**Name of Journal:** *World Journal of Orthopedics*

**Manuscript NO:** 57819

**Manuscript Type:** OPINION REVIEW

**Anterior glenohumeral instability: Current review with technical pearls and pitfalls of arthroscopic soft-tissue stabilization**

Apostolakos JM *et al*. Arthroscopic stabilization in anterior shoulder instability

John M Apostolakos, Joshua Wright-Chisem, Lawrence V Gulotta, Samuel A Taylor, Joshua S Dines

**John M Apostolakos, Joshua Wright-Chisem, Lawrence V Gulotta, Samuel A Taylor, Joshua S Dines,** Department of Sports Medicine and Shoulder Surgery, Hospital for Special Surgery, New York, NY 10021, United States

**Author contributions:** Apostolakos JM was the author primarily responsible for the writing and editing of the text; Wright-Chisem J assisted in the writing and editing of the text; Gulotta LV provided critical expertise and input into the material of the text; Taylor SA provided critical expertise and input into the material of the text; Dines JS provided critical expertise and input into the material of the text.

**Corresponding author: John M Apostolakos, MD, Surgeon,** Department of Sports Medicine and Shoulder Surgery, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021, United States. apostolakosj@hss.edu

**Received:** June 30, 2020

**Revised:** December 16, 2020

**Accepted:** December 23, 2020

**Published online:** January 18, 2021

**Abstract**

The glenohumeral joint (GHJ) allows for a wide range of motion, but is also particularly vulnerable to episodes of instability. Anterior GHJ instability is especially frequent among young, athletic populations during contact sporting events. Many first time dislocators can be managed non-operatively with a period of immobilization and rehabilitation, however certain patient populations are at higher risk for recurrent instability and may require surgical intervention for adequate stabilization. Determination of the optimal treatment strategy should be made on a case-by-case basis while weighing both patient specific factors and injury patterns (*i.e.*, bone loss). The purpose of this review is to describe the relevant anatomical stabilizers of the GHJ, risk factors for recurrent instability including bony lesions, indications for arthroscopic *vs* open surgical management, clinical history and physical examination techniques, imaging modalities, and pearls/pitfalls of arthroscopic soft-tissue stabilization for anterior glenohumeral instability.

**Key Words:** Arthroscopic; Soft-tissue; Anterior instability; Glenohumeral; Functional anatomy; Recurrent instability

**©The** **Author(s) 2021.** Published by Baishideng Publishing Group Inc. All rights reserved.

Apostolakos JM, Wright-Chisem J, Gulotta LV, Taylor SA, Dines JS. Anterior glenohumeral instability: Current review with technical pearls and pitfalls of arthroscopic soft-tissue stabilization. *World J Orthop* 2021; 12(1): 1-13 URL: https://www.wjgnet.com/2218-5836/full/v12/i1/1.htm DOI: https://dx.doi.org/10.5312/wjo.v12.i1.1

**Core Tip:** Management of the patient with anterior shoulder instability is a common yet complex condition for the orthopaedic clinician. To optimize the evaluation and management of these patients the clinician must ensure a detailed and thorough clinical and radiographic workup, have a thorough understanding of the dynamic, static, and bony stabilizers of the glenohumeral joint, and understand the common causes of failed surgical intervention in order to address these concerns when appropriate. This review describes the current evidence on anterior glenohumeral instability including functional anatomy, risk factors for recurrent instability, clinical history and physical examination techniques, imaging modalities, and operative pearls and pitfalls.

**INTRODUCTION**

The unique structure of the glenohumeral joint (GHJ) allows for a wide range of motion, but also makes the joint particularly vulnerable to episodes of instability[1]. Anterior instability is the most common form, accounting for 80%-98% of all GHJ instability events among young, athletic populations particularly during contact sporting events with the shoulder in the abducted and externally rotated position[2-10]. In 2018, the MOON Shoulder Instability Study reported on the descriptive epidemiology of 863 patients who underwent surgical intervention for GHJ instability[11]. They found the mean age for the cohort was 24 years with males representing 82% of all patients. The primary direction of instability was most commonly anterior for male (74%) and female (73%) patients with football (24%) and basketball (13%) the most common sports during which the injury occurred. The etiology of instability events ranges from ligamentous laxity to traumatic dislocation events, with the latter being the most common with an overall incidence of 1.7%[7,12].

Many first time dislocators can be managed non-operatively with a period of immobilization and rehabilitation, however, certain patient populations are at higher risk for recurrent instability which can lead to substantial time loss from active participation/training and may require surgical intervention for adequate stabilization[4,13,14]. Operative techniques aimed at addressing GHJ instability are variable and range from arthroscopic soft-tissue stabilization, open soft-tissue stabilization, as well as techniques aimed at addressing bone loss such as the Latarjet procedure, autologous bone graft transfer, and allograft bone transfers. Determination of the optimal treatment strategy should be made on a case-by-case basis while weighing patient specific factors such as age, activity/sport/working status, goals, and previous history of instability events. Additionally, injury specific factors should also be considered such as acuity of injury and the degree of bone loss which will be discussed in more detail later in this text.

The purpose of this review is to describe the relevant anatomical stabilizers of the GHJ, risk factors for recurrent instability including bony lesions, indications for arthroscopic *vs* open surgical management, clinical history and physical examination techniques, imaging modalities, and pearls/pitfalls of arthroscopic soft-tissue stabilization for anterior glenohumeral instability.

**Functional Anatomy**

GHJ stability is provided through a complex interplay of passive and dynamic stabilizers[1,15-19]. Passive stabilizers include the rotator interval [superior glenohumeral ligament (SGHL), coracohumeral ligament, and joint capsule], the middle glenohumeral ligament (MGHL), and most importantly the inferior glenohumeral ligament complex (IGHL)[20]. The glenoid labrum runs circumferentially along the glenoid rim and serves as the point of insertion for all of the GH ligaments[1]. The SGHL prevents inferior translation of the adducted shoulder, the MGHL resists anterior translation in the externally rotated shoulder in abduction up to 45 degrees, and the IGHL can be broken down into the anterior band which is the major restraint to anteroinferior translation in external rotation with abduction > 45 degrees and the posterior band which resists posterior translation in the flexed and internally rotated shoulder[1,20-25]. The labrum deepens the glenoid socket and acts as a physiologic bumper to prevent GHJ instability[1]. Furthermore, the fibrocartilaginous labrum which circumferentially surrounds the glenoid and provides stabilization to the GHJ is tight in its anteroinferior attachment and loose in the superior attachment with a great deal of anatomic variation[1,21]. Acting in accordance with these ligamentous and capsular stabilizers are surrounding muscles providing dynamic stabilization which include the deltoid, biceps brachii, and the rotator cuff muscles. The basis for dynamic stability is the theory that instability occurs at end-range positions which place the GHJ at its maximum vulnerability in regards to dislocation. Muscular activity acts to compress the humeral head against the center of the glenoid fossa thereby stabilizing during these end-range motions[15,17-19,26].

While there are several ligamentous and muscular components to stability, the glenoid and humeral head add an additional osseous component for stabilization. Therefore, in the evaluation of GHJ instability a proper understanding of the bony anatomy and pathoanatomy is critical to determine an accurate diagnosis and treatment plan. When considering the size of the glenoid in comparison to the humeral head it is clear that even a small bony lesion can lead to significant instability by altering the bony articulation of the glenoid and humeral head[21,27-29]. The glenoid is a pear shaped bone which is widest in the inferior half and is tilted anteriorly[1,26]. Wide variability in the size and inclination of the glenoid make bony lesions related to instability especially challenging to treat. The articulation between the glenoid and humeral head is important to consider in the patient with recurrent anterior instability. Burkhart and Danaceau[30] described the “articular arc” between these bones and determined that defects in this arc could lead to engaging lesions and instability events.

