width can complicate accurate measurements.

Although correlation with arthroscopy has been considered reliable, two studies called this into question. Kralinger et al[21] found that the bare spot was often not present, severely deformed owing to degenerative disease, or eccentric. Eccentricity was caused by the inferior radius and differences between the anterior and posterior radii, which placed the bare spot closer to the anterior rim in intact specimens. Such a placement may lead to overestimation of bony loss when measuring arthroscopically. Aigner et al[22] confirmed that the bare spot was not concentrically located along the inferior margin or referencing anterior or posterior. More recently, Bakshi et al[23] reinforced such results by describing four different types of similar CT measurements that arthroscopy overestimated the amount of bone loss.[23] Not all patients had a CT scan, but Auffarth et al[24] showed multiple missed glenoid rim fractures and Hill-Sachs lesions between different observers on radiographs. Even dedicated and appropriate films can miss these. Because of the difficulty in determining treatment even with CT or MRI in conjunction with arthroscopy, surgeons should consider use of advanced imaging in determining glenoid bone loss.

Subcritical Bone Loss

Shaha et al[25] advanced the idea of glenoid bone loss through impaction by analyzing subcritical bone loss. Initial results showed that patients who underwent successful arthroscopic repair had an average of 14.5% bone loss, whereas patients with unsuccessful treatments had an average of 21% bone loss. Subcritical thresholds were calculated with a 25% risk of dislocation after arthroscopic repair with more than 7% bone loss and a 95% risk above a threshold of 17.1%.

A follow-up study divided patients into quartiles based on bone loss and correlated preoperative MRI using the Western Ontario Stability Index (WOSI) to determine risks of failure.[26] In this military population, most patients (89%) had some bone loss and fewer (19%) had critical bone loss. Patients with critical bone loss had a 27.8% risk of undergoing unsuccessful treatment, whereas those with less than critical loss had a 7.3% risk. Using a sub-critical threshold of 13.5%, the study found a much higher rate of dislocation above this threshold (21.9% to 4.9%) and a significant difference in WOSI scores. When excluding unsuccessful treatments, patients with more than 13.5% bone loss had a significantly lower WOSI score. The findings showed unacceptable results with subcritical bone loss, even without re-dislocation, which supports that bone loss is better viewed on a continuum rather than a strict cutoff to help guide treatment.

Surgical Treatment

Treatment options have typically involved activity modification, bracing, and physical therapy.[27] Surgical treatments include arthroscopic anteroinferior capsulolabral repairs with or without capsular shift, anatomic versus non-anatomic bony augmentation procedures guided by the size of the glenoid and humeral bone deficit, and posterior capsulodesis and rotator cuff tenodesis procedures of the Hill-Sachs lesion (Remplissage procedure).[27] Using cadavers, one study showed that restoring glenoid concavity also restored translation stability to that of the intact joint or greater.[11]

Laterjet Transfer

Latarjet transfer uses a sling from the conjoined tendon, capsular augmentation and bone block from the corocoid to help restore glenoid loss and confer anterior stability.[27] Mook et al[27] retrospectively reviewed 35 patients who had a Latarjet procedure for treating instability and calculated the anticipated postoperative glenoid track. Eight patients had recurrent instability, with four (50%) having off-track lesions. Three of the patients with unstable shoulders underwent revision treatment, and all three had off-track lesions. Of the on-track lesions, four of 25 were unstable. Subsequently, off-track lesions were four times more likely to be unstable after Latarjet stabilization. Yet the results should be interpreted carefully. Five patients in the unsuccessful-treatment group had subluxation but not frank dislocation. Additionally, the sling effect after Latarjet reconstruction can add stability and soft-tissue constraint beyond restoring glenoid depth and arc length.[27]

Yang et al[28] reviewed modified Latarjet stabilization and evaluated glenoid bone loss and engaging lesions. All patients had engaging lesions at arthroscopy. The group with less than 25% glenoid bone loss had improved motion and WOSI scores. This group had fewer revisions, but this was not statistically significant.

Reimplissage Procedure

To address off-track lesions, useful techniques to prevent the lesion from engaging include bone grafting and Remplissage procedure to fill in the defect. Warner et al[29] reported on using iliac crest autograft in patients who underwent unsuccessful treatment with a previous Bankart repair. Despite a small loss of motion, all patients returned to sports-related activity such as professional-level, contact-based sports. Healing was noted on postoperative radiographs and CT.

