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Glenohumeral Instability

Xinning Li, Stephen A. Parada, Richard Ma, and Josef K. Eichinger

INTRODUCTION TO GLENOHUMERAL INSTABILITY

Glenohumeral instability is a common problem in the young, athletic patient population, with anterior instability being more common than posterior or multidirectional instability (MDI).[66,72,225] The incidence of anterior glenohumeral instability in the United States population is 0.08 per 1,000 person-years.[175,256] There are certain at-risk populations that have been identified such as collision athletes (football and rugby players)[176,256] and military personnel.[175] Young males participating in sports develop anterior glenohumeral instability at rates as high as 3% per year.[176,256] The incidence of anterior glenohumeral instability in military personnel, estimated as 1.69 per 1,000 person-years, is even higher than contact athletes.[175] Less information is available on the incidence of posterior instability and MDI as these forms of instability are comparatively less common. As with anterior instability, posterior instability is more commonly found in the active-duty military population.[174,219]

ASSESSMENT OF GLENOHUMERAL INSTABILITY

Evaluation of a patient with suspected shoulder instability should always begin with a thorough history of the index injury as well as antecedent shoulder function. Furthermore, arm dominance along with the level and type of sporting competition should be documented. The mechanism of injury can also provide useful information on the extent of injury and the potential direction of instability in order to

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direct work-up modalities and strategies for management. It is also important to document patient age at the time of the first instability event, number of dislocation and/or subluxation events, requirement for manual reduction and/or sedation in an emergency room setting, position of the arm during the instability event, and any prior nonoperative or surgical intervention.[116] Instability events that occur while at rest or while in positions not typically associated with risk of dislocation (i.e., with the shoulder in an adducted position) are particularly worrisome and can serve as a harbinger of more complex instability.

Physical examination should consist of inspection, palpation, and range of motion (ROM) assessment (passive and active) with comparison to the contralateral shoulder.[139] Increased external rotation may imply anterior hyperlaxity, and asymmetric hyperabduction greater than 15 degrees difference from the contralateral shoulder (Gagey test) with scapular stabilization may indicate incompetency of the inferior glenohumeral ligament complex (IGHLC).[67] Neurovascular examination is also necessary to exclude the presence of associated injuries, in particular the axillary nerve due to its tethered position and close proximity to the axilla. Resting scapular position and dynamic scapular motion throughout an overhead arc of shoulder motion should also be documented, as the presence of scapular dyskinesia or winging may contribute to the feeling of instability and may affect the timing of any operative treatment. Undiagnosed scapular winging may also lead to symptoms of glenohumeral instability.[253] There are a multitude of provocative special tests for glenohumeral instability which are usually considered to be the most critical portion of the physical examination and are discussed in the Signs and Symptoms section (see below).

MECHANISMS OF INJURY FOR GLENOHUMERAL INSTABILITY

Glenohumeral instability is typically related to a traumatic event that can occur at any age as a result of injury during athletic competitions and falls. While externally applied forces are the most common mechanism, noncontact or muscular imbalance events such as missed punches or seizures can also result in dislocation events. Individuals with generalized laxity or genetic collagen disorders may experience instability as the result of attritional injury to the joint capsule or via a low energy mechanism or muscular imbalance. In general, traumatic dislocations are classified by the direction, which can be anterior, posterior, or inferior. Depending on the patient factors (age, collagen laxity, and muscle strength) and degree of force imparted to the injured shoulder, dislocations will result in varying degrees of damage during a primary or repeat dislocation. Contact sport participation, and in particular tackling or collision sports, represents the most common mechanism of injury for dislocation.[144,176]

Anterior shoulder dislocations can result from either falls onto a forward flexed arm in external rotation (Fig. 34-1A) or tackling in collision sports, where the arm is extended and experiences a posteriorly directed force (Fig. 34-1B). Posterior shoulder dislocations can result from athletic injuries and falls, but seizures and electrocution also represent common mechanisms. Seizures and electrocution may also result in a locked posterior dislocations due to the relative increased combined muscular mass of anterior internal rotator muscles (subscapularis, anterior deltoid, and pectoralis major) which overcome the posterior external rotator muscles (infraspinatus, teres minor, posterior deltoid, and latissimus) acting on an internally rotated and adducted limb. Similarly, a fall onto

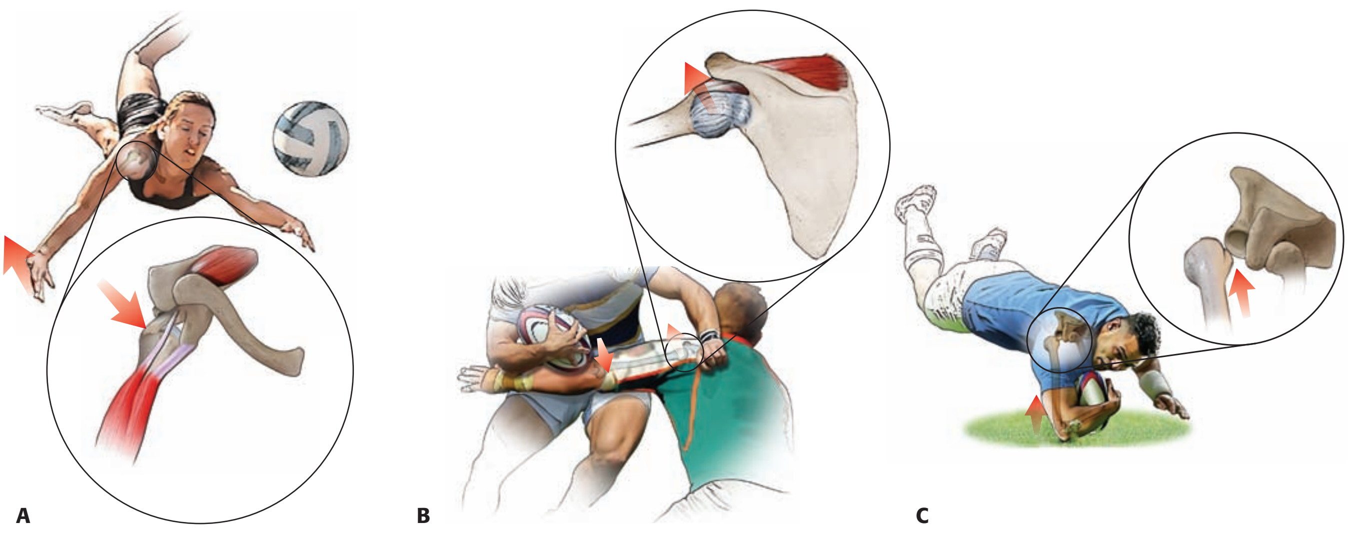


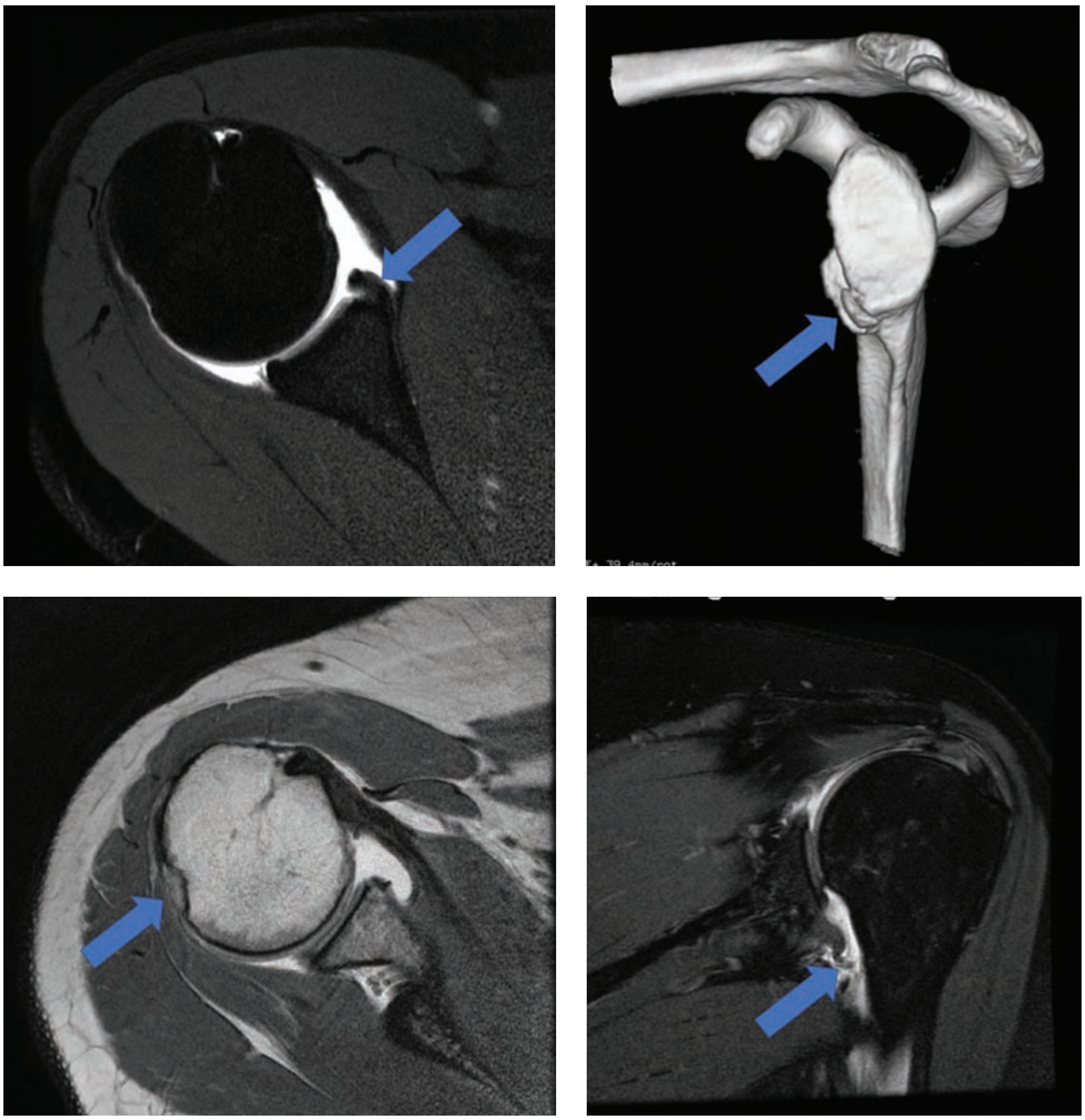
Figure 34-1. A: Fall onto a forward flexed and externally rotated arm will result in anterior shoulder subluxation or dislocation. **B:** Tackling an opponent with the arm straight and extended may result in anterior shoulder instability, especially if a posteriorly directed force occurs. **C:** A fall onto a forward flexed and internally rotated arm can also result in a posteriorly directed force which creates a posterior force vector of the humeral head relative to the glenoid resulting in posterior shoulder instability.

a forward flexed and internally rotated arm can also result in a posteriorly directed force, which creates a posterior force vector of the humeral head relative to the glenoid (Fig. 34-1C). Luxatio erecta, or inferior shoulder dislocation, occurs with forced hyperabduction of the arm and a levering of the humeral head against the acromion.[53,272]

INJURIES ASSOCIATED WITH GLENOHUMERAL INSTABILITY

Glenohumeral instability typically results in an injury to the capsule and labrum. Bankart originally identified the labral tear as the essential lesion creating shoulder instability (Fig. 34-2A), but, in reality, a spectrum of injuries occurs with instability events.[12] Depending on the direction and degree of force applied to the limb, a variety of injuries can occur to the capsule, ligaments, labrum, articular cartilage, rotator cuff, neurologic structures, and bone. Bony injuries include fractures to the glenoid and humeral head known as bony Bankart (Fig. 34-2B) or Hill–Sachs lesions (Fig. 34-2C), respectively. A Hill–Sachs lesion represents an impaction fracture of the posterior humeral head against the firmer glenoid rim.[89] Less frequently, coracoid fractures, greater tuberosity fractures, and lesser tuberosity fractures are seen with higher energy injuries.[240] Capsular and ligamentous injuries include stretching and rupture along with avulsion from the humeral side known as humeral avulsion of

A



C

Figure 34-2. **A:** Axial T2-weighted magnetic resonance image with arthrogram (MRA) demonstrates anterior inferior labral tear or "Bankart" lesion. **B:** CT image with 3D reconstruction of the glenoid shows "bony Bankart" lesion on the anterior inferior glenoid. **C:** Axial T1-weighted MRA image shows "Hill–Sachs" lesion on the posterior humeral head. **D:** Coronal T2 MRA image shows humeral avulsion of glenohumeral ligament (HAGL) lesion.

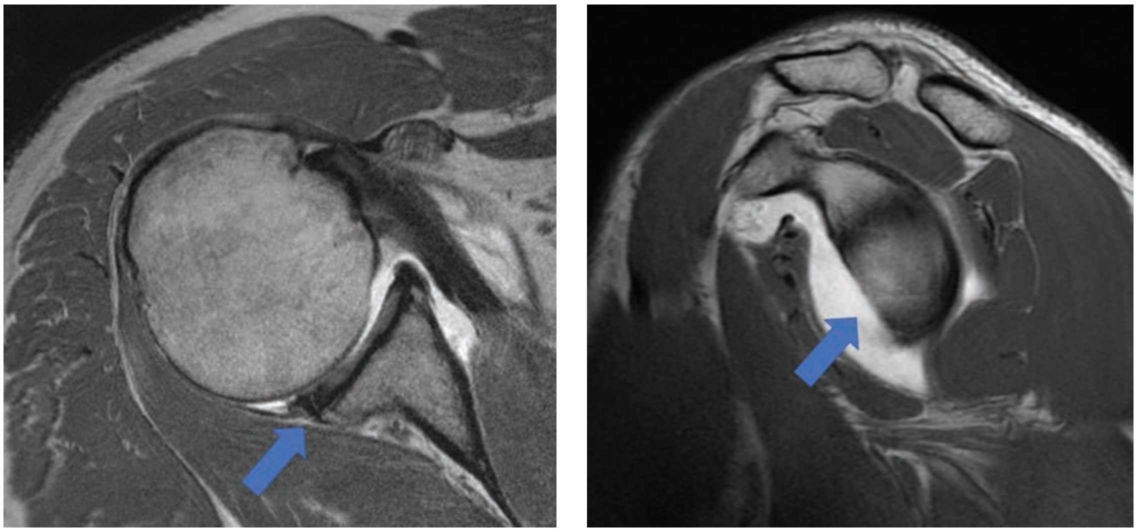


Figure 34-3. **A:** Axial T1 MRA image shows posterior labral tear (*arrow*). Using arthrogram will increase both sensitivity and specificity in the diagnosis for labral tears. **B:** Recurrent anterior dislocation can lead to attritional changes to the anterior inferior glenoid resulting in bone loss (*arrow*).

the glenohumeral ligaments (HAGL lesions) and are also associated with anterior shoulder instability (Fig. 34-2D).[266]

Posterior dislocations can result in similar "reversed" lesions of the glenoid (reverse Bankart fracture) and humerus (reverse Hill–Sachs lesion), and can also cause tears to the capsule and posterior labrum (Fig. 34-3A). Recurrent traumatic events can result in attritional or additive lesions over time (Fig. 34-3B).[151] Rotator cuff tears as a result of instability occur more frequently in females and older patients with the incidence increasing for patients aged 40 years and older.[193,214] Neurologic lesions following shoulder instability injuries typically involve the axillary nerve and can occur with shoulder dislocation, including a 13.5% incidence with anterior shoulder dislocations.[193]