A proper understanding of the anatomy related to the GHJ is critical to properly evaluate, diagnose, and treat anterior GHJ instability. The surgeon needs to have a precise understanding of both the normal and variant anatomy of the capsulolabral complex as well as the dynamic muscular stabilizers to properly evaluate and surgically manage injury. Additionally, an understanding of the bony anatomy of the glenoid and humeral head come into play as the clinician needs to thoroughly evaluate and manage these defects. These challenges will be described further in later sections of this text.

**Risk Factors for Recurrent Glenohumeral Instability**

Although GHJ instability is considered a relatively common event in young athletes and physically active patient populations, oftentimes first-time dislocators can be effectively managed non-operatively[3-6,31]. However, several proposed risk factors associated with recurrent instability events have been described. Of these reported risk factors, the most closely associated with recurrence include a history of instability events, age at the time of initial injury, contact sports, overhead athletes, and those with ligamentous laxity[4,7,21,32-36]. In addition, the most challenging injuries to treat are those with concomitant bony pathologies. During an anterior GHJ instability event there can be bony injury to the glenoid (referred to as a bony Bankart lesion), the humeral head (referred to as a Hill-Sachs lesions), or to both structures (bipolar lesions). Several studies have reported on the relationship between GHJ instability and bony deficits with recurrent instability rates in correlation with the size of the bony lesion[34,37]. In the past these injuries were managed with isolated soft tissue repairs, however growing evidence of recurrent instability raised questions as to the appropriate management of these injuries. An investigation performed by Burkhart *et al*[29] reported on 194 consecutive arthroscopic Bankart cases and found recurrence rates of 4% in those without significant bone defects as compared to 67% in those with humeral and/or glenoid lesions. These findings added evidence to the recurrent instability in those with untreated bony lesions and increased the awareness and treatment of these pathologies. In the management of patients with anterior GHJ instability it is important to think about the bony risk factors for recurrent instability and to modify these risk factors when possible to improve clinical results. Some of these potential risk factors related to bony defects have been researched in the literature and include.

***Glenoid defects: the bony Bankart***

Glenoid lesions have been reported to occur in 22%-41% of first time dislocation events and up to 86% of recurrent events[28,32,38,39]. Bony Bankart lesions occur during anterior GHJ instability as the dislocation of the humeral head creates a bony lesion on the anteroinferior aspect of the glenoid in addition to avulsion of the anteroinferior labrum. Burkhart *et al*[29] described the normal glenoid to appear pear shaped with a wider diameter in the inferior aspect as compared to the superior aspect. They went on to describe the “inverted pear” phenomenon which was in reference to the pathologic appearance of the glenoid resulting from a bony Bankart injury where the superior aspect of the glenoid appeared wider in diameter as compared to the inferior aspect. This change disrupts the arc of motion while the arm is abducted and externally which places the GHJ at a higher risk of redislocation. This theory was then confirmed by the biomechanical work of Gerber *et al*[40] who reported that increasing loss of the anteroinferior glenoid arc was associated with decreased resistance to dislocation. Bigliani *et al*[28] further categorized glenoid lesions and provided prognostic factors as follows: Type 1 Lesions involve a non-displaced anterior glenoid fragment, type 2 Lesions involve a small anterior fragment detached from the labrum, type 3a lesions involve < 25% anterior glenoid deficiency, and type 3b lesions involve > 25% anterior glenoid deficiency.

***Humeral head defects: the Hill-Sachs lesion***

In addition to glenoid sided lesions, a bony lesion to the posterolateral aspect of the humeral head is referred to as a “Hill-Sachs” lesion and can also lead to GHJ instability. These bony defects following first time GHJ dislocation have been reported to be found in up to 70% of patients[32,41]. In their review of 91 patients, Boileau *et al*[35] found Hill-Sachs lesions to be significantly related to failure. The failures resulting from Hill-Sachs lesions are theorized to result secondary to the articular arc defect which causes engagement of the humerus against the anterior glenoid rim referred to as the “engaging Hill-Sachs” lesion[29,35]. In their investigation, Burkhart *et al*[29] reported recurrent anterior GHJ instability in 100% (*n* = 3) of patients found to have an “engaging” Hill-Sachs lesion treated with arthroscopic Bankart repairs for traumatic anteroinferior instability. Although the clinical correlation between humeral defects and recurrent dislocation has been reported, there is a lack of current information regarding the size of the defect and relation to instability.

***The combined bony Bankart and Hill-Sachs injury***

While bony Bankart and Hill-Sachs lesions can occur in isolation, these injuries may also occur concurrently. A recent cadaveric study by Arciero *et al*[42] reported on these combined injuries. The study developed models for bony lesions based on computed tomography (CT) scans from 142 consecutive patients presenting with GHJ instability. The authors found that combined glenoid and humeral lesions displayed an additive and negative effect on GHJ stability. More specifically, they found that in patients with moderate sized Hill-Sachs lesions (defined as 50th percentile within the population of 142 consecutive patients), a glenoid lesion as small as 2 mm significantly compromised the stability of a soft tissue Bankart repair. These findings led to the conclusion that combined glenoid and humeral head defects have an additive and negative effect on glenohumeral stability.

***The “glenoid track” concept***

This description of the zone of contact between the glenoid and humeral head during elevation of the arm is termed the “glenoid track”[43]. This concept was initially described by Yamamoto *et al*[43] in a cadaveric study focused on the location and width of this “glenoid track” during various degrees of abduction while maintaining maximum external rotation and horizontal extension. The investigators found that the zone of contact shifted from the inferomedial to the superolateral portion aspect of the humeral head. They determined the width of the track from the rotator cuff attachment site of the greater tuberosity to be 84% ± 14% of the width of the glenoid (assuming no bone injury to the glenoid) and used this concept to determine the risk of a Hill-Sachs lesion engaging the glenoid rim in cases with and without bony injury. If the bony injury to the humeral head is located within the width of the glenoid track then there is no opportunity for the Hill-Sachs lesion to over-ride the glenoid creating a potential instability event. However, in cases where the Hill-Sachs lesion extends beyond the width of the glenoid track this creates an opportunity for instability. Another important aspect of this concept is that the width of the glenoid track is determined solely on the width of the glenoid meaning that a bony Bankart directly correlates with a decrease in width of the glenoid track. This concept was not the first to describe bony lesions as they relate to anterior glenohumeral instability, however this provided a new concept to evaluate both humeral and glenoid sided lesions simultaneously as the authors concluded that if the medial margin of a Hill-Sachs lesion is more medial than the glenoid track then standard stabilization techniques are unlikely to adequately address the bony sources of instability. Several investigations have identified “off-track” lesions to be at higher risk for recurrent instability[44-48]. Most recently, in a 2020 investigation by Yian *et al*[36] the authors reported on 540 patients undergoing primary arthroscopic Bankart repair and found “off-track” glenoid lesions to be statistically significantly associated with higher rates of recurrent instability (odds ratio, OR 2.86).