Zhu et al[30] reported promising results with the Remplissage procedure used in 49 patients, all of whom had engaging lesions and less than 25% glenoid loss. There was a single re-dislocation from new trauma, two subluxations, and one with apprehension. Including these four patients, the failure rate was 8.2% (but 48 of 49 reported satisfaction with treatment). Most patients (71.4%) returned to preoperative levels of sports participation.

One study[31] reported long-term follow-up on the Remplissage procedure alone used in 59 patients with less than 25% glenoid bone loss. Findings of the MRI were used to diagnose Hill-Sachs lesions, but nine patients were not diagnosed successfully (all had glenoid bone loss). Recurrent instability was noted in 4.4% of patients after trauma during sports. Some (10.2%) had pain, apprehension, or did not return to sports but showed no signs of persistent instability. No loss of motion was noted.

Postoperative Results

Because many patients are athletes, the question of returning to sports is important to consider in postoperative follow-up. A cohort of patients who underwent the Remplissage procedure had a 12% re-dislocation rate, in which 6% were traumatic and 6% were atraumatic.[32] All underwent a revision procedure and had no further dislocations. Many patients (90%) were satisfied to very satisfied after operative treatment, and 70% expressed that the treatment greatly improved their quality of life. Almost all of them returned to sports or work, and 85% were satisfied with their level of participation. However, 69% were throwing athletes and two-thirds had throwing issues. This group had an average loss of 4.8° of external rotation, and most commonly had trouble with windup or loss of velocity. Overhead athletes returned to sports activity, but throwing athletes were less successful in returning and showed that greater than four dislocations preoperatively may increase the risk of postoperative dislocation. Although a trend was noted, patients with revisions did not have a significantly higher rate of dislocation than those who underwent only one procedure.

Comparing postoperative outcomes between primary arthroscopic Remplissage versus revision procedure, McCabe et al[33] found that the decision to perform a Remplissage procedure was not made until intraoperatively in almost half of patients, using the bare spot method. This illustrated the need for advanced imaging and preoperative planning. No difference was noted preoperatively between the primary and revision group. The primary group had no dislocations after repair. The re-dislocations all happened in the revision group, accounting for almost one-third of that group, and all were because of new traumatic events.

When comparing postoperative outcomes of Latarjet and Remplissage biomechanically, both restored stiffness to near preoperative levles.[34] Despite small difference in motion, no significant difference was found compared to the intact specimens.[34] A secondary measure showed Latarjet with fewer dislocations than the Remplissage, but this was not significant as the study was underpowered.[34]

Conclusion

In a young population, anterior shoulder disability is a notable problem that limits activity.[4] Treatment of the unstable shoulder, including complex groups of recurrent instability after primary stabilization, overhead athletes and contact athletes, should involve careful preoperative planning and intraoperative decision making.[5] The use of CT or MRI preoperatively should be seriously considered to evaluate not only soft-tissue damage, but also glenoid bone defects and the medial extent of any Hill-Sachs lesion to determine whether it is on- or off-track.[15,17] This objective planning is still corroborated by intraoperative evaluation and specifics of each patient.[21-23]

Using the following algorithm can help guide surgical treatment. Treatment should center on first evaluating bone loss and on-track or off-track lesions, and categorizing them into four groups. Patients with less than 20% bone loss and an on-track lesions can be treated with arthroscopic Bankart repair alone. Usually, these are small Hill-Sachs lesions. If the lesion is off-track, then a Remplissage procedure should be added. For glenoid bone loss greater than 25%, on-track lesions can be treated with a Latarjet procedure. For off-track lesions, the lesion should be re-evaluated after Latarjet. If the lesion engages, then humeral-sided treatment such as a Remplissage or allografting to address the lesion, converting it to an on-track lesion should be considered.[5] Furthermore, the idea of subcritical bone loss, along with individual factors, should help guide the algorithm.

Some of these specific populations who often present with anterior shoulder instability include overhead-throwing athletes who may lose external rotation following Remplissage.[32] This can make an otherwise successful operative treatment less desirable because it may limit return to activity. Depending on goals, a Latarjet procedure may be a more appropriate treatment option. Additionally, there is an overall trend toward unsuccessful outcomes of revisions, suggesting that aggressive surgical treatment for these patients, may be beneficial.[27, 28] Considering each patient's goals as well as findings during preoperative evaluation and work-up can help the surgeon plan and perform an appropriate stabilization procedure, increasing the likelihood of returning the patient to prior levels of activity.

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Conflict of Interest

The author reports no conflicts of interest.

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