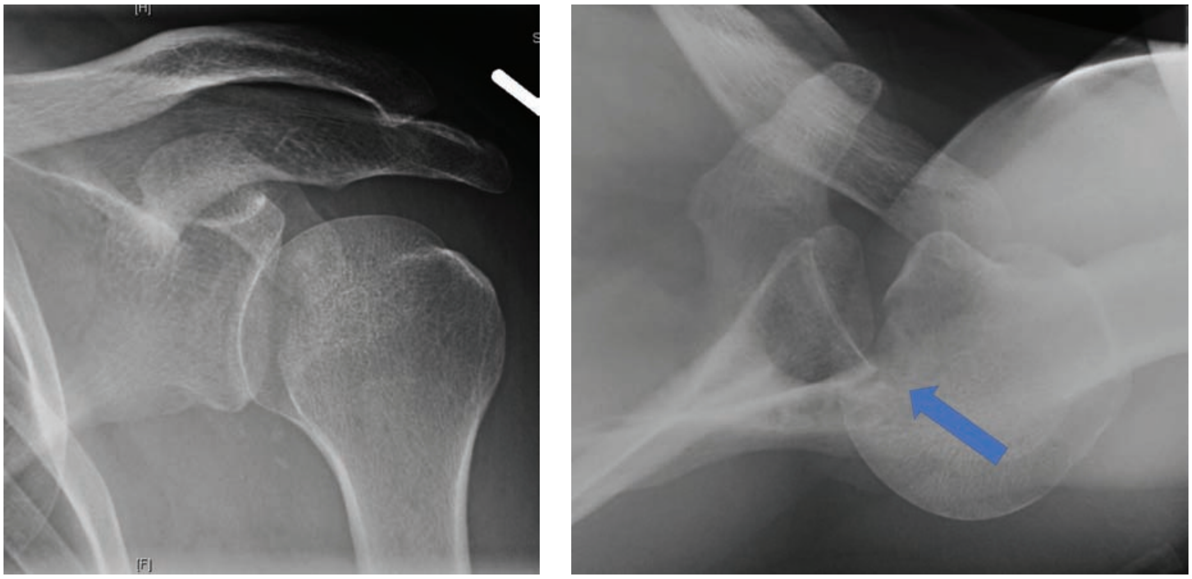
SIGNS AND SYMPTOMS OF GLENOHUMERAL INSTABILITY

Acute dislocations are painful events that typically result in patients seeking emergent care. Patients presenting with a shoulder dislocation may demonstrate a deformed shoulder depending on the body habitus and direction of dislocation. An anterior dislocation may reveal a posterior sulcus while a posterior dislocation may conversely reveal an anterior sulcus. Bruising and ecchymosis can be present in a subacute presentation of a dislocation event. Contributing to pain is muscle spasm which results from an attempt to provide stabilization of the dislocated joint. Restricted active and passive motions (especially rotation) are typical findings. The position of the arm is in slight abduction for an anterior dislocation. Posterior dislocation can be missed given that the arm is held in internal rotation and adduction. The examination is characterized by a lack of external rotation and forward flexion. The lack of striking deformity and "sling position" of the arm can result in missed or delayed diagnosis of posterior shoulder dislocations (Fig. 34-4).[88] Inferior dislocations or luxatio erecta is a striking presentation in which the affected arm is locked in hyperabduction with the humeral head locked underneath the glenoid. In addition to testing the axillary nerve, appropriate radiographic evaluation is essential for diagnosis of shoulder dislocations and is covered in the section on imaging and other diagnostic studies for glenohumeral instability.

Physical Examination for Glenohumeral Instability

For individuals presenting with a history of shoulder subluxations or dislocation events, a variety of tests can be performed to assist in diagnosis and identifying associated lesions. Initial examination should include a complete neurovascular examination to document any neurologic or vascular deficits. Brachial plexus lesions and vascular lesions are rare but can present with high-energy traumatic events. Specifically, testing of the axillary nerve is performed by assessing light touch over the lateral deltoid and by palpating the deltoid muscle for contraction while having the patient abduct the arm against resistance at the elbow.

Documentation of active and passive ROM of the shoulder for internal and external rotation as well as forward flexion and abduction is important (Figs. 34-5 and 34-6). Marked loss of motion is seen with persistent dislocations and rotator cuff lesions. The evaluation of the shoulder with a recent dislocation event can be challenging due to pain, but substantial motion loss mandates orthogonal radiographic imaging. Rotator cuff testing is also an essential part of the shoulder instability examination particularly in patients over the age of 40 years as the incidence of rotator cuff lesions increases. Testing of the rotator cuff within the patient's range of comfort is essential and can identify subtle rotator cuff findings in the acutely painful patient. The belly press or bear hug test is the most effective test to evaluate the function of the subscapularis in the acutely injured patient (Fig. 34-7). Testing of resisted shoulder abduction in the first 30 degrees of shoulder flexion with the arm internally rotated is effective for evaluating the supraspinatus (Fig. 34-8A). Jobe's test or the empty can test are similar tests but performed traditionally with greater degrees of shoulder

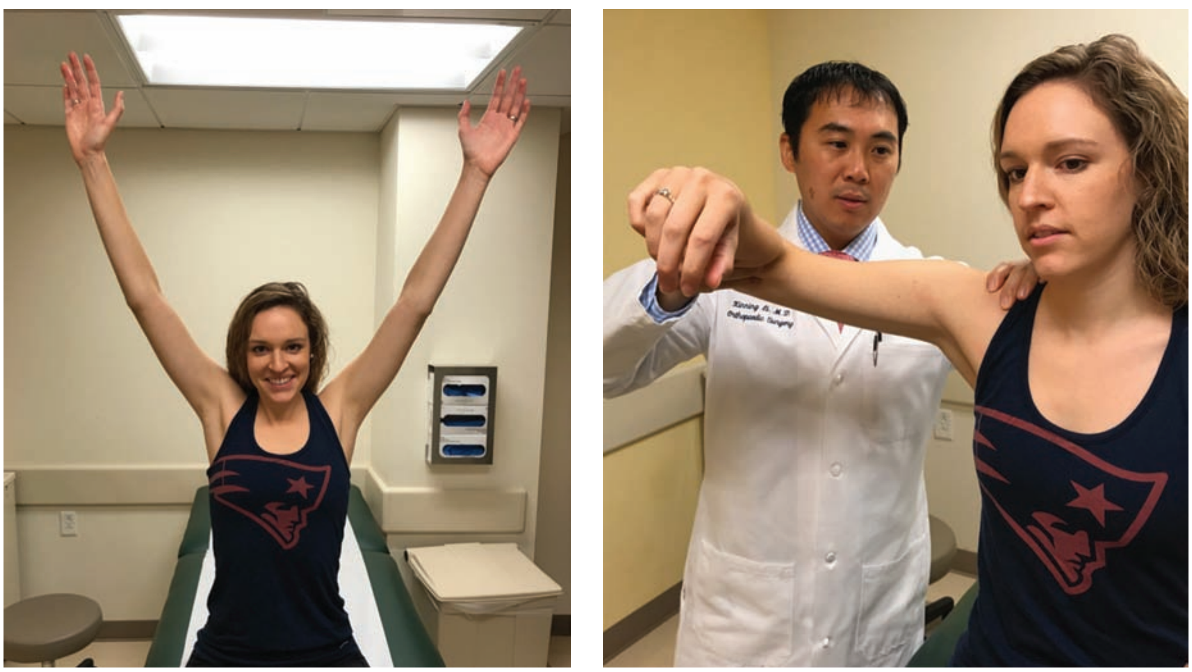


A

Figure 34-4. **A:** The left shoulder after trauma appears to be centered and located on the Grashey view. **B:** Axillary view shows the humeral head is posteriorly dislocated and locked onto the glenoid with a large reverse Hill–Sachs lesion (*arrow*). These images are of the same patient who presented to the emergency room after trauma to the left shoulder.

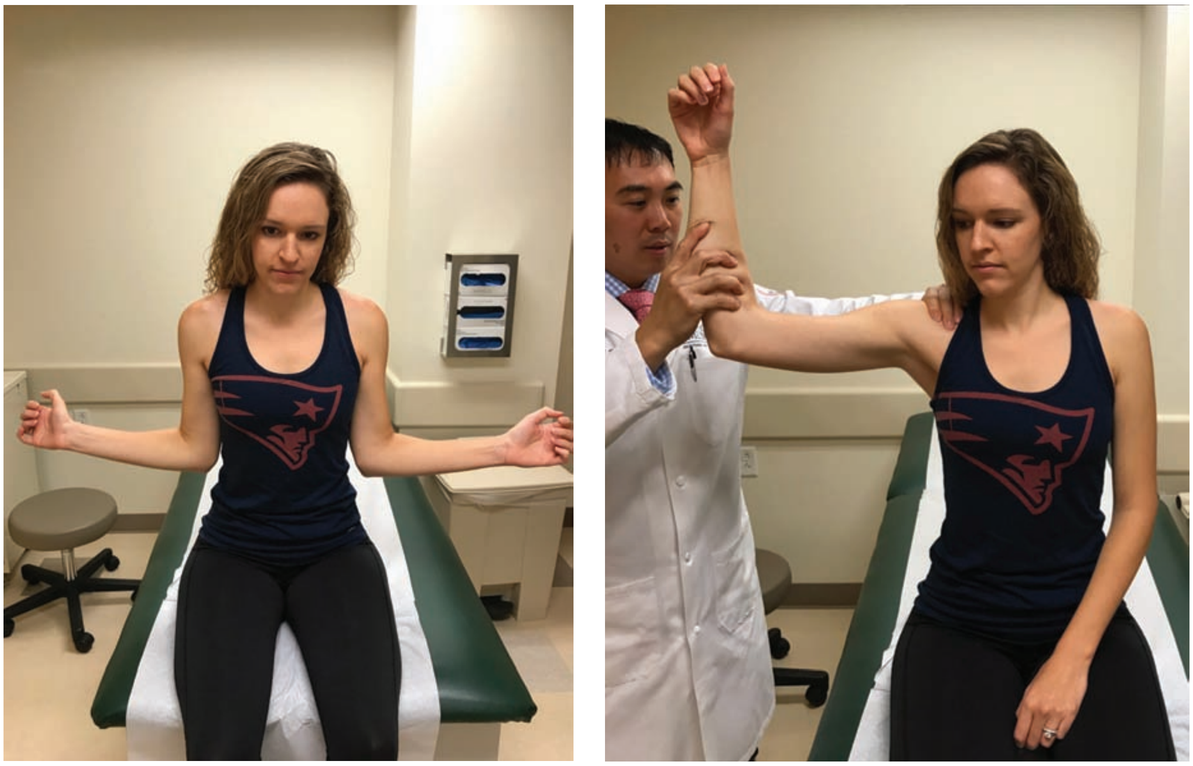
abduction which may be too painful for a patient who presents with an acute shoulder dislocation (Fig. 34-8B). Evaluation of the infraspinatus is performed by applying resisted external rotation with the elbow flexed to 90 degrees and, again, is performed within the patient's comfortable ROM (Fig. 34-8C).

Occasionally, patients will describe a history of a dislocation event and have subsequent specific complaints of instability or subluxation. Besides a description of instability or recurrent dislocations, the most common complaint of shoulder instability is pain coupled with restricted shoulder motion. Patients with anterior shoulder instability will experience symptoms of apprehension with shoulder abduction and external rotation, and also can experience symptoms of pain and instability with placement of the arm in an overhead position. It is important for the clinician to look for these signs when evaluating patients with suspected shoulder instability and shoulder pain.



A

Figure 34-5. **A:** Both passive and active forward flexion in the plane of the scapula is measured with the patient sitting. **B:** Abduction is measured with the scapula stabilized.



C

Figure 34-5. (*Continued*) **C** and **D:** External rotation is measured with the arm at the side and in 90 degrees of abduction.

A

Figure 34-6. Internal rotation measurement is done with the arm in 90 degrees of abduction with the scapula stabilized (**A**) and also with the arm at the side (**B**). With the arm at the side, the lumbar or thoracic vertebral level that is reached by the thumb is documented.

A

Figure 34-7. A: Belly press test is done with the elbow bent in 90 degrees and the elbow forward. The patient is asked to hold the hand on the belly while resistive force is applied. Either weakness or pain is a positive test. B: Bear hug test is done with the hand on the contralateral shoulder. Resistance is applied and a positive test is either weakness or pain. Both tests are designed to evaluate for subscapularis rupture.

Specific tests for anterior instability include the anterior apprehension sign in which the arm is placed into an abducted (90 degrees) and maximally externally rotated (ABER) position with the patient in the supine position resulting in a feeling of pain, discomfort, and potential instability (Fig. 34-9A). From this position of ABER, the relocation test can conveniently be performed in which a posteriorly applied force to the proximal humerus will elicit a feeling of reduced apprehension or pain from the patient (Fig. 34-9B). Furthermore, an anterior release test (surprise test) can also be performed by removing the posteriorly directed force abruptly when the patient's arm is in the 90 degrees of abduction, 90 degrees of elbow flexion,

A, B

Figure 34-8. A: In the acute injury setting, testing of resisted shoulder abduction in the first 30 degrees of shoulder flexing with the arm internally rotated is effective for evaluating the supraspinatus. B: Jobe's test or the empty can test are similar tests but performed traditionally with greater degrees of shoulder abduction which may be too painful for a patient who presents with a recent shoulder dislocation. C: Evaluation of the infraspinatus is performed by applying resisted external rotation with the elbow flexed to 90 degrees.

A, B

Figure 34-9. A: Anterior apprehension sign is done with the patient in the supine position in which the arm is placed into 90 degrees of abducted and maximally externally rotated (ABER) position resulting in a feeling of pain, discomfort, and potential instability. **B:** From this position of ABER, the relocation test can be conveniently performed in which a posteriorly applied force to the proximal humerus will elicit a feeling of reduced apprehension or pain from the patient. **C:** An anterior release test (surprise test) can also be performed by removing the posteriorly directed force (*arrow*) when the patient's arm is in the 90 degrees of abduction, 90 degrees of elbow flexion, and maximal external rotation.

and maximal external rotation position (Fig. 34-9C). A feeling of pain or apprehension is a positive result. Caution should be taken not to dislocate the patient's shoulder with this anterior release testing.

Lo et al. evaluated the validity of these three provocative tests on anterior shoulder instability and found that in patients with the feeling of apprehension on all three tests, the mean positive and negative predictive values were 93.6% and 71.9%, respectively.[136,137] The anterior release or surprise test was the single most accurate test for diagnosing anterior instability (sensitivity 63.9% and specificity 98.9%) compared to the other two tests. Furthermore, feeling of apprehension was more accurate than pain as a criterion for diagnosing instability. Since the essential lesion for anterior shoulder instability is damage to the anterior capsule–labral–ligamentous structures, the position of ABER places these structures under tension or challenges their function which results in both apprehension and pain. Other provocative described tests for glenohumeral instability include the load and shift test (Fig. 34-10A) and anterior or posterior drawer testing (Fig. 34-10B). Bushnell et al. proposed the "bony apprehension test" for shoulder instability in which the feeling of apprehension is experienced at or below 45 degrees of abduction and 45 degrees of external rotation as a means of screening for significant bony lesions (Fig. 34-10C).[36] The authors found the sensitivity and specificity as 100% and 86%, respectively, in predicting bony lesions in patients after anterior instability with this special testing.