**Indications for Arthroscopic *vs* Open Surgical Management**

The purpose of surgical management of anteroinferior labral injuries is to reduce the risk of recurrent instability events. Historically, the rate of recurrent glenohumeral dislocations following open surgical repair have been lower (5%-9%)[49-51] as compared to arthroscopic interventions (5%-33%)[52-54]. Traditionally, open Bankart repair performed simultaneously with a capsular shift was considered the preferred management option, however improvements in arthroscopic techniques and implants have resulted in arthroscopic stabilization becoming the currently preferred technique for management of recurrent anterior GHJ instability[55-57]. One of the major advantages of the arthroscopic technique is that it does not violate the subscapularis which could potentially lead to functional deficits in external rotation[49]. Several high level investigations have reported similar rates of recurrent instability following arthroscopic *vs* open surgical intervention[53,55,58,59]. While these investigations found similar outcomes in results following both arthroscopic and open stabilization procedures, only short term outcomes were reported. Others have argued that outcomes between arthroscopic and open stabilization cannot be established in 2-3 years of followup[56]. Supporting this argument, longer-term studies have found much higher rates of recurrent shoulder instability following arthroscopic repair ranging from 17%-35% at 5-10 years[60-63]. This is in comparison to longer-term studies reporting on outcomes of open Bankart repairs with recurrence rates of 15%-17.5% at 10-20 years[61,62,64]. Although it may seem reasonable to utilize an open Bankart repair following initial failure of an arthroscopic technique, the current literature shows inferior outcomes in patients undergoing revision open Bankart compared to primary open Bankart[65-67]. Despite the abundance of clinical outcomes on this topic, indications for primary open Bankart repair remain controversial[56]. Some advocate for open Bankart repair in the setting of male collision athletes younger than 20 years, patients with subcritical (10%-20%) glenoid bone loss, patients with 10 or more shoulder dislocations, patients who have failed arthroscopic Bankart repair with less than 20% glenoid bone loss, and those with poor capsulolabral tissue[56].

When considering operative intervention it is also critical to evaluate associated bony injuries as discussed in previous sections of this manuscript. Amounts of bone loss initially thought to be adequately treated with Bankart repair is shrinking. Historically, anteroinferior glenoid bone loss of ≥ 25% of the inferior glenoid diameter is managed with glenoid bone grafting with a coracoid autograft (Latarjet), iliac autograft, or allograft[29,35,40,54,68-71]. Cadaveric investigations have shown that bone loss of > 21% has resulted in residual instability, resulting in some advocating for a threshold of 20% glenoid bone defect to be an indication for bony stabilization[54,72]. A 2015 investigation by Shaha *et al*[73] reported increased shoulder pain and decreased function in patients after arthroscopic Bankart repair with bone loss of 13.5%-19.8% of the inferior glenoid which they termed “subcritical” bone loss. This investigation led to the potential role of bony augmentation in patients with this “subcritical” bone loss of the glenoid. More recently, Pickett and Svoboda[54] reported their threshold for a Latarjet procedure to be 20% glenoid bone loss while also considering the procedure in contact athletes with “subcritical” (13%-19%) glenoid bone loss.

The clinical implications of Hill-Sachs lesions is not completely understood, original thought was that lesions > 16% of the humeral head diameter, those whose volume exceed 1000 mm3, or patients who experienced a clunking sensation with the arm in 90 degrees of abduction and 90 degrees of external rotation required operative intervention[54,74]. Others advocated that defects > 20%-25% of the humeral head diameter required management with an allograft[54,75]. These investigations preceded the concept of the glenoid track by Yamamoto *et al*[43] which was discussed earlier in this text.

While many investigations have reported on glenoid or humeral sided bone lesions, in practice these injuries can occur concurrently. Di Giacomo *et al*[68] proposed an algorithm in patients with bipolar lesions with varying degrees of glenoid and humeral head involvement. The authors broke patients down into the following four groups with their associated treatment: (1) Group 1: < 25% glenoid bone loss and on-track Hill-Sachs defect can be treated with an arthroscopic Bankart repair; (2) Group 2: < 25% glenoid bone loss and off-track Hill-Sachs defect can be treated with an arthroscopic Bankart repair and remplissage; (3) Group 3: > 25% glenoid bone loss and on-track Hill-Sachs defect require a Latarjet procedure; and (4) Group 4: > 25% glenoid bone loss and off-track Hill-Sachs defect require a Latarjet procedure and may need an additional bony procedure to address the humeral head.

It would seem practical to utilize the glenoid track concept to assist in surgical planning as it incorporates bony lesions to both the glenoid and humeral head. Due to the fact that this initial concept was described *in vitro*, some theorized it may not represent true conditions of recurrent instability due to its lack of including factors such as laxity of the capsulolabral complex. In theory, this could lead to a smaller sized Hill-Sachs lesion facilitating an engaging bipolar lesion causing recurrent instability[44,76]. However, there is growing evidence supporting clinical outcomes using the glenoid track concept while lowering the threshold for glenoid bone loss[48,77]. More specifically, Metzger *et al*[77] reported on 205 patients with recurrent anterior shoulder instability. The patients had a mean glenoid bone loss of 7.6% (range 0%-29%) with 22% of patients engaging on clinical exam under anesthesia (EUA). When comparing clinical EUA findings with radiographic findings, 84.5% of patients with radiographic findings suggestive of an engaging lesion displayed clinical evidence of an engaging lesion on EUA while only 12.4% clinically engaged during EUA without radiographic evidence of engagement (*P* < 0.001). The investigation demonstrated that glenohumeral engagement was well predicted based on preoperative glenoid and humeral head bone loss measurements using the glenoid track concept. Supporting these findings, a 2016 investigation by Shaha *et al*[48] reported on 57 shoulders over a two year period treated with a primary arthroscopic Bankart reconstruction. The authors reported 10 instability recurrences (18%) with 4 (8%) failures in the on-track patients as compared to 6 (75%) in the off-track group (*P* = 0.0001). Importantly, they reported the positive predictive value (PPV) of an off-track measurement was 75% compared to a 44% PPV in those with glenoid bone loss of > 20%. They concluded that the application of the glenoid track concept was superior to using glenoid bone loss alone when predicting post-operative stability.

More recently, a 2018 Yang *et al*[76] investigated the relationship between the Hill-Sachs interval and the glenoid track. The investigators retrospectively reviewed 160 patients who underwent an arthroscopic Bankart repair with a minimum of 24 mo follow up. They reported that a Hill-Sachs interval to glenoid track width ratio (H/G ratio) of ≥ 0.7 was a significant predictor of higher risk for recurrent instability. This value was validated by the recent findings of Chen *et al*[44] who found the H/G ratio of ≥ 0.7 to be comparable to the instability severity index score (ISIS) for predicting an increased risk of recurrent instability after arthroscopic Bankart repair. The ISIS was initially developed by Balg *et al*[78] and utilizes a combination of clinical characteristics and radiographic findings to predict risk for recurrent instability. It has been validated by several studies as a useful tool in predicting recurrent instability[44,79-83].

**Clinical History and Physical Exam**

The history of injury should include a description of the position of the arm, force applied, and point of force[84]. The typical mechanism for an anterior GHJ dislocation is a force to an extended, abducted, and externally rotated upper extremity[84]. Clinical history elicited during the initial encounter should also include evaluation of other sources of instability such as connective tissue disorders or generalized joint laxity. Connective tissue disorders such as Ehlers Danlos or Marfan’s syndrome should be ruled out by inspecting for skin hyper-extensibility, widened atrophic scarring, family history, personal history of instability events, and evaluation of joint hypermobility utilizing the Beighton criteria when clinically appropriate[85]. Evaluation should always include comparison to the contralateral shoulder.

Examination of the shoulder should include evaluation of the cervical spine, visualization of bilateral shoulders for evidence of muscular atrophy or deformities, active and passive range of motion, and a neurovascular exam with careful evaluation of the axillary nerve[32]. Finally, evaluation should include specific laxity and instability testing. It is important for the clinician to differentiate GHJ instability which is described as symptomatic and reproducible dislocation of the joint as compared to generalized joint laxity which is characterized by loose ligamentous tissue causing chronic pain and instability during minor events.