Evaluation of the patient with subacute posterior instability is more subtle and difficult to diagnose. The predominant symptom of patients with posterior shoulder instability is pain. Provocative testing includes the jerk test which is done in the sitting position with an axial force applied to the arm in 90 degrees of abduction and internal rotation. The arm is then horizontally adducted while the axial load is maintained (Fig. 34-11A,B). A feeling of a clunk or jerk elicited with or without pain is considered a positive test (Fig. 34-11C). Kim et al.[120]

A, B

Figure 34-10. A: Load and shift examination is performed with the patient in the supine position. With the arm is abducted 90 degrees and the elbow bent, both anterior- and posterior-directed force is applied to the humeral head with slight axial compression. Grading of translation: 1+ (the humeral head to the glenoid rim and back), 2+ (the humeral head translates past the glenoid rim and back), and 3+ (the humeral head is locked out past the glenoid rim and does not translate back to the center of the glenoid). **B:** Anterior or posterior drawer test is done in the sitting position. The humeral head is translated both anteriorly and posteriorly. **C:** Bony apprehension test is done with the arm below 45 degrees of abduction and 45 degrees of external rotation. If the patient has feelings of apprehension or pain with this arm position, either a bony Bankart lesion or moderate-to-severe anterior glenoid bone loss should be suspected.

A, B

Figure 34-11. **A:** The posterior jerk test is done in the sitting position with an axial force applied to the arm in 90 degrees of abduction and maximal internal rotation. **B:** The arm is then horizontally adducted with the scapula stabilized while the axial load is maintained. **C:** A feeling of a clunk or jerk elicited with or without pain is considered a positive test. This patient's humeral head dislocated posteriorly with the above maneuver and then self-reduced with the arm back in the neutral position.

evaluated the painful jerk test as a predictor of success in nonoperative treatment of posteroinferior shoulder instability. In the subgroup of patients with both pain and a clunk, they found a significantly higher failure rate after conservative management than the group that did not have pain. Overall, in the painless jerk group, 93% of the patients responded to an intense rehabilitation program after a mean of 4 months compared to 16% of patients in the painful jerk group that responded to the same program.[120]

Occasionally, patients will demonstrate an active jerk test. Similarly, another apprehension-inducing provocative test involves placing the arm in the position of internal rotation, forward flexion, and adduction which will create a condition in which the dynamic stabilizers (posterior rotator cuff muscles) are turned off, and the force vector of the proximal humerus directs posterior to the glenoid, resulting in loading of the static posterior stabilizing structures of the glenoid (labrum, capsule, and ligaments). The addition of a downward force to the arm potentiates the feeling of apprehension and pain. Comparing the pain and response of the patient to the alternative position of the arm in an external rotation and abduction in the plane of the scapula should diminish the symptoms of apprehension and pain by allowing the dynamic posterior shoulder stabilizers of the posterior deltoid and rotator cuff to be active and the force vector to point at the glenoid. Pain and discomfort is still likely to be present but at a reduced amount compared with the previous position. Posterior load and shift examination and posterior drawer testing are also useful adjuncts for testing of posterior instability.

Assessment of patients with possible MDI starts with inspection, palpation, and ROM assessment, with comparison to the contralateral shoulder.[139] Assessment of motion should begin with observing active ROM. Patients will frequently have a supraphysiologic ROM in all planes about the shoulder. Scapulothoracic motion along with possible winging should also be evaluated, necessitating the physician to have an unobstructed view of the patient's shoulder girdle, while still respecting patient's modesty. At our institution, we utilize disposable paper shorts which have been modified to allow female patients to wear it in the style of a tube top, allowing the clinician to observe shoulder and scapular motion unimpeded (Fig. 34-12). The Beighton hypermobility score should be assessed on every patient with suspected MDI, consisting of examination of passive dorsiflexion of the small finger metacarpophalangeal joint (MCPJ) greater than 90 degrees, passive dorsiflexion of the bilateral thumbs to the volar forearms (Fig. 34-13A), hyperextension of the bilateral elbows greater than 10 degrees (Fig. 34-13B), hyperextension of the bilateral knees greater than 10 degrees, and the ability for the patient to rest the palms flat on the floor with forward flexion of the trunk and knees fully extended (Table 34-1).[16]

TABLE 34-1. Beighton Score for Hyperlaxity

Joint	Positive Finding
Small finger metacarpophalangeal joint (bilateral)	Passive dorsiflexion >90 degrees (Left = 1 point and right = 1 point)
Thumb (bilateral)	Passive dorsiflexion to the volar forearm (Left = 1 point and right = 1 point)
Elbow (bilateral)	Hyperextension >10 degrees (Left = 1 point and right = 1 point)
Knee (bilateral)	Hyperextension >10 degrees (Left = 1 point and right = 1 point)
Trunk	Forward flexion with knees fully extended results in palms resting flat on the floor (Positive finding is 1 point)
Total score	9 Points

One point is given to each side for a positive finding. The maximal total score is 9. Any adult patient with >5/9 positive findings is considered hypermobile and any children with >6/9 fits the definition of hypermobile.

A

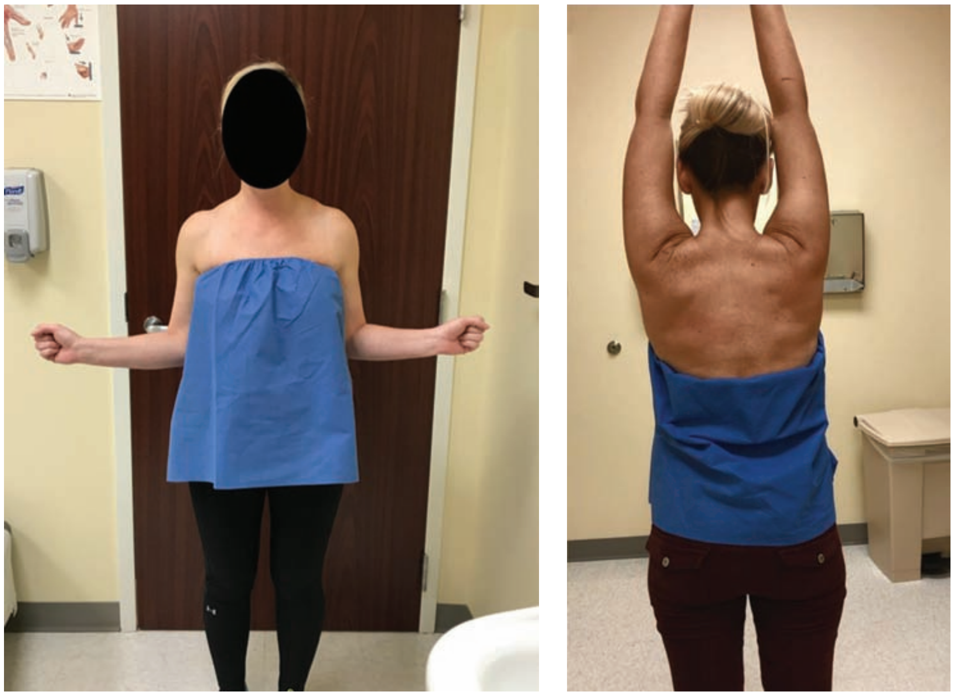


Figure 34-12. Disposable paper shorts have been modified to allow female patients to wear it in the style of a tube-top (**A**), allowing the clinician to observe shoulder and scapular motion both from the front and the back (**B**).

A

Figure 34-13. A: This patient presents with symptoms of shoulder pain and diagnosis of multidirectional instability. The Beighton hypermobility score was measured. Passive dorsiflexion of the bilateral thumbs touched his forearm. **B:** Hyperextension of the elbow was also observed with more than 10 degrees of hyperextension.

A

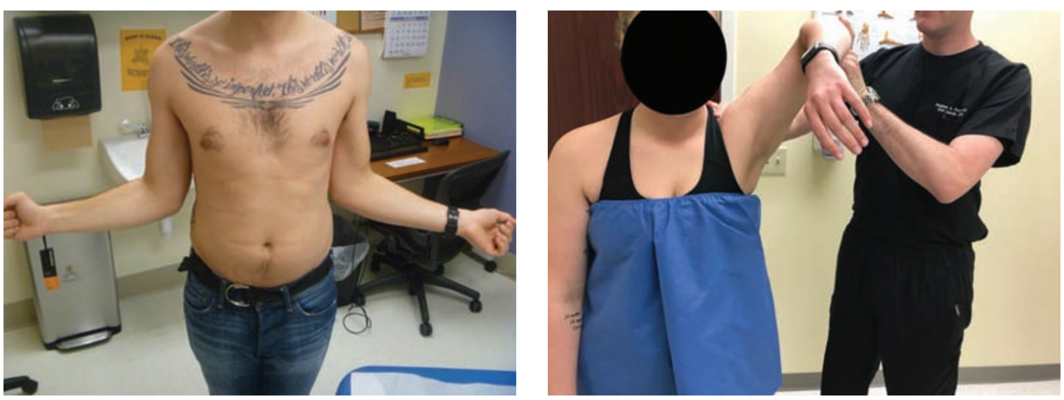


Figure 34-14. A: Patient with MDI and hyperlaxity with increased external rotation of >90 degrees with the arm at the side. **B:** Hyperabduction of 130 degrees and more than 20 degrees more than the contralateral side is a positive Gagey sign.

A, B

Figure 34-15. **A:** The sulcus sign is used for inferior instability and laxity. **A:** With the patient in the sitting position. **B:** A downward force is applied to the arm with the elbow bent. A positive sulcus sign is seen with inferior translation of the humeral head at least 1 to 2 cm from the acromion (*arrow*). **C:** The same test is also done with the arm in maximum external rotation to evaluate for laxity in the rotator interval.

Increased external rotation may imply anterior hyperlaxity (Fig. 34-14A), and asymmetric hyperabduction greater than 15 degrees of difference from the contralateral shoulder (Gagey test) with scapular stabilization may indicate incompetency of the inferior glenohumeral ligament complex (IGHLC) (Fig. 34-14B). Additional special tests include the sulcus sign for inferior instability, and the anterior and posterior load and shift. The sulcus test assesses inferior instability and is tested by applying inferior traction with the arm at the side (Fig. 34-15A).[84] A positive test results in inferior translation of at least 1 to 2 cm. This can cause the appearance of a skin dimpling (*arrow*) inferior to the lateral aspect of the acromion (Fig. 34-15B). A positive sulcus sign is also noted (*arrow*) then with the arm taken into external rotation (Fig. 34-15C). A sulcus sign that persists with the arm past 45 degrees external rotation is thought to represent an increased spectrum of inferior instability related to a widened or incompetent rotator interval.[183] Apprehension and Jobe relocation tests are considered the most diagnostic for identifying anterior shoulder instability, with a positive predictive value of 96%.[128] The Jerk test, Kim test, and push–pull examination maneuvers will help exclude posterior instability and, in combination with the above described testing, the diagnosis of MDI may be elicited. Furthermore, pathology of the biceps–superior labral complex (SLAP) may also be assessed with the O'Brien test, Crank test, dynamic labral shear test, and Yergason test.

IMAGING AND OTHER DIAGNOSTIC STUDIES FOR GLENOHUMERAL INSTABILITY

Radiography

Patients presenting with shoulder instability and dislocations are initially imaged with standard radiographs. Radiographs provide an overview of the bony anatomy, orientation of the humeral head in relation to the glenoid, and initial assessment for both bony Bankart and Hill–Sachs lesions among other associated pathologies. Given the orientation of the glenohumeral joint, radiographs can be obtained relative to the body or aligned to the scapula. Anteroposterior (AP), Grashey (true AP view), Y, and axillary views are typically obtained (Fig. 34-16). The AP view is aligned with the body (Fig. 34-17A) while the Grashey view

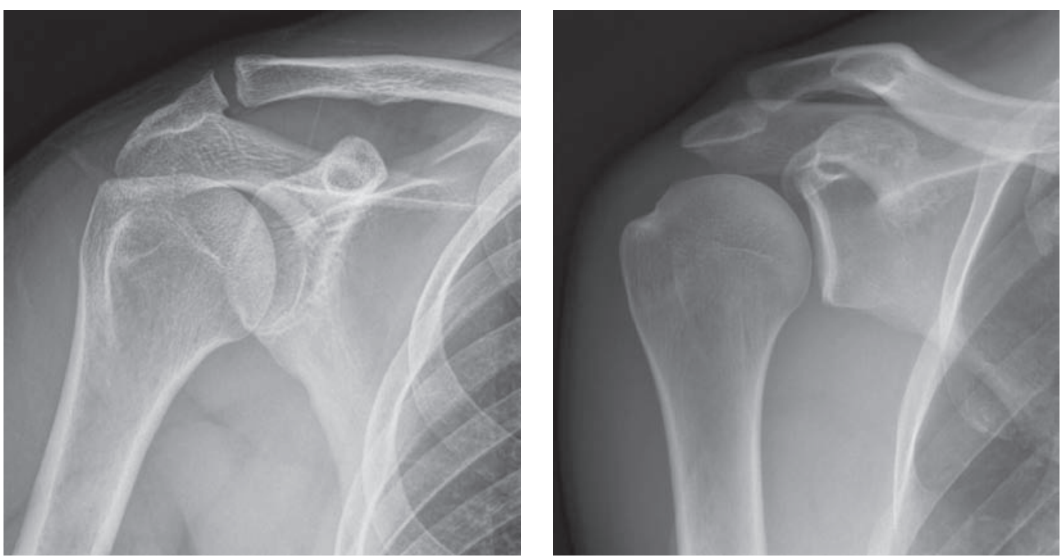


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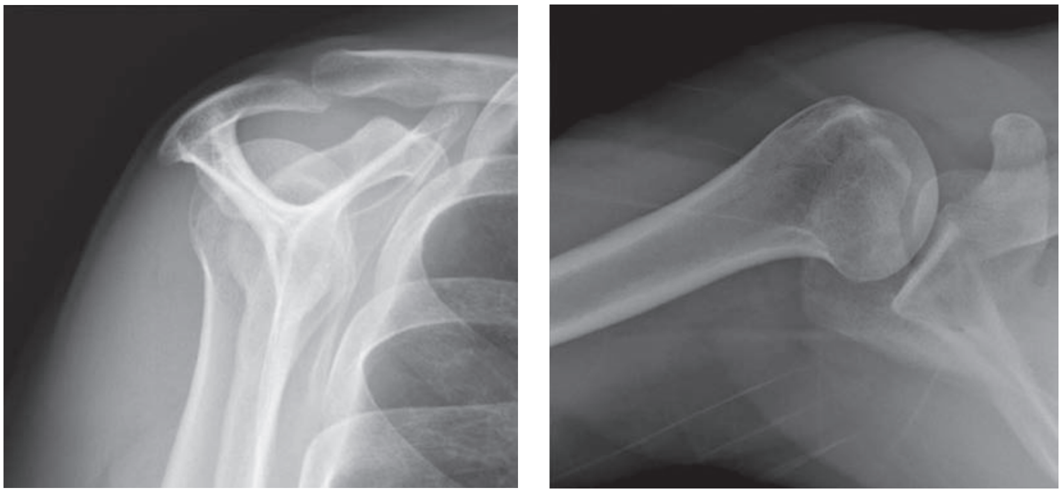
Figure 34-16. **A:** Anterior–posterior radiographic view of the shoulder. **B:** Grashey true view.



C

Figure 34-16. (*Continued*) **C:** Scapular "Y" view. **D:** Axillary view which is considered the standard view for the evaluation of the relationship of the humeral head to the glenoid.