Tests specific to joint laxity include the load and shift test and the sulcus test. In the load and shift test an axial load is placed on the shoulder to center the humeral head onto the glenoid cavity and the examiner stabilizes the shoulder girdle with one hand while applying an anterior or posterior load to the proximal humerus with the other hand[32]. Increased translation in the anterior or posterior directions indicates joint laxity in that plane. The sulcus test is performed while the patient stands with their arm at the side while the examiner places a downward force onto the arm. It can be indicative of inferior laxity if a sulcus, or hollowing, occurs inferior to the acromion. Both of these tests should be performed in comparison to the contralateral side. In regards to testing for joint stability the clinician may perform the apprehension test and the jerk test. The apprehension test is performed with the patient in a supine or standing position. The arm is held in 90 degrees of abduction and in external rotation. The examiner places one hand behind the scapula for stabilization while simultaneously pulling back on the wrist putting the patient into further external rotation. The patient with anterior instability becomes apprehensive during this maneuver[84]. The jerk test is performed with the patient in internal rotation and flexed to 90 degrees. With one hand stabilizing the scapula the examiner grasps the elbow and places an axial load onto the humerus while simultaneously moving the arm horizontally across the body. The clinician is evaluating for a sudden “jerk” of the humeral head sliding off of the posterior glenoid followed by a “clunk” when the arm is brought back to the original positioning[84]. A positive jerk test is indicative of posterior instability.

***Imaging***

Initial radiographic workup of GHJ dislocation should include plain radiographs with anteroposterior (AP), infraspinatus outlet, and axillary views to evaluate for bony pathology and the version of the glenoid. Angled views such as the apical oblique view, Stryker notch view, and the West Point view could also be obtained to better visualize bony defects to the glenoid and posterolateral humeral head[84]. If there is further clinical or radiographic concern for bony pathology, or in cases of recurrent episodes of instability, computed tomography (CT) imaging with 3D reconstruction remains the gold standard for evaluation of bony injury[28,32]. In addition to evaluation of bony deficits, magnetic resonance imaging (MRI) is the preferred method for evaluation of the soft tissues of the shoulder joint, specifically for evaluation of the glenoid labrum and rotator cuff. Based on its location, the GHJ is inherently difficult to image and the best positioning is with the arm in a neutral or externally rotated position as internal rotation of the shoulder can cause labral and/or anteroinferior capsule redundancy which obscures tears[1,86]. In general, several consecutive images should be reviewed when evaluating an MRI and MR arthrography may also be utilized to increase visualization[1,87].

**Operative Pearls and Pitfalls of Arthroscopic Bankart Repair**

***Patient positioning***

Based on the importance of the inferior anchor placement the clinician should consider the benefits and disadvantages of beach chair *vs* lateral decubitus positions. In regards to the beach chair positioning the benefits include easier conversion from arthroscopic to open, anatomic orientation of the joint, rotational control of the shoulder, and optimal visualization of the subacromial joint. Despite these advantages, the major difficulty with beach chair orientation is decreased visualization of the inferior aspects of the joint. In comparison, the lateral decubitus positioning allows for increased joint space as traction can be applied in addition to improved access and visualization to the inferior GHJ. Despite this advantage it’s important to note that the disadvantages of lateral decubitus positioning include non-anatomic orientation, difficult conversion from arthroscopic to open, challenging positioning for the anesthesia team, and the possibility of traction related injury.

In regards to the optimized visualization/access to the inferior joint, a systematic review with meta-regression analysis conducted by Frank *et al*[88] on outcomes of arthroscopic anterior shoulder instability cases in beach chair *vs* lateral positioning. The study reported on 64 studies including 3668 shoulders and found the overall recurrent instability rates were 14.65% in the beach chair positioning patients as compared to 8.5% in the lateral decubitus positioning. Although the study reported decreased recurrence rates within the lateral decubitus group the differences in range of motion, return to activity, and Rowe scores between groups were not significant. Although patient positioning may be related to recurrent instability events it is important to recognize that these results do not necessarily suggest a more or less successful surgery as clinical outcome scores were similar and the fact that recurrence is a difficult measure of operative success based on the wide spectrum inherit to the term “instability.”

***Portal placement***

Optimal portal placement is crucial during the operative management of GHJ instability. With incorrect or inadequate portal placement the visualization into the joint can be severely compromised and can also dramatically increase the technical difficulty. Ideal placement of the portals allows for adequate visualization for proper diagnostic arthroscopy and eases the technical demands of anchor placement. Initial portal placement begins with standard posterior portal located roughly 2 cm inferior and 1 cm medial to the posterolateral corner of the acromion. Next, the anterosuperior (AS) portal is placed anterolateral to the edge of the acromion and lateral to the coracoid under direct visualization. Ideal intraarticular placement of this portal is just posterior to the insertion of the long head of the biceps. The primary purpose of the AS portal is to visualize the inferior, anterior, and posterior capsule while allowing for a thorough diagnostic scope to evaluate and recognize the anatomy of the shoulder. During this stage of the procedure the surgeon will evaluate the capsular volume, biceps tendon, glenohumeral ligaments, rotator cuff, and the anterior, posterior, and inferior labrum. Next, the anterior and posterior working portals can be created under direct visualization. During creation of these portals an “outside in” technique is utilized meaning a spinal needed is used to ensure ideal placement. For the anterior portal the needle should be placed between the acromioclavicular joint and the lateral coracoid. Intraarticularly the needed will ideally pierce the capsule just superior to the subscapularis tendon directly parallel to the surface of the glenoid. The posterior portal is created slightly inferior to the arch of the acromion and directed towards the coracoid process. Proper placement of these portals will allow the surgeon to visually appreciate the entire capsulolabral complex.

***Labrum and glenoid preparation***

Adequate labral preparation is a critical component of anterior GHJ instability repairs as error during this step may lead to recurrent instability due to inadequate capsulolabral plication. An elevator device can be used during this step to peel the labrum off the glenoid surface. After elevating the labrum from the glenoid neck a small shaver can be used to prepare the surface of the glenoid for anchor placement. Preparation of the labrum should be completed prior to preparation of the glenoid surface and anchor placement.

***Anchor placement***

Ideal anchor placement is below the 3 o’clock position placed 2-3 mm from the glenoid rim at a 45 degree angle relative to the anterior glenoid rim[21]. Anchors can then be placed approximately 7 mm apart. Based on the study performed by Boileau *et al*[35] at least 4 suture anchors should be utilized as 3 or fewer were found to be at higher risk for recurrent instability. During this stage of the procedure it is critical to achieve inferior anchor placement onto the glenoid. There are several portal positions and guides available to the surgeon to achieve this low placement however there remains no perfect option. A biomechanical study by Frank *et al*[89] reported on inferior anchor placement in 30 cadavers which were randomized into 3 test groups based on portal location and drill guide. The study found that there was no significant difference in ultimate load to failure among anchors placed *via* the 3 techniques. However, the authors did conclude that midglenoid portal anchors drilled with a straight or curved guide placed at the 5 o’clock position displayed significantly increased risk of opposite cortex perforation. Although the clinical applicability of these findings remained unclear, the study prompted discussion regarding ideal patient positioning in order to visualize the inferior glenoid in order to place the inferior anchor.

***Rehabilitation***

The authors prefer an abduction sling post-operatively in order to keep the shoulder in neutral positioning. Physical therapy then begins 7-10 d post-operatively with passive and active range of motion (ROM) for 4 wk (forward flexion to 130 degrees, external rotation to 30 degrees), ROM progression from 4-6 wk (forward flexion to 180 degrees, external rotation to 60 degrees), followed by resistive strengthening from 8-12 wk, and return to full sports and activities at 4-6 mo[21].