(true AP view) is oriented to the scapula with the radiographic beam centered onto the glenohumeral joint line (Fig. 34-17B). In patients who are able to abduct the arm, an axillary view must be obtained in order to evaluate for anterior or posterior humeral head subluxation or dislocation (Fig. 34-17C). This view is centered on the epicenter of the humeral head and the glenoid and provides an unambiguous view of anteroposterior glenohumeral alignment. Clinical concerns of anterior or posterior glenohumeral subluxation/dislocation and osseous Bankart lesions can best be evaluated with the axillary view. Alternatively, if the patient is unable to abduct their arm due to the acuity of injury, a scapular "Y" view must be obtained to evaluate the relationship of the humeral head to the glenoid (Figs. 34-17C and 34-18A). In a systematic review of posterior shoulder dislocations, Xu et al.[269] reported a missed initial diagnosis in 73% of patients (150) due to the lack of an axillary view, Y view, or computed tomography (CT) imaging. Of these 150 patients, almost all (147/150 or 98%) had only AP or lateral views of the shoulder. When the axillary or Y-view radiographs were made subsequently, the diagnosis of posterior dislocation was confirmed in 100% of patients.

In the subset of patients who present acutely with guarding and are unable to abduct the shoulder to obtain the axillary view, the scapular "Y" view (Figs. 34-17C and 34-18A) or a Velpeau view must be obtained to evaluate for subluxation or dislocation (Fig. 34-18B). Silfverskiold et al.[213] compared the axillary and scapular "Y" view in 75 consecutive patients with suspected shoulder dislocations and found that in 69 patients (92%), both views resulted in the same diagnosis. However, 81% of patients preferred the scapular "Y" view because of less pain, and the radiology technician also preferred the "Y" view due to the ease of obtaining the image compared to the axillary view. Additionally, a Velpeau view can also be obtained in these patients who are guarding. This is done with the patient in the sling and the radiographic plate positioned posteriorly and

A, B

Figure 34-17. **A:** Anteroposterior radiographic view is performed with the beam aligned to the body. **B:** Grashey view is done with the beam centered with the glenohumeral joint line. **C:** Axillary view is done with the arm in abduction and the plate is placed behind the patient's shoulder in the supine position. The radiographic beam is aimed 45 degrees to the axilla.

A

Figure 34-18. A: Scapular "Y" view. **B:** Velpeau view is done with the patient sitting down and the plate is positioned behind the patient. The radiographic beam is aimed down toward the plate at about 60 degrees.

under the shoulder (Fig. 34-18B) with the patient leaning back and the beam directed down to the plate.

Alternatively, a modified axillary view has been proposed by positioning the patient sitting on the radiographic table with the hand of the affected side on the table and the arm abducted 60 degrees.[208] The x-ray beam is pointed down to the glenohumeral joint, perpendicular to the table, in a superior to inferior direction. The radiographic plate is directly positioned on the table under the shadow formed by the shoulder contour with the anterior border behind the greater tuberosity. The body should lean slightly (approximately 10 degrees) toward the plate and tilted slightly backwards (Fig. 34-19A). Another modified axillary view is obtained with the patient leaning slightly forward. The plate is positioned behind the patient with the radiographic beam aiming down about 45 degrees toward the plate (Fig. 34-19B). This position provides greater comfort for the patient especially in the setting of acute traumatic dislocation.

Other special radiographic views that can assist in identifying pathology related to shoulder instability include the Stryker Notch, West Point, and the Bernageau profile views. The Stryker

A

Figure 34-19. A: Modified Velpeau view is done with positioning the patient sitting on the radiographic table with the hand of the affected side on the table and the arm abducted 60 degrees. The x-ray beam is pointed down to the glenohumeral joint, perpendicular to the table, superior to inferior in direction. The radiographic plate is directly positioned on the table under the shadow formed by the shoulder contour with the anterior border behind the greater trochanter. The body should lean slightly 10 degrees toward the plate and slightly tilted backwards. **B:** Boston Medical Center modified Velpeau view is done with the patient leaning slightly forward. The plate is positioned behind the patient with the radiographic beam aiming down 45 degrees toward the plate. This position provides comfort for the patient especially in the setting of acute traumatic dislocation.

A, B

Figure 34-20. **A:** Stryker notch view done in the standing position, the elbow points straight in front of the patient's face. The beam is angled about 10 degrees cephalad to the shoulder and plate. **B:** West Point view is done with the patient in the prone position and the forearm hanging off the table with the head turned away from the plate. With the cassette on the superior aspect of the shoulder, the x-ray beam is centered on the axilla and aimed at 25 degrees downward form the horizon (**B**) and 25 degrees medial to the plate (**C**). With this view, the radiographic beam is tangential to the anteroinferior rim of the glenoid to allow excellent visualization and detection of bony Bankart lesions.

Notch and West Point views increase the detection of Hill–Sachs and Bankart lesions, respectively. For the Stryker Notch view, the patient can be standing or supine. The arm is voluntarily extended vertically with the hand placed behind the head, making the humerus parallel to the table. In the standing position, the elbow points straight in front of the patient's face, and in the supine position, it points toward the ceiling. The beam is angled about 10 degrees cephalad to the shoulder and plate (Fig. 34-20A). For a West Point view, the patient is prone with the head turned away from the cassette. The forearm can hang off the table or with the elbow extended and the arm abducted 90 degrees from the long axis of the body, resulting in the humerus parallel to the tabletop. With the cassette on the superior aspect of the shoulder, the x-ray beam is centered on the axilla and aimed at 25 degrees downward from the horizon and 25 degrees medial (Fig. 34-20B,C). With this view, the radiographic beam is tangential to the anteroinferior rim of the glenoid to allow excellent visualization and detection of bony Bankart lesions.

The Bernageau profile view originated from France and can be used to evaluate anterior glenoid bone loss (Fig. 34-21A).[19] Ahmed et al. described using this view to calculate the distance between the anterior and posterior glenoid rims and to compare these measurements between the left and right shoulders (Fig. 34-21B).[2] The Bernageau view has been shown to have similar accuracy and reproducibility as CT in detecting and measuring the degree of glenoid erosion.[3] There is also the added benefit that radiographs are less costly, easier to perform, and available to a larger population.

A

Figure 34-21. **A:** Bernageau view is done with the patient's arm flexed and the radiographic beam positioned in line with the scapula spine. The angle of the beam is coming down toward the plate at about 30 to 40 degrees in line with the glenoid. This view provides a glenoid profile view. **B:** The anterior rim of the glenoid is perfectly visualized. In this patient, there was no anterior glenoid bone loss.

Magnetic Resonance Imaging and Arthrography

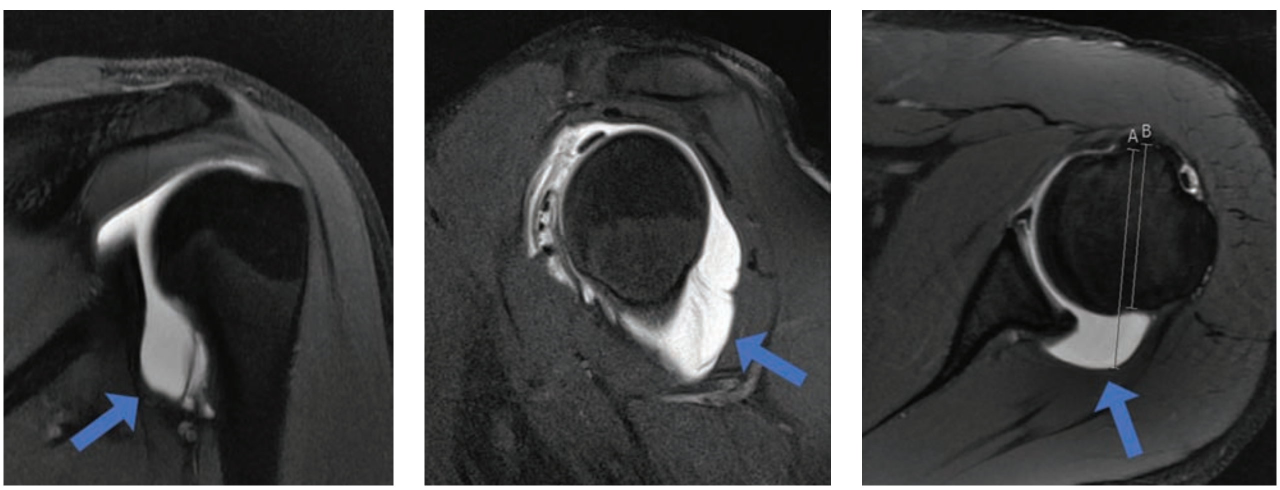
Traditional magnetic resonance imaging (MRI) is a diagnostic tool to complement both physical examination and standard radiographs in the management of patients with anterior shoulder instability. It is utilized for evaluation of soft tissues, which can be performed with high contrast and spatial resolution. Magnetic resonance (MR) accuracy in identifying labral and rotator cuff tears in the literature ranges from 70% to 100%.[198,241,266] The acquired multi-planar imaging allows for the detailed evaluation of the glenoid, labrum, joint capsule, and rotator cuff in different planes. MR arthrography or arthrogram (MRA) refers to MRI of a joint that has been injected with an intra-articular contrast agent such as diluted gadolinium or saline solution. The contrast material is injected prior to MRI by fluoroscopic or ultrasound guidance under strict aseptic technique. By distending the joint capsule, the cartilage, ligaments, and labrum are outlined with contrast, increasing the sensitivity for detecting tears and other lesions. It should be noted that in the acute dislocation setting, a joint effusion with distension of the joint may outline these structures similarly, making the arthrogram unnecessary.[266] This form of MRI has proven utility by increasing both sensitivity and specificity in detecting injuries to the capsulolabral–ligamentous complex as compared to traditional MRI.[8] In a meta-analysis of the diagnostic test accuracy of MRA compared to MRI for the detection of glenoid labral injuries, Smith et al.[218] evaluated 6 studies including 4,667 shoulders. They found greater diagnostic test accuracy for MRA over MRI in the detection of glenoid labral lesions (MRA sensitivity 88% and specificity 93% vs. MRI sensitivity 76% and specificity 87%).

With standard MRI or MRA, the shoulder is routinely positioned in neutral or partial external rotation but other alternative positions can be used to increase the sensitivity for detecting labroligamentous injuries. Abduction and external rotation (ABER) of the arm is an alternative position that is utilized to increase the sensitivity and specificity for detecting anteroinferior labroligamentous injury.[230] However, limited ROM or pain may prohibit patients from performing this provocative maneuver. Schreinemachers et al.[206] retrospectively compared the accuracy of MRA and MRA in the ABER position for the detection and characterization of anteroinferior labroligamentous lesions with arthroscopic evaluation as the standard. The authors found that full routine MRI or MRA examination had similar accuracy as the ABER sequence in evaluating the anteroinferior labral–ligamentous complex. Conversely, Tian et al.[230] performed a similar study evaluating the added value of the ABER position and found that the sensitivity of MRA with the ABER position for detecting anteroinferior labral lesions was significantly higher than that of the MRA in neutral position and more effective in identifying Perthes lesions.

MRAs can also demonstrate a patulous capsule on the coronal, sagittal, and axial imaging in patients with MDI (Fig. 34-22). MRAs can be helpful in evaluating lesions of the rotator interval and other associated findings as well that may ultimately affect the eventual surgical plan.[183] The presence of glenoid dysplasia, increased capsular cross-sectional area, and increased glenoid retroversion have all been found to be associated with increased posterior labral tears and symptomatic instability.[68,69] Parada et al. also demonstrated that glenoid retroversion was significantly increased in patients with symptomatic posterior labral tears but there was no significant association between instability and increased humeral head subluxation.[181] Often, patients with MDI will present to the orthopedic surgeon already having had an MRI or MRA and so these studies should be reviewed. Clinicians should keep in mind, however, that the diagnosis of MDI is a clinical one, and as such, the need for expensive and/or invasive imaging should be weighed against the information that will be gained from these studies.

Computerized Tomography Scan

Computerized tomography (CT) has traditionally been the main diagnostic imaging modality for evaluating bone loss related to anterior shoulder instability.[226] CT scans are readily available,



A, B

Figure 34-22. A: Coronal T2-weighted MRA image shows patulous inferior capsule (*arrow*) in a patient with MDI. **B:** Sagittal oblique T2 MRA also confirms the enlarged capsule (*arrow*). **C:** Axial T2 MRA image demonstrates increased posterior capsule volume (*arrow*) without any evidence of posterior labral tear in this patient with MDI.

rapidly acquired, and provide excellent fine bony detail. Anterior shoulder dislocations can often lead to glenoid bone rim fractures (bony Bankart lesion), and repeated subluxations or dislocations can remodel the anterior-inferior glenoid.[226] Such pathology is well imaged by CT, as the imaging can detect the smallest osseous fragments and glenoid asymmetry. When acquired with high resolution and thin slices, 3D volume-rendered reformats can also be created with the humeral head digitally subtracted providing further visualization of the glenoid fossa for preoperative planning and measurement or calculation of the amount of bone loss.

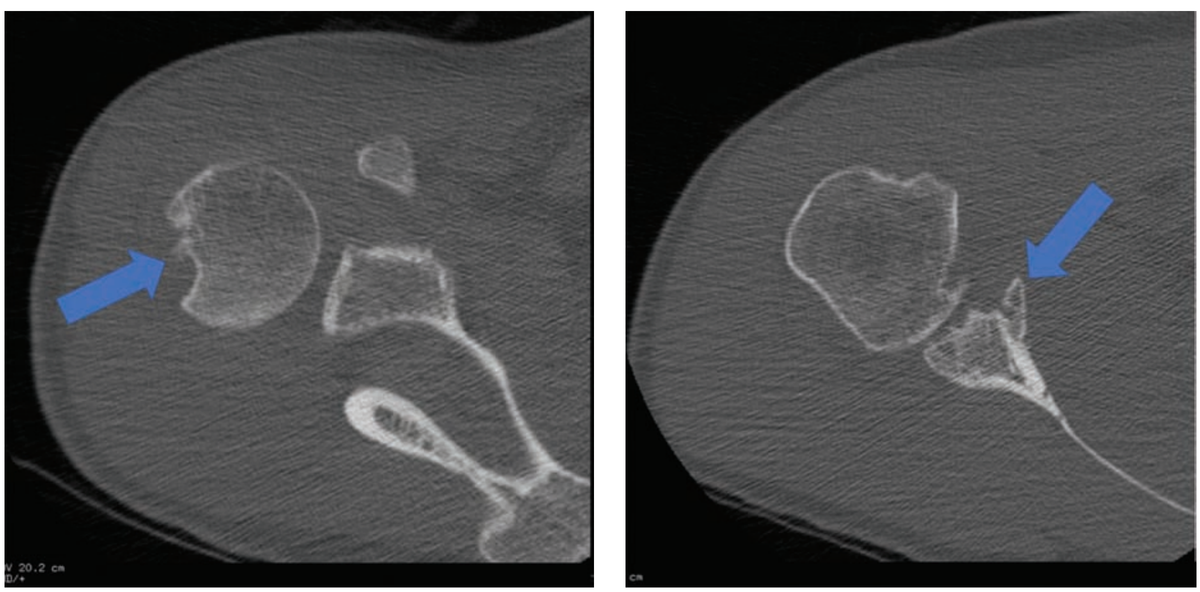
In the evaluation of the posterolateral humeral head compression fracture, also called the Hill–Sachs lesion, CT scans with 3D reconstruction images provided a similar diagnostic accuracy to arthroscopy. However, a purely cartilaginous defect of the posterior superior humeral head was difficult to diagnose with CT imaging. The prevalence and size of the Hill–Sachs lesions was also directly related to the number of subluxations or dislocations.[179] While isolated Hill–Sachs lesions or those associated with small Bankart lesions may be less clinically significant, bipolar lesions (Hill–Sachs and Bankart lesions occurring together) may require the surgeon to address both-sided pathology with arthroscopic Bankart repair and humeral head remplissage to maintain stability and minimize failure.[147] Nakagawa et al.[161] found that the prevalence of bipolar lesions was 33% in shoulder with primary instability and 62% in shoulders with recurrent instability. The size of the Hill–Sachs lesion was directly correlated with the size of the glenoid lesion. Postoperative recurrence of instability or failure of surgery was 29% in patients with bipolar lesions. Thus, if such bipolar lesions are suspected, CT scan with 3D reconstruction is critical for the identification and sizing of these lesions to direct surgical management and improve outcome in patients with shoulder instability (Fig. 34-23).