**CONCLUSION**

Management of the patient with anterior shoulder instability is a common yet complex condition for the orthopaedic surgeon. To optimize the evaluation and management of these patients the provider must ensure a detailed and thorough clinical and radiographic workup, have a thorough understanding of the dynamic, static, and bony stabilizers of the GHJ, and understand the common causes of failed surgical intervention in order to address these concerns when appropriate.

**REFERENCES**

1 **Apostolakos J**, Yang J, Hoberman A, Shoji M, Weinreb J, Voss A, DiVenere J, Mazzocca A. Glenoid Labrum. In: Bain G, Itoi E, Di Giacomo G, Sugaya H. Normal and Pathological Anatomy of the Shoulder. Springer, 2015: 83-91

2 **Owens BD**, Campbell SE, Cameron KL. Risk factors for anterior glenohumeral instability. *Am J Sports Med* 2014; **42**: 2591-2596 [PMID: 25248922 DOI: 10.1177/0363546514551149]

3 **Owens BD**, Duffey ML, Nelson BJ, DeBerardino TM, Taylor DC, Mountcastle SB. The incidence and characteristics of shoulder instability at the United States Military Academy. *Am J Sports Med* 2007; **35**: 1168-1173 [PMID: 17581976 DOI: 10.1177/0363546506295179]

4 **Cameron KL**, Mountcastle SB, Nelson BJ, DeBerardino TM, Duffey ML, Svoboda SJ, Owens BD. History of shoulder instability and subsequent injury during four years of follow-up: a survival analysis. *J Bone Joint Surg Am* 2013; **95**: 439-445 [PMID: 23467867 DOI: 10.2106/JBJS.L.00252]

5 **Owens BD**, Agel J, Mountcastle SB, Cameron KL, Nelson BJ. Incidence of glenohumeral instability in collegiate athletics. *Am J Sports Med* 2009; **37**: 1750-1754 [PMID: 19556471 DOI: 10.1177/0363546509334591]

6 **Kerr ZY**, Collins CL, Pommering TL, Fields SK, Comstock RD. Dislocation/separation injuries among US high school athletes in 9 selected sports: 2005-2009. *Clin J Sport Med* 2011; **21**: 101-108 [PMID: 21358499 DOI: 10.1097/JSM.0b013e31820bd1b6]

7 **Frank RM**, Romeo AA. Arthroscopic soft tissue reconstruction in anterior shoulder instability. *Orthopade* 2018; **47**: 121-128 [PMID: 29435624 DOI: 10.1007/s00132-018-3532-9]

8 **Krøner K**, Lind T, Jensen J. The epidemiology of shoulder dislocations. *Arch Orthop Trauma Surg* 1989; **108**: 288-290 [PMID: 2789505 DOI: 10.1007/BF00932317]

9 **Yeap JS**, Lee DJ, Fazir M, Borhan TA, Kareem BA. The epidemiology of shoulder dislocations in Malaysia. *Med J Malaysia* 2004; **59 Suppl F**: 19-23 [PMID: 15941156]

10 **Trojan JD**, Meyer LE, Edgar CM, Brown SM, Mulcahey MK. Epidemiology of Shoulder Instability Injuries in Collision Collegiate Sports From 2009 to 2014. *Arthroscopy* 2020; **36**: 36-43 [PMID: 31864594 DOI: 10.1016/j.arthro.2019.07.008]

11 **Kraeutler MJ**, McCarty EC, Belk JW, Wolf BR, Hettrich CM, Ortiz SF; MOON Shoulder Instability Group, Bravman JT, Baumgarten KM, Bishop JY, Bollier MJ, Brophy RH, Carey JL, Carpenter JE, Cox CL, Feeley BT, Grant JA, Jones GL, Kuhn JE, Kelly JD, Ma CB, Marx RG, Miller BS, Sennett BJ, Smith MV, Wright RW, Zhang AL. Descriptive Epidemiology of the MOON Shoulder Instability Cohort. *Am J Sports Med* 2018; **46**: 1064-1069 [PMID: 29505730 DOI: 10.1177/0363546518755752]

12 **Romeo AA**, Cohen BS, Carreira DS. Traumatic anterior shoulder instability. *Orthop Clin North Am* 2001; **32**: 399-409 [PMID: 11888135 DOI: 10.1016/s0030-5898(05)70209-1]

13 **Bishop JA**, Crall TS, Kocher MS. Operative versus nonoperative treatment after primary traumatic anterior glenohumeral dislocation: expected-value decision analysis. *J Shoulder Elbow Surg* 2011; **20**: 1087-1094 [PMID: 21530321 DOI: 10.1016/j.jse.2011.01.031]

14 **Handoll HH**, Almaiyah MA, Rangan A. Surgical versus non-surgical treatment for acute anterior shoulder dislocation. *Cochrane Database Syst Rev* 2004: CD004325 [PMID: 14974064 DOI: 10.1002/14651858.CD004325.pub2]

15 **Howell SM**, Galinat BJ, Renzi AJ, Marone PJ. Normal and abnormal mechanics of the glenohumeral joint in the horizontal plane. *J Bone Joint Surg Am* 1988; **70**: 227-232 [PMID: 3343267]

16 **Itoi E**, Newman SR, Kuechle DK, Morrey BF, An KN. Dynamic anterior stabilisers of the shoulder with the arm in abduction. *J Bone Joint Surg Br* 1994; **76**: 834-836 [PMID: 8083280]

17 **Karduna AR**, Williams GR, Williams JL, Iannotti JP. Kinematics of the glenohumeral joint: influences of muscle forces, ligamentous constraints, and articular geometry. *J Orthop Res* 1996; **14**: 986-993 [PMID: 8982143 DOI: 10.1002/jor.1100140620]

18 **Kelkar R**, Wang VM, Flatow EL, Newton PM, Ateshian GA, Bigliani LU, Pawluk RJ, Mow VC. Glenohumeral mechanics: a study of articular geometry, contact, and kinematics. *J Shoulder Elbow Surg* 2001; **10**: 73-84 [PMID: 11182740 DOI: 10.1067/mse.2001.111959]

19 **Poppen NK**, Walker PS. Normal and abnormal motion of the shoulder. *J Bone Joint Surg Am* 1976; **58**: 195-201 [PMID: 1254624]

20 **O'Brien SJ**, Neves MC, Arnoczky SP, Rozbruck SR, Dicarlo EF, Warren RF, Schwartz R, Wickiewicz TL. The anatomy and histology of the inferior glenohumeral ligament complex of the shoulder. *Am J Sports Med* 1990; **18**: 449-456 [PMID: 2252083 DOI: 10.1177/036354659001800501]

21 **Provencher MT**, Ghodadra N, Romeo AA. Arthroscopic management of anterior instability: pearls, pitfalls, and lessons learned. *Orthop Clin North Am* 2010; **41**: 325-337 [PMID: 20497809 DOI: 10.1016/j.ocl.2010.02.007]

22 **Burkart AC**, Debski RE. Anatomy and function of the glenohumeral ligaments in anterior shoulder instability. *Clin Orthop Relat Res* 2002: 32-39 [PMID: 12072743 DOI: 10.1097/00003086-200207000-00005]

23 **Soslowsky LJ**, Malicky DM, Blasier RB. Active and passive factors in inferior glenohumeral stabilization: a biomechanical model. *J Shoulder Elbow Surg* 1997; **6**: 371-379 [PMID: 9285877 DOI: 10.1016/s1058-2746(97)90005-7]

24 **Turkel SJ**, Panio MW, Marshall JL, Girgis FG. Stabilizing mechanisms preventing anterior dislocation of the glenohumeral joint. *J Bone Joint Surg Am* 1981; **63**: 1208-1217 [PMID: 7287791]

25 **Warner JJ**, Deng XH, Warren RF, Torzilli PA. Static capsuloligamentous restraints to superior-inferior translation of the glenohumeral joint. *Am J Sports Med* 1992; **20**: 675-685 [PMID: 1456361 DOI: 10.1177/036354659202000608]

26 **Rothman RH**, Marvel JP Jr, Heppenstall RB. Anatomic considerations in glenohumeral joint. *Orthop Clin North Am* 1975; **6**: 341-352 [PMID: 1093084]

27 **Ferrari DA**. Capsular ligaments of the shoulder. Anatomical and functional study of the anterior superior capsule. *Am J Sports Med* 1990; **18**: 20-24 [PMID: 2301686 DOI: 10.1177/036354659001800103]

28 **Bigliani LU**, Newton PM, Steinmann SP, Connor PM, Mcllveen SJ. Glenoid rim lesions associated with recurrent anterior dislocation of the shoulder. *Am J Sports Med* 1998; **26**: 41-45 [PMID: 9474399 DOI: 10.1177/03635465980260012301]

29 **Burkhart SS**, De Beer JF. Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repairs: significance of the inverted-pear glenoid and the humeral engaging Hill-Sachs lesion. *Arthroscopy* 2000; **16**: 677-694 [PMID: 11027751 DOI: 10.1053/jars.2000.17715]

30 **Burkhart SS**, Danaceau SM. Articular arc length mismatch as a cause of failed bankart repair. *Arthroscopy* 2000; **16**: 740-744 [PMID: 11027759 DOI: 10.1053/jars.2000.7794]

31 **Owens BD**, Dawson L, Burks R, Cameron KL. Incidence of shoulder dislocation in the United States military: demographic considerations from a high-risk population. *J Bone Joint Surg Am* 2009; **91**: 791-796 [PMID: 19339562 DOI: 10.2106/JBJS.H.00514]

32 **Garcia GH**, Liu JN, Dines DM, Dines JS. Effect of bone loss in anterior shoulder instability. *World J Orthop* 2015; **6**: 421-433 [PMID: 26085984 DOI: 10.5312/wjo.v6.i5.421]

33 **Taylor DC**, Krasinski KL. Adolescent shoulder injuries: consensus and controversies. *J Bone Joint Surg Am* 2009; **91**: 462-473 [PMID: 19181993]

34 **Kralinger FS**, Golser K, Wischatta R, Wambacher M, Sperner G. Predicting recurrence after primary anterior shoulder dislocation. *Am J Sports Med* 2002; **30**: 116-120 [PMID: 11799007 DOI: 10.1177/03635465020300010501]

35 **Boileau P**, Villalba M, Héry JY, Balg F, Ahrens P, Neyton L. Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. *J Bone Joint Surg Am* 2006; **88**: 1755-1763 [PMID: 16882898 DOI: 10.2106/JBJS.E.00817]

36 **Yian EH**, Weathers M, Knott JR, Sodl JF, Spencer HT. Predicting Failure After Primary Arthroscopic Bankart Repair: Analysis of a Statistical Model Using Anatomic Risk Factors. *Arthroscopy* 2020; **36**: 964-970 [PMID: 31926270 DOI: 10.1016/j.arthro.2019.11.109]

37 **Cetik O**, Uslu M, Ozsar BK. The relationship between Hill-Sachs lesion and recurrent anterior shoulder dislocation. *Acta Orthop Belg* 2007; **73**: 175-178 [PMID: 17515227]

38 **Taylor DC**, Arciero RA. Pathologic changes associated with shoulder dislocations. Arthroscopic and physical examination findings in first-time, traumatic anterior dislocations. *Am J Sports Med* 1997; **25**: 306-311 [PMID: 9167808 DOI: 10.1177/036354659702500306]

39 **Griffith JF**, Antonio GE, Yung PS, Wong EM, Yu AB, Ahuja AT, Chan KM. Prevalence, pattern, and spectrum of glenoid bone loss in anterior shoulder dislocation: CT analysis of 218 patients. *AJR Am J Roentgenol* 2008; **190**: 1247-1254 [PMID: 18430839 DOI: 10.2214/AJR.07.3009]

40 **Gerber C**, Nyffeler RW. Classification of glenohumeral joint instability. *Clin Orthop Relat Res* 2002: 65-76 [PMID: 12072747 DOI: 10.1097/00003086-200207000-00009]

41 **Robinson CM**, Dobson RJ. Anterior instability of the shoulder after trauma. *J Bone Joint Surg Br* 2004; **86**: 469-479 [PMID: 15174539 DOI: 10.1302/0301-620x.86b4]

42 **Arciero RA**, Parrino A, Bernhardson AS, Diaz-Doran V, Obopilwe E, Cote MP, Golijanin P, Mazzocca AD, Provencher MT. The effect of a combined glenoid and Hill-Sachs defect on glenohumeral stability: a biomechanical cadaveric study using 3-dimensional modeling of 142 patients. *Am J Sports Med* 2015; **43**: 1422-1429 [PMID: 25794869 DOI: 10.1177/0363546515574677]

43 **Yamamoto N**, Itoi E, Abe H, Minagawa H, Seki N, Shimada Y, Okada K. Contact between the glenoid and the humeral head in abduction, external rotation, and horizontal extension: a new concept of glenoid track. *J Shoulder Elbow Surg* 2007; **16**: 649-656 [PMID: 17644006 DOI: 10.1016/j.jse.2006.12.012]

44 **Chen KH**, Yang TC, Chiang ER, Wang HY, Ma HL. The Hill-Sachs interval to glenoid track width ratio is comparable to the instability severity index score for predicting risk of recurrent instability after arthroscopic Bankart repair. *Knee Surg Sports Traumatol Arthrosc* 2020 [PMID: 32253482 DOI: 10.1007/s00167-020-05955-0]

45 **Hatta T**, Yamamoto N, Shinagawa K, Kawakami J, Itoi E. Surgical decision making based on the on-track/off-track concept for anterior shoulder instability: a case-control study. *JSES Open Access* 2019; **3**: 25-28 [PMID: 30976732 DOI: 10.1016/j.jses.2018.10.001]

46 **Locher J**, Wilken F, Beitzel K, Buchmann S, Longo UG, Denaro V, Imhoff AB. Hill-Sachs Off-track Lesions as Risk Factor for Recurrence of Instability After Arthroscopic Bankart Repair. *Arthroscopy* 2016; **32**: 1993-1999 [PMID: 27161511 DOI: 10.1016/j.arthro.2016.03.005]

47 **Momaya AM**, Tokish JM. Applying the Glenoid Track Concept in the Management of Patients with Anterior Shoulder Instability. *Curr Rev Musculoskelet Med* 2017; **10**: 463-468 [PMID: 28994025 DOI: 10.1007/s12178-017-9436-1]

48 **Shaha JS**, Cook JB, Rowles DJ, Bottoni CR, Shaha SH, Tokish JM. Clinical Validation of the Glenoid Track Concept in Anterior Glenohumeral Instability. *J Bone Joint Surg Am* 2016; **98**: 1918-1923 [PMID: 27852909 DOI: 10.2106/JBJS.15.01099]

49 **Gill TJ**, Micheli LJ, Gebhard F, Binder C. Bankart repair for anterior instability of the shoulder. Long-term outcome. *J Bone Joint Surg Am* 1997; **79**: 850-857 [PMID: 9199382 DOI: 10.2106/00004623-199706000-00008]