Evaluation of Glenoid Bone Loss

The amount of glenoid bone loss significantly impacts the outcome and recurrence rate after arthroscopic Bankart repair. Burkhart et al.[31] reported a high recurrence rate of 67% after arthroscopic Bankart repair in patients with more than 25% preoperative glenoid bone loss. However, in patients without significant bone loss, the recurrence rate was 4%. Biomechanical studies have also confirmed the above findings and showed that an osseous defect that is >21% of the glenoid length caused instability and limitation of shoulder ROM after Bankart repair.[107] Thus, it is critical to evaluate the exact amount of glenoid bone loss preoperatively to indicate patients for either arthroscopic repair or bone procedure. Once a critical threshold is met for bone loss, there is a higher failure rate of arthroscopic Bankart repair; other repair options, such as a Latarjet, should be considered for surgical management.

Various methods, including calculating the glenoid width, length, and surface area, have been developed to measure the amount of bone loss in a standardized fashion. Burkhart et al. proposed a unique method of quantifying glenoid bone loss arthroscopically using the center of the glenoid or the bare spot. Using a probe of 3 mm, the distance from both the anterior (Da) and the posterior margin to the bare spot (Dp) is measured. Amount of glenoid bone loss is defined as $(Dp - Da)/2 \times Dp \times 100$. However, the bare spot was not consistently located at the center of the glenoid. Miyatake et al.[156] evaluated the accuracy of using the bare spot arthroscopically and found that in 29% of patients (10 shoulders), there was a greater than 5% difference from the standard 3D CT measurements.

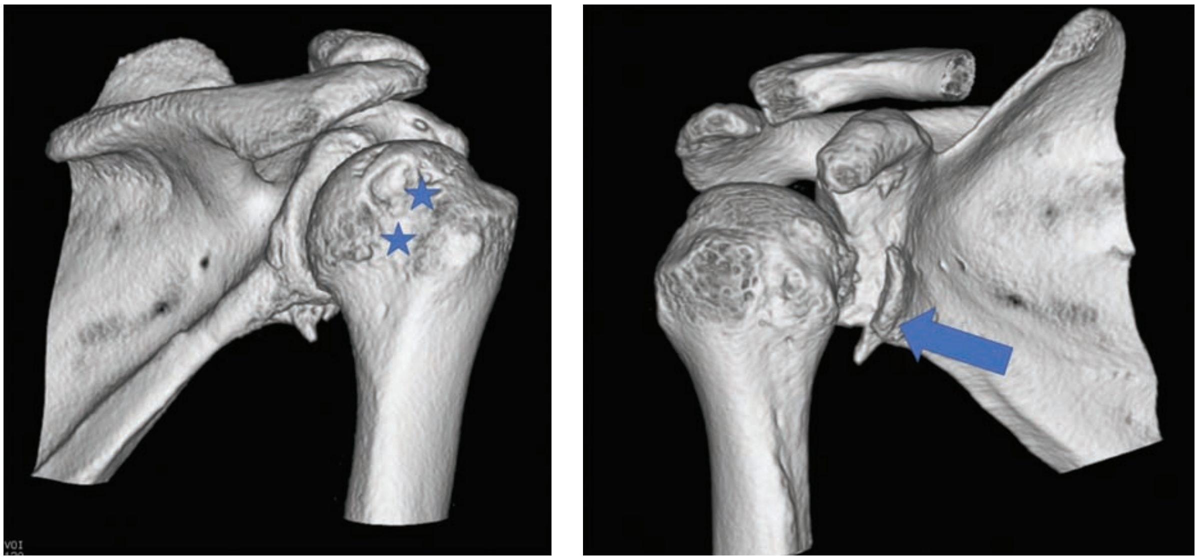
Several authors have described different methods of using either unilateral 2D CT images or 3D CT utilizing an assumed inferior circle of the glenoid on the affected side comparing it



A

Figure 34-23. Bipolar lesion with CT to show both glenoid bone loss and humeral head bone loss or Hill–Sachs lesion. **A:** Axial CT image shows the large Hill–Sachs lesion on the posterior humeral head (*arrow*). **B:** Axial CT image shows the large anterior bony Bankart lesion with glenoid bone loss.

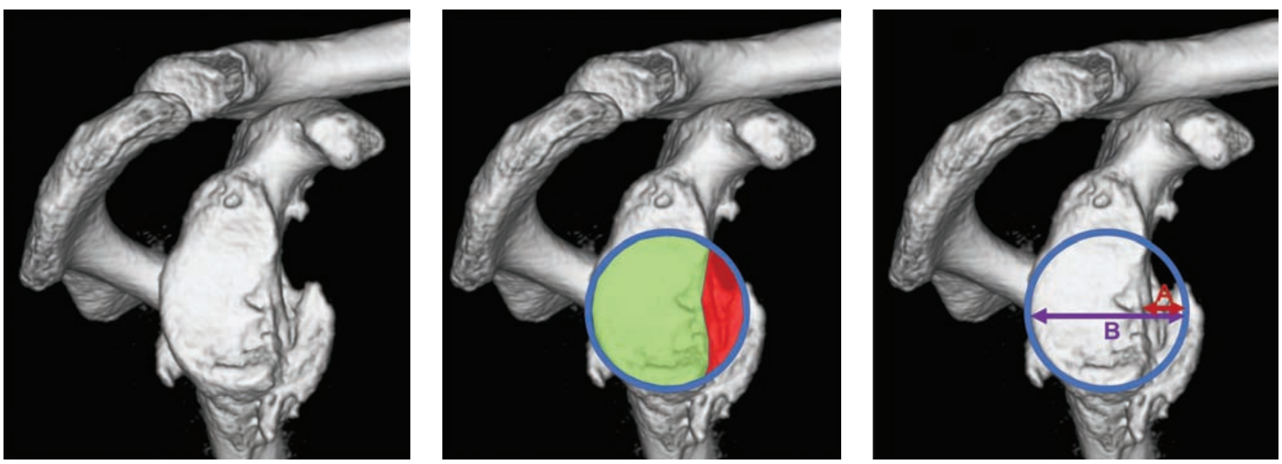
(*continues*)



C

Figure 34-23. (*Continued*) **C:** CT with 3D reconstruction shows the Hills–Sachs lesions (*stars*). **D:** CT with 3D reconstruction shows the anterior bone Bankart lesions (*arrow*) and glenoid bone loss.

to the contralateral normal side to calculate for the amount of glenoid bone loss based on the assumption that there are no side-to-side differences.[189,210] Most of these techniques use the ratio of the width of the missing bone anteriorly to the anteroposterior diameter of the uninjured glenoid or the diameter of the best fit circle on the affected glenoid.[168,226] The "circle method" is the most widely used method for estimating glenoid bone loss and provides useful presurgical planning information. This utilizes surface area measurements that can be performed accurately on the sagittal view of a 2D or 3D volume-rendered CT reformat or 2D sagittal MR image of the glenoid fossa (Fig. 34-24A). En face, the normal inferior glenoid contour can be approximated to a true fit circle. Thus, the size of a Bankart lesion or glenoid bone loss can be calculated by comparing the surface area of the bone defect with the expected normal surface area of the glenoid fossa as measured by the best fit circle (Fig. 34-24B). Sugaya[226] proposed an en face 3D CT view of the glenoid and quantifying the amount of glenoid bone loss as a percentage defect of the glenoid based on a ratio of the missing anterior glenoid width against the diameter of the assumed inferior circle of the entire glenoid (Fig. 34-24C). This method has been shown to be both very reproducible and accurate in calculating the amount of glenoid bone loss.



A, B

Figure 34-24. **A:** CT image with 3D reconstruction of the glenoid and en face view of the glenoid fossa. A large bony Bankart lesion is seen anteriorly with critical bone loss. **B:** Perfect circle is drawn to match the inferior 2/3 of the glenoid. Using the surface area method, the size of the glenoid defect is calculated by dividing the surface area of the bone defect (*red*) with the normal surface area of the entire glenoid fossa (*circle*). **C:** Another method of measuring glenoid bone loss is calculating the percentage defect of the glenoid based on a ratio of the missing anterior glenoid width (*A*) against the diameter of the assumed inferior circle of the entire glenoid (*B*). The percentage bone loss is $A/B \times 100 = \%$ bone loss.

Gyftopoulos et al.[80] recently evaluated the diagnostic accuracy of using the circle method on MRI in calculating glenoid bone loss compared to the standard 3D CT imaging. They found MRI accuracy was only 1.3% different overall compared with the CT imaging and concluded that using the circle method with MRI can be an accurate alternative to 3D CT. Owens et al.[173] proposed an equation for predicting the normal glenoid width in both males and females for calculating glenoid bone loss. They evaluated 1,264 MR images and found that glenoid width was correlated to the glenoid height measurements and that males and females were different in their respective measurements. The formula for normal glenoid width in males is (1/3 height) + 15 mm and in females is (1/3 height + 13 mm). With this standardized formula, it is possible to make accurate calculations of the amount of glenoid bone loss with only a digital ruler and an MRI of the injured shoulder.

Critical Glenoid Defect Size

The size of the glenoid bone defect is a major risk factor for failure after arthroscopic repair due to altered mechanics and the effect on the stability of the shoulder.[137] The prevalence of glenoid rim lesions has been reported as high as 90%, including 50% of bony Bankart lesions and 40% erosion of the anterior glenoid in patients with recurrent shoulder instability.[227] Recurrence rate after arthroscopic stabilization is unacceptable in patients with significant bone loss or an inverted pear glenoid morphology.[31] Lo et al.[137] demonstrated in a cadaver study that the inverted pear glenoid indicated at least 25% to 27% loss to the anterior-inferior glenoid width. It is essential for surgeons to look for and accurately calculate the amount of anterior glenoid bone loss to properly indicate patients for surgery between arthroscopic repair and bony procedures (Latarjet, bone grafting, etc.).

Historically, 20% to 25% of anterior glenoid bone loss was defined as the "Critical" cutoff that needs to be addressed with a bone procedure at the primary operation.[31,32] Recently, the idea of "Subcritical" bone loss was introduced by Shaha et al.[209] in a study that reported significantly worse outcomes in patients with >13.5% glenoid bone loss after arthroscopic Bankart repair and recommended addressing these patients with either Latarjet or an additional combined procedure to further stabilize the shoulder and decrease the risk of recurrence. The authors evaluated 75 anterior instability patients who underwent arthroscopic repair in a military institution. The cohort was divided into quartiles based on bone loss. In patients who failed with recurrent instability, the amount of glenoid bone loss was significantly higher than the group that did not fail (25% vs. 13%). Furthermore, the authors also found that bone loss greater than 13.5% led to a clinically significant increase in the Western Ontario Shoulder Instability scores consistent with unacceptable outcome even in the subset of patients who did not sustain a recurrent dislocation. Shin et al.,[211] in a similar study, reported 17.3% bone loss as the "critical" value that led to surgical failure and recurrence of instability after arthroscopic repair. In the patient group with less than 17.3% bone loss, the failure rate was 3.7% compared with a 42.9% failure rate in the group with over 17.3% bone loss. Biomechanically, a recent study also reported glenoid defects of over 15% or more of the largest anteroposterior glenoid width as the "critical" bone loss amount in which a soft tissue repair cannot restore normal glenohumeral translation. This restricts rotational ROM and leads to abnormal humeral head translation.[212]

CLASSIFICATION OF GLENOHUMERAL INSTABILITY

The spectrum of shoulder instability ranges from subluxation to locked-dislocation. Subluxation is defined as the translation of the humeral head against the glenoid without complete separation of the articular surfaces and spontaneous reduction occurs when the abnormal force is removed and the humeral head reduces back to the normal anatomic position. A subluxation can occur in one of three types or directions: anterior, posterior, or inferior. The other end of the spectrum is dislocation where excessive translation of the humeral head results in complete separation of the articular surfaces. In these instances, the humeral head does not self-reduce when the abnormal force is removed. These patients often require manual reduction maneuvers with either conscious sedation or muscle paralysis (usually in the operating room) to the humeral head to the anatomic position. Owens et al.[178] prospectively evaluated shoulder instability in 38 patients who sustained a first-time anterior glenohumeral subluxation event and proposed a new spectrum of injury termed "Transient luxation." Transient luxation is between a subluxation and a dislocation as these patients experience a subluxation event that momentarily causes a separation of the articular surfaces but self-reduces. Furthermore, these patients will present with either a Bankart lesion on the anterior glenoid or a Hill–Sachs lesion on the posterior superior humeral head.

A variety of classification systems for glenohumeral instability have been proposed by various authors throughout the years. However, there is currently no universally accepted classification system for glenohumeral instability. It is difficult to develop a comprehensive classification system for shoulder instability that can define the relevant etiology, mechanism, and pathology in every patient. Furthermore, none of these proposed classifications has undergone validation or reliability testing. Additionally, trying to define the appropriate treatment for each group within a classification has proven to be difficult.

A well-defined classification system for glenohumeral instability should help identify the pathology by the direction of instability, subluxation or dislocation, whether it is traumatic or atraumatic, primary or recurrent, the anatomic structures that are involved, the presence or absence of generalized joint laxity, voluntary or involuntary dislocations, and any underlying collagen or neuromuscular disorder. Furthermore, the classification should provide us with information regarding the natural history and prognosis as it relates to the instability event and offer recommendations regarding the treatment.

Glenohumeral Instability:
FEDS SYSTEM CLASSIFICATION

FREQUENCY—Patient is asked, "How many episodes have you had in the last year?"
a. Solitary—"1 Episode"
b. Occasional—"2 to 5 Episodes"
c. Frequent— ">5 Episodes"

ETIOLOGY—The patient is asked, "Did you have an injury to cause this?"
a. Traumatic—"Yes"
b. Atraumatic—"No"

DIRECTION – The patient is asked, "What direction does the shoulder go out most of the time?"
a. Anterior—"Out the front"
b. Inferior—"Out the bottom"
c. Posterior—"Out the back"

SEVERITY—The patient is asked, "Have you ever needed help getting the shoulder back in joint?"
a. Subluxation—"No"
b. Dislocation—"Yes"

The FEDS (Frequency, Etiology, Dislocation, Severity) classification system for shoulder instability was developed by Dr. Kuhn at the Vanderbilt University Medical Center.[126] This is the only classification developed from a systemic review of the literature to determine which features of instability were used most commonly by the other proposed classifications in the literature for shoulder instability. Of all the criteria, four features were seen in more than 50% of the proposed classification systems: frequency, etiology, direction, and severity. Interestingly, these four features also reflected the results from a survey of the American Shoulder and Elbow Surgeons (ASES). Furthermore, the FEDS system of classification was assessed for both inter-observer and intra-observer agreement between six sports medicine trained physicians in 48 patients with shoulder instability. Intra-observer agreement was 84% to 97% (k 0.69 to 0.87) and inter-observer agreement was 82% to 90% (k 0.44 to 0.76), representing substantial to excellent agreement.[127]

Glenohumeral Instability: OTA CLASSIFICATION

Glenohumeral joint (10-A)
1. Anterior dislocation (10-A1)
2. Posterior dislocation (10-A2)
3. Lateral (theoretical) dislocation (10-A3)
4. Medial (theoretical) dislocation (10-A4)
5. Other (inferior—luxatio erecta) (10-A5)

The Orthopaedic Trauma Association (OTA) classification is based on the direction of instability (Fig. 34-25). The glenohumeral joint is designation 10-A. Anterior dislocation is classified as 1, and thus the OTA classification is 10-A1. For posterior dislocation, it is 2, or 10-A2. Both medial and lateral dislocations are theoretical classifications and not typically seen in clinical dislocations. Inferior dislocation is rare, also termed *luxatio erecta* and classified as 10-A5.

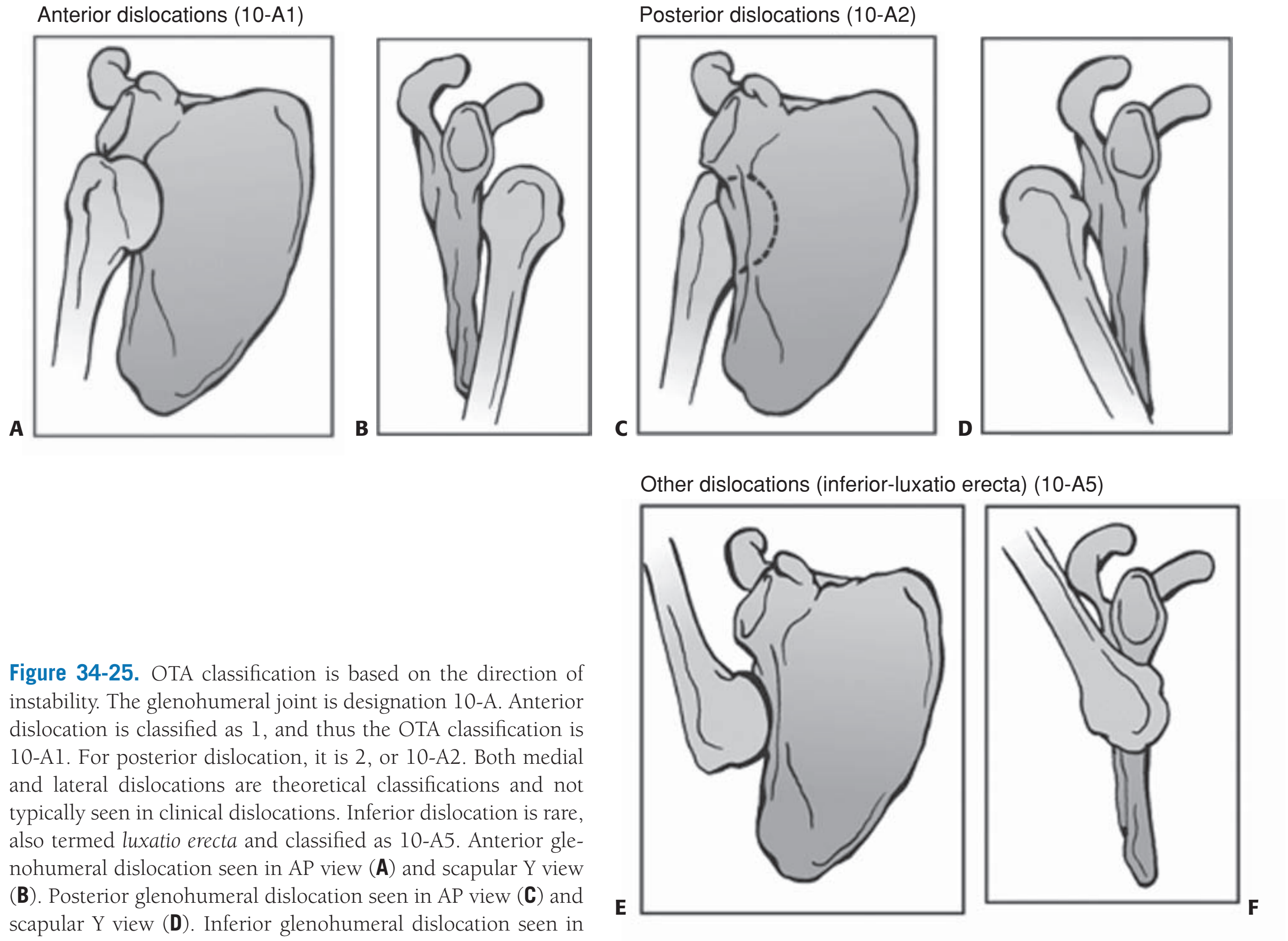


Figure 34-25. OTA classification is based on the direction of instability. The glenohumeral joint is designation 10-A. Anterior dislocation is classified as 1, and thus the OTA classification is 10-A1. For posterior dislocation, it is 2, or 10-A2. Both medial and lateral dislocations are theoretical classifications and not typically seen in clinical dislocations. Inferior dislocation is rare, also termed *luxatio erecta* and classified as 10-A5. Anterior glenohumeral dislocation seen in AP view (**A**) and scapular Y view (**B**). Posterior glenohumeral dislocation seen in AP view (**C**) and scapular Y view (**D**). Inferior glenohumeral dislocation seen in AP view (**E**) and scapular Y view (**F**).

Glenohumeral Instability:
MATSEN AND THOMAS CLASSIFICATION

TUBS
a. Trauma
b. Unidirectional
c. Bankart lesion
d. Surgery

AMBRII
a. Atraumatic
b. Multidirectional
c. Bilateral laxity
d. Rehabilitation
e. If surgery is necessary, then need to tighten
  1. Inferior Capsule
  2. Rotator Interval

Matsen et al.[148] described a simple classification of shoulder instability with two groups of patients with shoulder instability. In their retrospective review of open anterior Bankart repair cases, 97% of their patients had a classic Bankart lesion from a traumatic event. Therefore, their first group is characterized by a history of traumatic event leading to unidirectional shoulder instability. These shoulders are often found to have a tear in the anteroinferior glenohumeral ligament. In the high-risk patients, including male, younger age, or those participating in contact sports, surgical stabilization was recommended after primary dislocation to help prevent recurrent instability and further damage to the intrinsic intraarticular structures of the shoulder. TUBS represents Traumatic Unidirectional Bankart lesion and Surgery. In the second group of patients, there was no history of trauma and they are much more prone to the development of MDI. The first line of treatment in these patients is rehabilitation with the focus on rotator cuff and deltoid strengthening. If surgery is needed, the capsular laxity is managed with a shift done either arthroscopically or open. Both the inferior capsule and the rotator interval are closed during surgery to prevent recurrence of instability in this group of patients. Thus, the term AMBRII was developed for this second group of patients.

Glenohumeral Instability:
STANMORE CLASSIFICATION

Polar type 1—Traumatic and structural
a. Acute
b. Persistent
c. Recurrent

Polar type 2—Atraumatic and structural
a. Recurrent

Polar type 3—Muscle patterning and nonstructural
a. Recurrent
b. Persistent

In the Stanmore classification system (Fig. 34-26), the diagnosis of instability is made on the basis of clinical history, examination, and arthroscopic findings.[133] Additionally, if muscle dysfunction is suspected, electromyography (EMG) testing should be obtained. The authors prefer to present this model of instability with a triangle diagram to highlight the interplay between these three groups. Polar group 1 includes patients who present with a significant traumatic event that is unidirectional and results in a Bankart lesion in the anteroinferior glenoid. Polar group 2 includes patients who experience no history of shoulder trauma with capsular dysfunction and structural damage to either the labrum or the cartilage. Both polar groups 1 and 2 do not have any abnormal muscle patterning on clinical examination or EMG testing. In polar group 3, the patients have no history of trauma and no structural damage to the labrum or glenoid cartilage. They will often have capsular dysfunction with bilateral shoulder presentations. There can be overlap between the three polar groups.

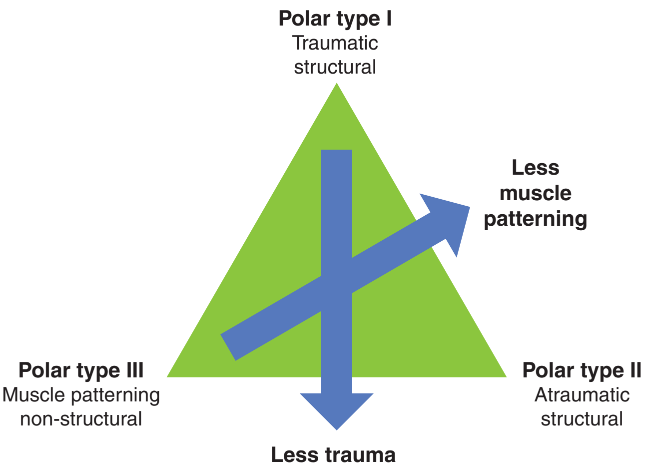


Figure 34-26. Stanmore classification system of shoulder instability; the diagnosis is made on the basis of clinical history, examination, and arthroscopic findings. Polar group 1 contains patients with traumatic event that is unidirectional resulting in a lesion on the MRI images. Polar group 2 patients experience no trauma but present with capsular dysfunction and structural damage to the labrum or cartilage. Group 3 polar patients have no history of trauma or structural damage within the shoulder joint. They typically will present with abnormal muscle patterning on clinical examination or EMG testing.

Glenohumeral Instability:
POSTERIOR INSTABILITY ABC CLASSIFICATION

A (First time)
  A1. Subluxation
  A2. Dislocation

B (Dynamic)
  B1. Functional
  B2. Structural

C (Static)
  C1. Constitutional
  C2. Acquired

The ABC classification of posterior shoulder instability was proposed by Moroder and Scheibel.[159] This system offers a simple yet comprehensive classification of posterior shoulder instability based on underlying pathophysiology, and the authors also proposed treatment methods based on a literature review (Table 34-2). The three main groups, ABC, are based on the type of

TABLE 34-2. ABC Classification of Posterior Dislocation

	A First Time	B Dynamic	C Static
Type 1	Subluxation	Functional	Constitutional
Type 2	Dislocation	Structural	Acquired

instability: first time, dynamic, or static. Group A or first-time traumatic posterior dislocation is further subdivided into subluxation (A1) or dislocation with temporary engagement (A2). In the case of no significant bony or soft tissue defects, conservative management is indicated. Critical humeral head or glenoid defects in patients with locked posterior dislocation (A2) will require either closed or open reduction with possible reconstruction based on the size of the defect. Group B comprises all patients with recurrent dynamic posterior instability that occurs during motion in the form of either functional (B1) or structural (B2) instability. In the functional group, pathologic activation of the rotator cuff muscles and the periscapular musculature results in abnormal posterior-directed forces in addition to underlying hyperlaxity, posterior capsule redundancy, or dysplasia. Conservative management with physical therapy is the recommended treatment method. In the B2 group, patients have dynamic instability with related structural damage including posterior Bankart lesions, glenoid bone loss, or reverse Hill–Sachs lesions. In these patients who have persistent pain after a trial of physical therapy, surgical management addressing the structural defect can provide a good to excellent outcome. Group C patients have chronic static instability by either constitutional structural deficiencies (C1) or acquired structural defects (C2). Surgical options include posterior capsulorrhaphy, bone grafting, glenoid osteotomy, or arthroplasty in the subset of patients with arthritis. These patients are difficult to manage with technically demanding procedures and unpredictable outcomes.

OUTCOME MEASURES FOR GLENOHUMERAL INSTABILITY

Western Ontario Shoulder Instability Index (WOSI)

The WOSI is a validated patient-reported outcome (PRO) tool that was developed in 1998 by Kirkley et al.[121] for the evaluation of the disease-specific quality of life in patients with shoulder instability. Items in the WOSI questionnaire were generated from the World Health Organization definition of health, expert reviews, and literature review as well as patient interviews. It is proven to be a useful outcome measure in several major clinical studies and has been translated and validated in Italian, German, Swedish, and Japanese.[202] The WOSI questionnaire consists of 21 items with each one scored on a 100 mm of Visual Analogue Scale (VAS).[240] There are four total domains to the WOSI with each item falling in to physical function (10 items), sports/recreation/work (4 items), lifestyle (4 items) and emotional well-being (3 items). Every question is scored between 0 and 100 points based on the VAS. The final score can range from 0 (best possible score—normal shoulder) to 2,100 (worse score—signifies extreme distress in shoulder-related quality of life). The test and retest reliability of the WOSI was 0.95 in the English language version and 0.94 in the Swedish language version.[195] The WOSI is widely used in clinical research in patients with shoulder instability and it is more responsive to the treatment of instability than both the ASES and DASH scores as well as the Rowe questionaire.[122,123]

Oxford Instability Shoulder Score (OISS) or Oxford Shoulder Instability Questionnaire (OSIQ)

The OISS or OSIQ was developed by Dawson et al.[54] in 1999 to assess PROs after shoulder instability. Several names and abbreviation have been used synonymously (OISS or OSIQ). The score in the test was generated by patient interviews. The questionnaire comprised 12 items, each of which has a total of five response categories ranked from the least to the most difficult. The items cover episodes of instability, daily activities, pain, work, social life, sports/hobbies, attention to shoulder problems, lifting, and lying positions with a total possible score ranging from 12 (best function) to 60 (worst function).

Melbourne Instability Shoulder Scale (MISS)

The MISS was developed by Watson et al.[257] in 2005 as a new instability-specific, self-administered questionnaire for shoulder instability. All of the items were generated from surgeon discussions, literature review, and patient interviews. These were further ranked based on importance by patients and surgeons, and a 22-item questionnaire was created with four total domains: Pain (4 items), Instability (5 items), Function (8 items), and Occupation/sports (5 items). Each item was scored using a 5-point Likert scale with 0 (worse score) to 100 points (best score). Watson et al.[257] reported the test–retest reliability of the MISS was 0.98 and has a greater range to detect changes in shoulder instability than the global Shoulder Rating Questionnaire (SRQ).

PATHOANATOMY AND APPLIED ANATOMY RELATED TO GLENOHUMERAL INSTABILITY

Anatomically, the shoulder joint is uniquely arranged such that the lack of articular bony contact provides the joint with six degrees of freedom and ROM which makes it more susceptible to dislocation and injury. The shoulder joint relies on both static and dynamic structures that collectively maintain stability through the mid and end ranges of motion. Important static stabilizers include the articular anatomy of the joint with matched concavity and convexity of the ball-in-socket, as well as the glenoid labrum, which broadens and deepens the socket depth (Fig. 34-27). The vacuum seal of the closed joint capsule results in negative intra-articular pressure which may enhance the stabilizing effect of the capsuloligamentous structures. The balance between the static and dynamic stabilizers determines the stability of the shoulder joint. An imbalance among these stabilizing factors may result in instability occurring in the anterior, posterior, or inferior directions or it may be multidirectional in nature.[104,132,149] In addition to the above dynamic

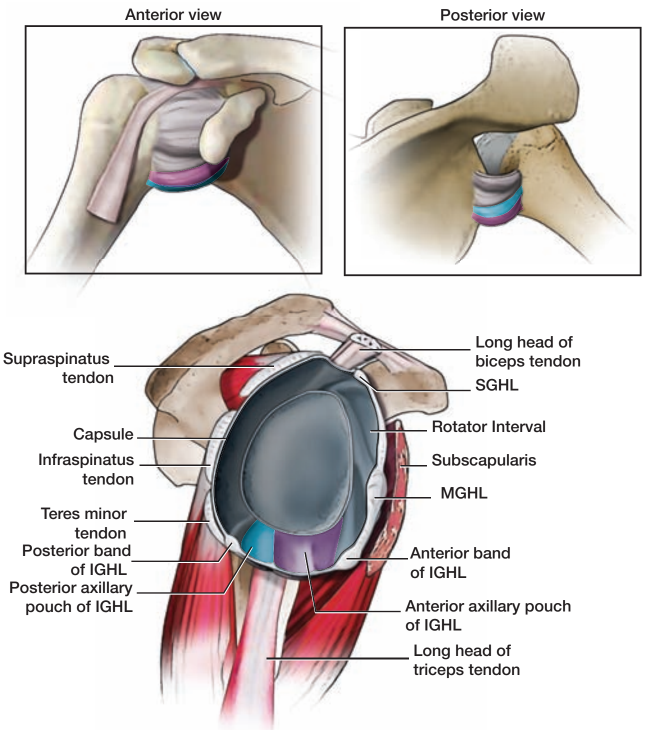


Figure 34-27. The shoulder joint relies on both static and dynamic structures to maintain stability. The anatomy and structures of the glenohumeral joint is illustrated in this image.

and static factors, proprioception also plays a significant role in the pathoetiology of shoulder instability.[251] Proprioception is the perception of motion of the joint, and it is an important mechanism by which the muscles receive a message to contract and guard against instability. A failure of proprioceptive feedback may contribute to instability.