50 **Guanche CA**, Quick DC, Sodergren KM, Buss DD. Arthroscopic versus open reconstruction of the shoulder in patients with isolated Bankart lesions. *Am J Sports Med* 1996; **24**: 144-148 [PMID: 8775110 DOI: 10.1177/036354659602400204]

51 **Cole BJ**, L'Insalata J, Irrgang J, Warner JJ. Comparison of arthroscopic and open anterior shoulder stabilization. A two to six-year follow-up study. *J Bone Joint Surg Am* 2000; **82**: 1108-1114 [PMID: 10954100 DOI: 10.2106/00004623-200008000-00007]

52 **Owens BD**, DeBerardino TM, Nelson BJ, Thurman J, Cameron KL, Taylor DC, Uhorchak JM, Arciero RA. Long-term follow-up of acute arthroscopic Bankart repair for initial anterior shoulder dislocations in young athletes. *Am J Sports Med* 2009; **37**: 669-673 [PMID: 19218560 DOI: 10.1177/0363546508328416]

53 **Bottoni CR**, Smith EL, Berkowitz MJ, Towle RB, Moore JH. Arthroscopic versus open shoulder stabilization for recurrent anterior instability: a prospective randomized clinical trial. *Am J Sports Med* 2006; **34**: 1730-1737 [PMID: 16735589 DOI: 10.1177/0363546506288239]

54 **Pickett A**, Svoboda S. Anterior Glenohumeral Instability. *Sports Med Arthrosc Rev* 2017; **25**: 156-162 [PMID: 28777219 DOI: 10.1097/JSA.0000000000000157]

55 **Owens BD**, Cameron KL, Peck KY, DeBerardino TM, Nelson BJ, Taylor DC, Tenuta J, Svoboda SJ. Arthroscopic Versus Open Stabilization for Anterior Shoulder Subluxations. *Orthop J Sports Med* 2015; **3**: 2325967115571084 [PMID: 26535374 DOI: 10.1177/2325967115571084]

56 **Frank RM**, Arciero RA, Erickson BJ, Trenhaile ST, Provencher MT, Verma NN. Shoulder Instability: An American Perspective. *Instr Course Lect* 2018; **67**: 415-432 [PMID: 31411429]

57 **Owens BD**, Harrast JJ, Hurwitz SR, Thompson TL, Wolf JM. Surgical trends in Bankart repair: an analysis of data from the American Board of Orthopaedic Surgery certification examination. *Am J Sports Med* 2011; **39**: 1865-1869 [PMID: 21628637 DOI: 10.1177/0363546511406869]

58 **Jørgensen U**, Svend-Hansen H, Bak K, Pedersen I. Recurrent post-traumatic anterior shoulder dislocation--open versus arthroscopic repair. *Knee Surg Sports Traumatol Arthrosc* 1999; **7**: 118-124 [PMID: 10223535 DOI: 10.1007/s001670050133]

59 **Fabbriciani C**, Milano G, Demontis A, Fadda S, Ziranu F, Mulas PD. Arthroscopic versus open treatment of Bankart lesion of the shoulder: a prospective randomized study. *Arthroscopy* 2004; **20**: 456-462 [PMID: 15122134 DOI: 10.1016/j.arthro.2004.03.001]

60 **Castagna A**, Delle Rose G, Borroni M, Cillis BD, Conti M, Garofalo R, Ferguson D, Portinaro N. Arthroscopic stabilization of the shoulder in adolescent athletes participating in overhead or contact sports. *Arthroscopy* 2012; **28**: 309-315 [PMID: 22130494 DOI: 10.1016/j.arthro.2011.08.302]

61 **van der Linde JA**, van Kampen DA, Terwee CB, Dijksman LM, Kleinjan G, Willems WJ. Long-term results after arthroscopic shoulder stabilization using suture anchors: an 8- to 10-year follow-up. *Am J Sports Med* 2011; **39**: 2396-2403 [PMID: 21803980 DOI: 10.1177/0363546511415657]

62 **Castagna A**, Markopoulos N, Conti M, Delle Rose G, Papadakou E, Garofalo R. Arthroscopic bankart suture-anchor repair: radiological and clinical outcome at minimum 10 years of follow-up. *Am J Sports Med* 2010; **38**: 2012-2016 [PMID: 20595552 DOI: 10.1177/0363546510372614]

63 **Plath JE**, Aboalata M, Seppel G, Juretzko J, Waldt S, Vogt S, Imhoff AB. Prevalence of and Risk Factors for Dislocation Arthropathy: Radiological Long-term Outcome of Arthroscopic Bankart Repair in 100 Shoulders at an Average 13-Year Follow-up. *Am J Sports Med* 2015; **43**: 1084-1090 [PMID: 25731974 DOI: 10.1177/0363546515570621]

64 **Moroder P**, Odorizzi M, Pizzinini S, Demetz E, Resch H, Moroder P. Open Bankart Repair for the Treatment of Anterior Shoulder Instability without Substantial Osseous Glenoid Defects: Results After a Minimum Follow-up of Twenty Years. *J Bone Joint Surg Am* 2015; **97**: 1398-1405 [PMID: 26333734 DOI: 10.2106/JBJS.N.01214]

65 **Cho NS**, Yi JW, Lee BG, Rhee YG. Revision open Bankart surgery after arthroscopic repair for traumatic anterior shoulder instability. *Am J Sports Med* 2009; **37**: 2158-2164 [PMID: 19776342 DOI: 10.1177/0363546509339015]

66 **Sisto DJ**. Revision of failed arthroscopic bankart repairs. *Am J Sports Med* 2007; **35**: 537-541 [PMID: 17244898 DOI: 10.1177/0363546506296520]

67 **Neviaser AS**, Benke MT, Neviaser RJ. Open Bankart repair for revision of failed prior stabilization: outcome analysis at a mean of more than 10 years. *J Shoulder Elbow Surg* 2015; **24**: 897-901 [PMID: 25498480 DOI: 10.1016/j.jse.2014.11.036]

68 **Di Giacomo G**, Itoi E, Burkhart SS. Evolving concept of bipolar bone loss and the Hill-Sachs lesion: from "engaging/non-engaging" lesion to "on-track/off-track" lesion. *Arthroscopy* 2014; **30**: 90-98 [PMID: 24384275 DOI: 10.1016/j.arthro.2013.10.004]

69 **Di Giacomo G**, de Gasperis N, Costantini A, De Vita A, Beccaglia MA, Pouliart N. Does the presence of glenoid bone loss influence coracoid bone graft osteolysis after the Latarjet procedure? A computed tomography scan study in 2 groups of patients with and without glenoid bone loss. *J Shoulder Elbow Surg* 2014; **23**: 514-518 [PMID: 24406124 DOI: 10.1016/j.jse.2013.10.005]

70 **Provencher MT**, Bhatia S, Ghodadra NS, Grumet RC, Bach BR Jr, Dewing CB, LeClere L, Romeo AA. Recurrent shoulder instability: current concepts for evaluation and management of glenoid bone loss. *J Bone Joint Surg Am* 2010; **92 Suppl 2**: 133-151 [PMID: 21123597 DOI: 10.2106/JBJS.J.00906]

71 **Burkhart SS**, Debeer JF, Tehrany AM, Parten PM. Quantifying glenoid bone loss arthroscopically in shoulder instability. *Arthroscopy* 2002; **18**: 488-491 [PMID: 11987058 DOI: 10.1053/jars.2002.32212]

72 **Itoi E**, Lee SB, Berglund LJ, Berge LL, An KN. The effect of a glenoid defect on anteroinferior stability of the shoulder after Bankart repair: a cadaveric study. *J Bone Joint Surg Am* 2000; **82**: 35-46 [PMID: 10653082 DOI: 10.2106/00004623-200001000-00005]