Biomechanically, Warner et al.[249] showed that the primary restraint to inferior translation of the adducted shoulder is the superior glenohumeral ligament (SGHL).[88] With progressive abduction of the arm, the anterior and posterior-inferior GHL became the main static stabilizers in resisting inferior translation. Furthermore, the anterior portion of the inferior GHL was the primary restraint with the arm in 45 degrees of abduction and the posterior portion was the primary restraint with the arm in 90 degrees of abduction. Additionally, Warner et al.[249] also showed that venting of the shoulder capsule resulted in significant inferior translation of the humeral head via the loss of the inferior restraint and the vacuum effect. Thus, the so-called “sulcus sign” is believed to be the result of intra-articular vacuum effect and capsular laxity.

Patients with MDI have demonstrated a loss of proprioception compared with normal controls,[131] further confirming that MDI may play a role in stability. The rotator cuff musculature specifically provides compression of the humeral head against the glenoid.[135] As the glenoid socket is a lateral fossa within the scapula, the ability of the scapulothoracic musculature to position the scapula can either optimize or impair glenohumeral stability. For this reason, scapulothoracic dyskinesia should always be evaluated in patients who present with MDI as these patients can frequently exhibit scapulothoracic dyskinesia.[135] The pathoanatomy of MDI differs from both anterior and posterior instability and typically involves a large, patulous inferior capsule in both the anterior and posterior directions. This significantly increases the volume of the capsule. The extent of involvement of the rotator interval is a topic of debate in patients with MDI. Biomechanical studies on cadavers have demonstrated that the inferior capsule and the rotator interval are the primary restraints to inferior glenohumeral translation.[84,249] The inferior capsule is responsible for resisting inferior translation primarily with arm abduction to 90 degrees, while the rotator interval resists inferior translation with the arm at the side.

STATIC STABILIZERS

Articular Geometry and Concavity

The glenohumeral joint is composed of a large spherical humeral head that articulates with the smaller glenoid surface. The articular geometry contributes minimally to the overall stability of the glenohumeral joint due to the small area of the glenoid surface relative to the large humeral head and the relative mismatch of the bony curvature of the glenoid to the humeral head.[27,200] The shape of the glenoid is smaller superiorly and larger inferiorly, much like a “pear” configuration and produces a significant surface area and radius of curvature mismatch between the joint surfaces of the glenoid and the humeral head. Furthermore, unlike the hip joint, the glenoid does not constrain the humeral head as only up to 25% to 30% of the humeral head is in contact with the glenoid at various shoulder ROM.[220,221] Although the subchondral bone on the glenoid side is flatter than the humeral head, recent studies have demonstrated that the articular surface of the glenoid is highly congruent to the articular surface of the humeral head. Kelkar et al.[115] reported the average radii of curvature of the humeral head and glenoid articular surfaces were 25.5 ± 1.5 mm and 27.2 ± 1.6 mm, respectively. Thus, the mismatch in the articular cartilage in the glenoid and humeral head increases the conformity of the overall glenohumeral joint to within 3 mm. Furthermore, the glenoid concavity is deepened by the labrum that is attached circumferentially around the glenoid on the outer rim.[97] Biomechanical studies have demonstrated that joint conformity contributes more in controlling translation during active motions, whereas capsular constraints become more important during passive motions.[112] In terms of humeral version, there is minimal evidence that abnormal version contributes significantly to glenohumeral instability.[242]

Glenoid Labrum

The labrum is a fibrocartilaginous bumper that forms a circumferential ring around the glenoid and serves as an anchoring point for the capsuloligamentous structures (Fig. 34-27). Attachment to the articular cartilage occurs via a narrow fibrocartilaginous transition zone, but it is otherwise fibrous throughout the entire structure.[97] It is loosely attached superiorly above the equator and significant individual anatomic variability exists in this particular region.[51] In contrast, the anterior-inferior labrum is intimately attached to the glenoid rim and any detachment indicates an abnormality.[132] The essential contribution of the labrum to glenohumeral stability is by deepening the anterior-to-posterior depth of the glenoid socket from 2.5 to 5.0 mm and increasing the glenoid concavity to 9 mm in the superior-to-inferior plane. A loss of the labrum will decrease the overall depth of the socket by up to 50% in all directions.[98] Furthermore, the glenoid labrum increases the surface area for humeral head articulation and increases the excursion distance required for glenohumeral instability.[135,153]

Biomechanical studies have shown that the concavity-compression effect of the labrum is the most effective stabilizing mechanism in resisting tangential forces. With the labrum intact, the humeral head will resist tangential forces of up to 60% of the compressive load. The degree of compression stabilization also varies according to the circumferential location of the glenoid, where the greatest magnitude was observed both superiorly and inferiorly. This effect may be attributed to the greater glenoid-labrum depths in those two particular areas.[135] The average contribution of the labrum to glenohumeral stability through the concavity-compression is around 10%. This contribution also varies according to both arm position and direction of force with increased stability seen in the adducted position and inferior direction, respectively.[83,247]

Another stabilizing effect of the labrum is its contribution to the intra-articular negative pressure of the shoulder. Habermeyer et al.[81] have compared the glenohumeral joint to a piston surrounded by a valve. The labrum works as a valve block that seals the joint from atmospheric pressure. Traction of the arm in a stable shoulder with an intact labrum results in negative pressure that correlates with the amount of forces exerted. In contrast, in the unstable shoulder with detachment of the anterior-inferior labrum, the above phenomenon does not exist, and thus the piston and valve model is not valid. Absence of negative joint pressure will disturb both joint mechanics and the proprioception receptors that control motor feedback which stabilizes the shoulder dynamically from dislocating forces.

Capsule and Glenohumeral Ligaments

The shoulder capsule has about twice the surface area of the humeral head and allows for freedom of shoulder ROM.[149] The anterior capsule is thicker than the posterior capsule. Ciccone et al.[45] found that the anterior shoulder capsule averaged 2.42 mm, inferior capsule averaged 2.8 mm, and posterior capsule averaged at 2.2 mm thick. These distinct thickenings in the anterior capsule are called glenohumeral ligaments (GHLs) and play an important role in shoulder stability. Early cadaver studies have evaluated the role and function of these ligaments, comprising the SGHL, the middle glenohumeral ligament (MGHL), and the inferior glenohumeral ligament (IGHL). Each of these is further separated into anterior and posterior components. With rotation of the arm, specific ligaments tighten while others loosen. In the mid-ranges of motion (everyday activities), the capsule and GH ligaments are in a lax state, and therefore do not contribute significantly to shoulder stability. However, at the extremes of ROM, different GH ligaments will tighten according to the specific position of the arm and control humeral head translation to provide stability.[132,149] The following subsections will discuss the contributions of each GHL to shoulder stability.

Rotator Interval and Superior Glenohumeral Ligament

The "rotator interval" is a region that is between the superior border of the subscapularis tendon and the anterior border of the supraspinatus tendon. The two ligaments found within the rotator interval are the SGHL and the coracohumeral ligament (CHL).[37] The CHL is a dense fibrous structure that extends from the lateral aspect of the coracoid to the greater and lesser tuberosity of the humerus just adjacent to the bicipital groove.[111] Some investigators have demonstrated the CHL as a thin capsular fold without any ligamentous form,[52] while others have suggested that the CHL may represent an accessory insertion of the pectoralis minor tendon.[169]

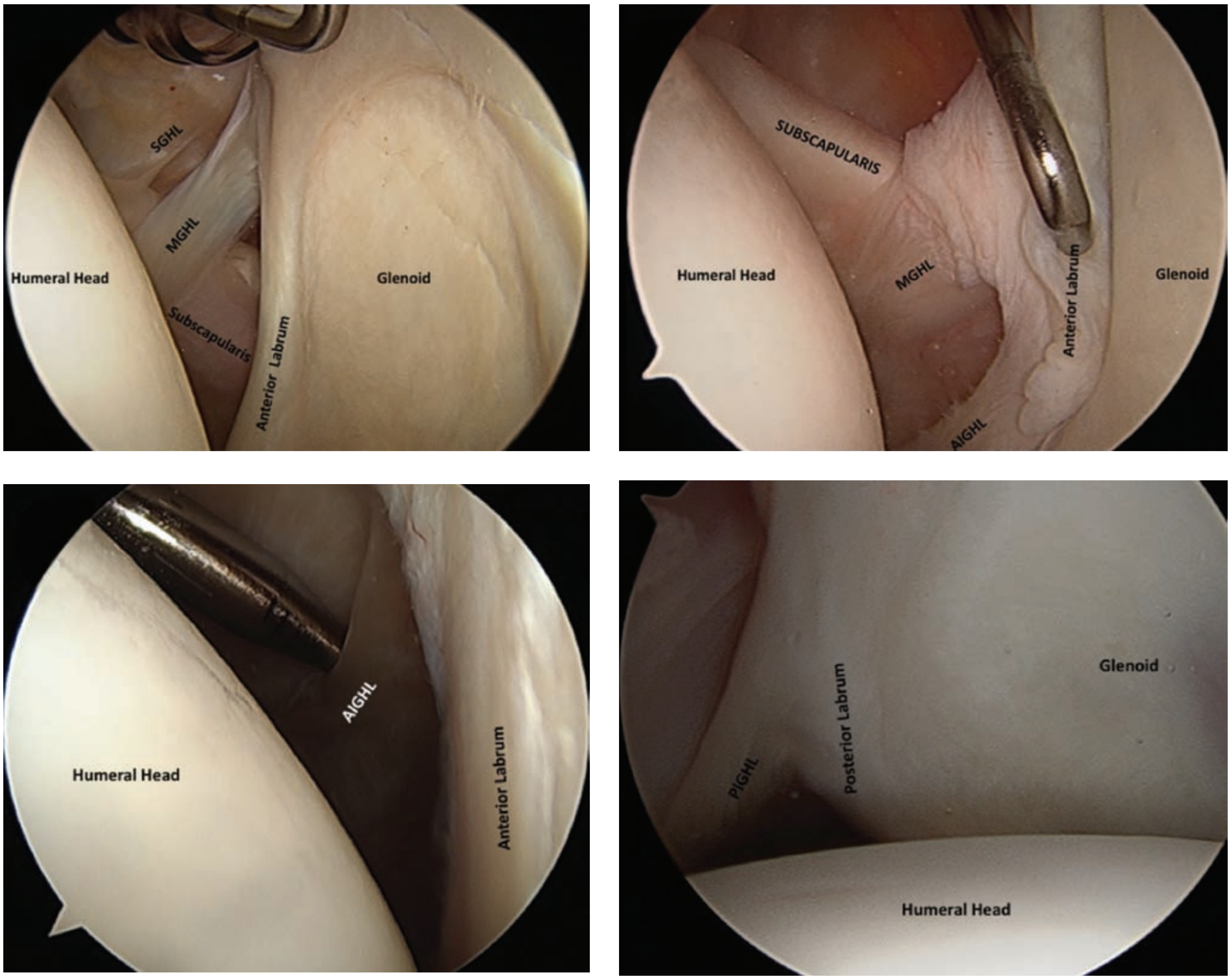
The SGHL originates from the supraglenoid tubercle anteroinferior to the origin of the long head of the biceps tendon and inserts onto the humerus on the proximal tip of the lesser tuberosity. Significant variations in the size and shape of the SGHL exist between individuals. The CHL and SGHL run parallel to each other in the rotator interval to limit inferior translation and external rotation in the adducted arm position or posterior translation with the arm in flexion, adduction, and internal rotation.[132,149] Furthermore, deficiency or injury to the rotator interval may result in MDI, while contracture in this region may limit external rotation and forward flexion.[102,103,167]

Middle Glenohumeral Ligament

The MGHL has the greatest variation among individuals and is absent in up to 30% of cases and is poorly defined in another 10%.[60,248,249] It originates from the superior glenoid just inferior to the SGHL between the 1 and 3 o'clock position and blends in with the subscapularis tendon as its insertion approximately 2 cm medial to the lesser tuberosity (Fig. 34-28A).[30,234] There are two variations to the MGHL that include a sheet-like structure that is confluent with the anterior band of the IGHL or a cord-like structure with a foraminal separation from the IGHL called a "Buford" complex.[231,264] The MGHL primarily limits anterior humeral head translation with the arm abducted to 45 degrees and externally rotated. When the arm is in the adducted position, the MGHL functions to limit external rotation and inferior translation.[149,172,234]

Inferior Glenohumeral Ligament Complex

The IGHLC is a hammock-like structure that originates from the anterior-inferior glenoid rim and labrum to insert below the MGHL on the inferior margin of the humeral articular surface and anatomic neck (Fig. 34-28B). The IGHLC is divided into three main components: a thick anterior band (Fig. 34-28B, *star*), a thinner posterior band, and the interposed axillary pouch between the two bands.[248] The IGHLC functions to support the humeral head and prevent translation when the arm is in the abducted position.[170] Global stability requires the function of all three components of the IGHLC. With abduction and external rotation of the arm, the entire complex becomes



A

C

Figure 34-28. **A:** Arthroscopic view of the shoulder shows the superior glenohumeral ligament (SGHL), middle glenohumeral ligament (MGHL) anterior labrum, and the subscapularis tendon. **B:** Alternative arthroscopic view showing the MGHL, anterior inferior band of the IGHL (AIGHL), and subscapularis muscle. **C:** Close arthroscopic view of the AIGHL and anterior labrum. **D:** Posterior view of the posterior labrum and posterior inferior glenohumeral ligament (PIGHL).

taut and moves beneath the humeral head to prevent anterior translation. However, with internal rotation and abduction, the IGHLC functions to limit posterior translation.[132,149]

DYNAMIC STABILIZERS

Rotator Cuff Musculature and Biceps Tendon

The rotator cuff musculature is comprised of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles. Contribution of the rotator cuff muscle group to glenohumeral stability occurs through three distinct mechanisms: (1) joint compression, (2) coordinated contraction of the rotator cuff muscle to guide the humeral head onto the center of the glenoid, and (3) dynamization of the glenohumeral ligament with shoulder ROM through the rotator cuff attachments.[200,229,248,268,270] Lippitt et al.[135] first described the effect of "concavity-compression" where compression of the humeral head into the glenoid cavity stabilizes it against translating forces (Fig. 34-29). Stability was greater in the hanging arm position compared with arm abduction-external rotation under the concavity-compression mechanism.[83] This indicates that the effect of concavity-compression may be an important stabilizer of the glenohumeral joint in the mid-ranges of motion when the capsuloligamentous structures are lax. When the arm is in the extremes of motion, the capsuloligament structures are stretched to enhance their contribution to stability. Warner et al.[252] further demonstrated that rotator cuff muscle strength differs in patients with shoulder instability compared to normal. McMahon et al.[150] have also shown significantly reduced EMG activity in the supraspinatus muscle from 30 to 60 degrees of abduction in patients with anterior shoulder instability. In a dynamic shoulder model, 50% reduction in the rotator cuff forces resulted in increased anterior displacement by 46% and posterior displacement by 31%.[268]

Figure 34-29. The rotator cuff muscle is responsible for the "concavity compression" in which activation of the rotator cuff results in compression of the humeral head into the glenoid cavity and stabilizing it against translational forces.