73 **Shaha JS**, Cook JB, Song DJ, Rowles DJ, Bottoni CR, Shaha SH, Tokish JM. Redefining "Critical" Bone Loss in Shoulder Instability: Functional Outcomes Worsen With "Subcritical" Bone Loss. *Am J Sports Med* 2015; **43**: 1719-1725 [PMID: 25883168 DOI: 10.1177/0363546515578250]

74 **Skendzel JG**, Sekiya JK. Diagnosis and management of humeral head bone loss in shoulder instability. *Am J Sports Med* 2012; **40**: 2633-2644 [PMID: 22343756 DOI: 10.1177/0363546512437314]

75 **Bühler M**, Gerber C. Shoulder instability related to epileptic seizures. *J Shoulder Elbow Surg* 2002; **11**: 339-344 [PMID: 12195251 DOI: 10.1067/mse.2002.124524]

76 **Yang TC**, Chen KH, Chiang ER, Chang MC, Ma HL. Using the "Hill-Sachs interval to glenoid track width ratio" for prediction of recurrent instability after arthroscopic Bankart repair. *Orthop Traumatol Surg Res* 2018; **104**: 797-801 [PMID: 29654932 DOI: 10.1016/j.otsr.2018.02.013]

77 **Metzger PD**, Barlow B, Leonardelli D, Peace W, Solomon DJ, Provencher MT. Clinical Application of the "Glenoid Track" Concept for Defining Humeral Head Engagement in Anterior Shoulder Instability: A Preliminary Report. *Orthop J Sports Med* 2013; **1**: 2325967113496213 [PMID: 26535236 DOI: 10.1177/2325967113496213]

78 **Balg F**, Boileau P. The instability severity index score. A simple pre-operative score to select patients for arthroscopic or open shoulder stabilisation. *J Bone Joint Surg Br* 2007; **89**: 1470-1477 [PMID: 17998184 DOI: 10.1302/0301-620X.89B11.18962]

79 **Boughebri O**, Maqdes A, Moraiti C, Dib C, Leclère FM, Valenti P. Results of 45 arthroscopic Bankart procedures: Does the ISIS remain a reliable prognostic assessment after 5 years? *Eur J Orthop Surg Traumatol* 2015; **25**: 709-716 [PMID: 25480327 DOI: 10.1007/s00590-014-1562-5]

80 **Loppini M**, Delle Rose G, Borroni M, Morenghi E, Pitino D, Domínguez Zamora C, Castagna A. Is the Instability Severity Index Score a Valid Tool for Predicting Failure After Primary Arthroscopic Stabilization for Anterior Glenohumeral Instability? *Arthroscopy* 2019; **35**: 361-366 [PMID: 30611589 DOI: 10.1016/j.arthro.2018.09.027]

81 **Phadnis J**, Arnold C, Elmorsy A, Flannery M. Utility of the Instability Severity Index Score in Predicting Failure After Arthroscopic Anterior Stabilization of the Shoulder. *Am J Sports Med* 2015; **43**: 1983-1988 [PMID: 26122385 DOI: 10.1177/0363546515587083]

82 **Thomazeau H**, Courage O, Barth J, Pélégri C, Charousset C, Lespagnol F, Nourissat G, Audebert S, Guillo S, Toussaint B, Lafosse L, Bradel J, Veillard D, Boileau P; French Arthroscopy Society. Can we improve the indication for Bankart arthroscopic repair? A preliminary clinical study using the ISIS score. *Orthop Traumatol Surg Res* 2010; **96**: S77-S83 [PMID: 21035419 DOI: 10.1016/j.otsr.2010.09.007]

83 **Thomazeau H**, Langlais T, Hardy A, Curado J, Herisson O, Mouton J, Charousset C, Courage O; French Arthroscopy Society, Nourissat G. Long-term, Prospective, Multicenter Study of Isolated Bankart Repair for a Patient Selection Method Based on the Instability Severity Index Score. *Am J Sports Med* 2019; **47**: 1057-1061 [PMID: 30883182 DOI: 10.1177/0363546519833920]

84 **Barnes L**, Parsons B, Lippitt S, Flatow E, FA M. Glenohumeral Instability. In: Rockwood Jr C, Matsen F, Wirth M, Lippitt S, Fehringer E, Sperling J. Rockwood and Matsen's The Shoulder. 5th ed. Elsevier, 2017: 543-649

85 **Beighton P**, Horan F. Orthopaedic aspects of the Ehlers-Danlos syndrome. *J Bone Joint Surg Br* 1969; **51**: 444-453 [PMID: 5820785]

86 **Carroll KW**, Helms CA. Magnetic resonance imaging of the shoulder: a review of potential sources of diagnostic errors. *Skeletal Radiol* 2002; **31**: 373-383 [PMID: 12107570 DOI: 10.1007/s00256-002-0528-6]

87 **Motamedi D**, Everist BM, Mahanty SR, Steinbach LS. Pitfalls in shoulder MRI: part 1--normal anatomy and anatomic variants. *AJR Am J Roentgenol* 2014; **203**: 501-507 [PMID: 25148152 DOI: 10.2214/AJR.14.12848]

88 **Frank RM**, Saccomanno MF, McDonald LS, Moric M, Romeo AA, Provencher MT. Outcomes of arthroscopic anterior shoulder instability in the beach chair versus lateral decubitus position: a systematic review and meta-regression analysis. *Arthroscopy* 2014; **30**: 1349-1365 [PMID: 25000864 DOI: 10.1016/j.arthro.2014.05.008]

89 **Frank RM**, Mall NA, Gupta D, Shewman E, Wang VM, Romeo AA, Cole BJ, Bach BR Jr, Provencher MT, Verma NN. Inferior suture anchor placement during arthroscopic Bankart repair: influence of portal placement and curved drill guide. *Am J Sports Med* 2014; **42**: 1182-1189 [PMID: 24576744 DOI: 10.1177/0363546514523722]

**Footnotes**

**Conflict-of-interest statement:** Drs. Apostolakos and Wright-Chisem have nothing to disclose. Dr. Gulotta is a paid consultant, present, or speaker and received research support from Biomet. He is a paid presenter or speaker for Exactech, Inc and receives IP royalties. He is on the editorial or governing board for the HSS Journal. Dr. Gulotta has stock or stock options with Imagen, Inc and Responsive Arthroscopy, Inc. He is a paid presenter or speaker for Smith and Nephew, outside the submitted work. Dr. Taylor is a paid consultant for DJ Orthopaedics and Mitek, outside the submitted work. Dr. Dines is a board or committee member for the American Shoulder and Elbow Surgeons. He is a paid consultant, presenter, or speaker with research support from Arthrex, Inc and is on the editorial or governing board for the Journal of Shoulder and Elbow Surgery. He receives IP royalties from Linvatec and publishing royalties with financial or material support from Thieme and Wolters Kluwer Health.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/Licenses/by-nc/4.0/

**Manuscript source:** Unsolicited manuscript

**Peer-review started:** June 30, 2020

**First decision:** December 11, 2020

**Article in press:**

**Specialty type:** Orthopedics

**Country/Territory of origin:** United States

**Peer-review report’s scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): 0

Grade C (Good): C

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Chou A **S-Editor:** Gao CC **L-Editor:** A **P-Editor:** Ma YJ



Published by **Baishideng Publishing Group Inc**

7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

**Telephone:** +1-925-3991568

**E-mail:** bpgoffice@wjgnet.com

**Help Desk:** https://www.f6publishing.com/helpdesk

https://www.wjgnet.com



**© 2021 Baishideng Publishing Group Inc. All rights reserved.**