Many investigators have studied the contribution of the biceps tendon to glenohumeral stability. The origin of the long head of the biceps tendon arises directly from both the supraglenoid tubercle and the superior glenoid labrum. Most of the attachment on the labrum is posterior in orientation.[238] Itoi et al.[106] evaluated the stabilizing effect of the biceps tendon in a cadaver model and found that both the long and short heads of the biceps have similar roles in preventing anterior shoulder instability with the arm in abduction and external rotation. Their role is further increased as the intrinsic shoulder stability decreases (capsule tear or Bankart lesion). Furthermore, the biceps becomes more important than the subscapularis in anterior stability as the stability from the capsuloligamentous structures decreases.[108]

DELTOID MUSCULATURE

The deltoid muscle is a large triangular, bulky muscle which contributes to approximately 20% of all shoulder muscles and comprises three portions, anterior, middle, and posterior.[15] Morrey et al.[160] proposed the four essential muscle dynamic stabilizing effects contributing to shoulder stability. This includes passive tension from the muscle bulk, muscle contraction that results in compression of the humeral head on the articular surface, joint motion that tightens the passive ligaments of the shoulder, and the barrier effect of the contracted muscle. Using a dynamic stability index, Lee and An[129] demonstrated that the middle and posterior deltoid provided more stability by generating greater compressive forces and lower shear forces than the anterior deltoid. Furthermore, the deltoid muscle produces more compressive force when the arm is elevated compared to the neutral position. With the arm in external rotation, the insertion of the deltoid moves more posteriorly in relation to the glenohumeral joint, and thus contraction at this position will produce a posteriorly directed compressive force and tensioning to reduce anterior instability. Kido et al.[117] also showed that with the capsule intact, anterior displacement is significantly reduced by application of load to the middle deltoid. However, with a simulated Bankart lesion, loading of each muscle portion significantly reduced anterior displacement. Thus, the stabilizing function of the deltoid becomes more essential as the shoulder becomes unstable.

PROPRIOCEPTION

Placement of the upper extremity and hand in space for daily function is dependent on the perception of the shoulder joint position in space and during motion. Capsule and ligaments function in joint stabilization by providing neurologic feedback that directly mediates joint position sensibility and muscle reflex stabilization. This sensory modality is called proprioception and is mediated by receptors in the muscular and cutaneous structures of the shoulder joint. Specialized nerve endings and proprioceptive mechanoreceptors (Pacinian corpuscles, Ruffini endings, Golgi tendon endings, etc.) have been shown to exist in the capsule and ligaments.[82,237] Stimulation of these mechanoreceptors results in muscle contraction around the joint that in turn results in compressional forces which function as an adaptive control for joint stabilization to counteract sudden movements in acceleration or deceleration.[251] It has been hypothesized that the receptors in the joint capsule respond to extremes in ROM or deep pressure that may occur because of glenohumeral translation.[46,77,78]

Both Warner et al.[251] and Lephart et al.[131] have shown that the proprioception of the shoulder joint is disrupted in patients with glenohumeral instability compared to the asymptomatic shoulders. Zuckerman et al.[280] reported that patients after open anterior stabilization procedure had 50% improvement of proprioceptive ability at the 6 months postsurgery time. This improved to 100% or similar to the contralateral shoulder at the one-year mark. Overall, the literature suggests that patients with recurrent shoulder instability will have a perceivable deficit in glenohumeral proprioception, which can be restored to normal after surgical repair or reconstruction. Capsuloligamentous structures may provide additional contributions to shoulder stability by providing the afferent feedback to reflexive muscle contraction of the rotator cuff, biceps, or deltoid.

TREATMENT OPTIONS FOR GLENOHUMERAL INSTABILITY

Treatment of shoulder instability requires a thorough understanding of the natural history. Most of the available literature documenting the natural history of shoulder instability focuses on anterior instability. Operative treatment as well as nonoperative treatment of anterior shoulder instability has been well studied, especially in young athletic populations. Controversy remains over the initial treatment of a patient who experiences a first-time anterior shoulder dislocation with surgical treatment often recommended for young, athletic patients to reduce risk of recurrent instability and further damage to the intra-articular structures.[8,26,56,262]

The initial treatment for posterior instability can be more complex as patients often do not present with classic instability signs and symptoms. Initial treatment in this population depends on the severity of injury and the extent of symptoms. Patients who are experiencing posterior pain without true instability are often managed nonoperatively initially, with surgical intervention being reserved for those who fail conservative therapy or present with frank posterior instability or recurrence of symptoms. Patients who present with MDI are initially treated nonoperatively with a focus on intense physical therapy to strengthen the rotator cuff, deltoid, and periscapular musculature. Surgical intervention in these patients should only be considered if they fail to improve after a lengthy course of glenohumeral and scapular stabilization therapy.

NONOPERATIVE TREATMENT OF GLENOHUMERAL INSTABILITY

The outcomes of nonoperative treatment of anterior shoulder instability are variable, and depend significantly on patient age. Hovelius et al.[92] published a landmark article in which they described long-term follow-up in 257 first-time anterior shoulder dislocations in patients less than 40 years old. They found that approximately two-thirds of patients had shoulder arthritis at a mean of 25 years follow-up. Additionally, almost half of patients less than 25 years old required eventual surgical stabilization. Robinson et al.[192] prospectively followed 252 patients under 35 years old who sustained an anterior glenohumeral dislocation and were treated with sling immobilization, followed by a physical therapy program. Recurrent instability developed in 55.7% of the shoulders within the first 2 years and increased to 66.8% at 5-year follow-up. They found younger male patients to be at greatest risk for recurrent anterior instability. Simonet et al. tracked the natural history of nonoperatively treated anterior instability in 116 patients at a mean of 4.6 years follow-up, and they documented an overall 33% rate of recurrent instability. When further stratified by age, they found that patients less than 20 years old had a 66% rate of recurrence. They also discovered that 82% of athletes sustained a recurrent dislocation versus 30% among patients not involved in athletics.[215,216] Henry et al. studied the natural history of 121 young athletes, mean age 19 years old, treated nonoperatively for an acute, first-time traumatic anterior shoulder dislocation. One hundred and six patients (88%) sustained a recurrent dislocation, and all repeat injuries occurred prior to 18 months after the initial instability event.[86] A recent meta-analysis pooled the results of 15 level I and II studies to determine the natural history of nonoperatively treated traumatic anterior shoulder instability. In this study, the authors identified an overall 21% recurrence rate, with a rate approaching 80% for males less than 20 years old.[255]

The literature on nonsurgical treatment of patients with either posterior instability or MDI is not as extensive as anterior glenohumeral instability. Posterior glenohumeral instability can present with patients complaining of posterior subluxation or dislocation due to a high-energy injury or, more commonly, vague posterior pain without symptoms of overt instability.[196] Arriving at the correct diagnosis in these cases can be difficult and delayed or even missed.[184] As with most injuries, the treatment is focused on reducing pain and symptoms while improving function. Unlike anterior glenohumeral instability, the natural history of a first-time posterior instability event is not well understood and risk factors for recurrent instability have not been well defined. Nonoperative management begins with immobilization until the patients have enough pain resolution to begin a physical therapy program. Activities that cause posterior pain or the sensation of instability should be avoided, and rotator cuff strengthening should be initiated once patients are able to tolerate this activity. Rehabilitation protocols should also focus on proprioception training as well as strengthening of the rotator cuff and scapulothoracic musculature. Large series of patients demonstrating successful nonoperative treatment of posterior instability are lacking.

Although there are no strict criteria to define MDI, it was first described as anterior and posterior instability associated with involuntary instability events[163] or instability in more than one direction.[5,10,162] Although this can occur with a large, traumatic labral tear, this terminology is generally used to describe injuries that occur after repetitive microtrauma. The acronyms TUBS (traumatic, unilateral, Bankart lesion, surgery) and AMBRI (atraumatic, multidirectional, bilateral, rehabilitation, inferior capsular shift) have been used historically to differentiate MDI from traumatic anterior or posterior labral tears. These acronyms do not serve to classify instability or differentiate pathology that dictates treatment options and, as such, are not utilized as commonly in recent literature. As MDI represents a spectrum of injuries superimposed on a spectrum of laxity, the clinical presentation can vary widely. The goal of treatment in these patients is to restore stability of the joint and decrease pain. For most patients, this is accomplished through nonoperative means with physical therapy, patient education, and avoidance of aggravating activities.

There are certain patient factors that may predict success with nonoperative management of anterior shoulder instability. As mentioned previously, the biggest indicator for a likely recurrent instability event following an anterior glenohumeral dislocation is age. Competitive contact or collision sport athletics is another patient factor that carries a high risk of recurrent instability. Therefore, older,[192] nonathletic[215,216] patients are identified as the group who have the highest success rate with nonoperative treatment after the primary subluxation or dislocation event. Increasing age as a positive prognostic factor is not indefinite, as older patients have a higher risk of having a concomitant glenoid rim fracture (bony Bankart) or a rotator cuff tear that may also require surgical intervention. Although the high-end of the age group that may fare well without surgery is difficult to define, age greater than 25 to 35 appears to be the low-end of this age range.[91,92,192]

Conversely, there are patient-specific factors that lead to a high rate of recurrent instability even following surgery. These factors were originally described by Balg and Boileau[11] and consist of age below 20 years, glenoid bone loss, humeral bone loss, frequent or advanced sports participation, collision sport participation, and the presence of shoulder hyperlaxity. The classification system is termed the Instability Severity Index Score (ISIS). Each of the above criteria is worth 2 points if present with the exception of type of sport and presence of shoulder hyperlaxity which are each worth 1 for a total of 10 points (Table 34-3). The authors found that patients with scores above 6 had a 70% chance of recurrent dislocation after a soft tissue repair, and, they favored a bony stability surgery in these individuals. With this scoring system (ISIS), Phadnis et al.[182] found in their series that a score of 4 or higher was associated with a 70% risk of failure. These studies also demonstrate high rates of recurrent instability even following surgery in young, competitive athletes who have glenoid or humeral bone loss; thus, these patients should not be routinely treated with conservative management.

Along with determining which patients are best served with nonoperative treatment, it is also important for clinicians to realize situations in which nonoperative treatment should not be recommended as a primary treatment option in patients presenting with glenohumeral instability, including age below 30 years, contact sports, recurrent instability, inability to adequately and safely perform job duties, or sport, and significant humeral or glenoid bone loss where further instability is imminent and/or progressive loss is inevitable.[34]

TABLE 34-3. Instability Severity Index Score

Prognostic Factors	Points
Age at Surgery	
≤20 yr	2
>20 yr	0
Degree of Sports Participation (Preoperatively)	
Competitive	2
Recreational or none	0
Type of Sports (Preoperatively)	
Contact or overhead	1
Other	0
Shoulder Hyperlaxity	
Hyperlaxity (ER > 90) anterior or inferior	1
Normal	0
Hill–Sachs on AP Radiograph	
Visible on external rotation	2
Not visible on external rotation	0
Glenoid Loss of Contour on True AP Radiograph	
Loss of contour or glenoid bone loss	2
No glenoid bone loss	0
Total points	**10**

Indications/Contraindications

Nonoperative Treatment of Glenohumeral Instability:
INDICATIONS AND CONTRAINDICATIONS

Indications	Relative Contraindications
• First-time subluxators or dislocators (anterior or posterior) without significant glenoid or humeral bone defect • Patients greater than 30 years of age and low demand • Patients who do not engage in athletics • Patients with MDI • Voluntary dislocators	• Demonstrated recurrent instability (subluxation or dislocation) • Instability with glenoid bone loss • Instability with engaging humeral bony defect • Primary dislocators that are young (<30), male, and play high-demand or contact sports • Bony Bankart lesions • Instability with sleep or lower levels of shoulder ROM

Outcomes

Multiple reports with Level I–IV evidence have reported the results of nonoperative treatment with regard to anterior glenohumeral instability. Henry and Genung[86] reported on the outcome of nonoperative treatment of 120 athletes with shoulder instability who averaged 19 years of age. Patients were divided into an immobilization group consisting of a sling and swathe for 3 to 6 weeks or to a no-immobilization group. There was an exceedingly high failure rate in both groups. After 18 months follow-up, there was a 90% recurrence in the immobilized patients and an 85% recurrence in the nonimmobilized group. The length of immobilization did not affect the recurrence rate and 79/120 (66%) patients ultimately received surgery for a recurrent dislocation. This was one of the first reports that concluded that young athletes should receive special consideration for surgical intervention after a first-time dislocation given the high recurrence rate.

Simonet et al. tracked the natural history of nonoperatively treated anterior glenohumeral instability in 116 patients at a mean 4.6 years follow-up. They documented an overall 33% rate of recurrent instability. Patients less than 20 years old had a 66% rate of recurrence. Athletes had a higher rate of sustaining a recurrent dislocation (82%) versus nonathletes (30%).[215,216] Wheeler et al. evaluated military cadets who were treated with either arthroscopic repair (9 patients) or nonoperative treatment (38 patients) at an average of 14 months.[262] They found a recurrence rate of 92% in the nonoperatively treated group compared with a 22% recurrence rate in the patients who had stabilization surgery. Military cadets were further evaluated by Arciero et al.[8] with either arthroscopic repair and rehabilitation (21 patients) or 1 month of immobilization followed by rehabilitation with a goal of returning to full activity by 4 months. They also found a substantial difference between the two groups with an 80% recurrence rate in the nonoperative group and a 14% recurrence rate in the operative group at an average follow-up of almost 3 years.

Bottoni et al.[26] performed a randomized controlled trial comparing nonoperative sling management versus early arthroscopic Bankart repair for young athletes with first-time anterior shoulder dislocations. At an average 36-months follow-up, 75% of patients treated nonoperatively had recurrent instability versus 11.1% in the arthroscopic stabilization group. Robinson et al.[192] prospectively followed 252 patients less than 35 years old, who sustained an anterior glenohumeral dislocation. Patients were treated with sling immobilization followed by a physical therapy program. Recurrent instability developed in 55.7% of the shoulders within the first 2 years and increased to 66.8% at 5-year follow-up. Younger male patients were most at risk of recurrent anterior instability. Jakobsen et al.[110] evaluated patients, although not specifically athletes, aged 15 to 39 years after a first-time anterior shoulder dislocation. Patients underwent arthroscopy to characterize the labral damage and then were randomized to nonoperative treatment versus open Bankart repair. Patients then went through an identical rehabilitation program consisting of a sling for 1 week and then initiation of motion. After 8 years of follow-up, 74% of patients who were treated without surgical repair had unsatisfactory results, whereas 72% of surgically repaired patients had good or excellent results.

Itoi et al.[109] popularized the idea of external rotation bracing for the management of patients with acute anterior shoulder dislocation. In an MRI study, Itoi et al.[109] reported that immobilization of the arm in external rotation better approximates the Bankart lesion to the glenoid neck than does the conventional position of internal rotation. A subsequent prospective clinical study of 40 patients with acute shoulder dislocations immobilized in either internal or external rotation showed a significant difference in the rate of recurrence in patients under the age of 30 years. In the external rotation group, the recurrence rate was 0% compared to the internal rotation group of 45% with a mean follow-up of 15.5 months.[105] However, several recent trials have shown no difference in the recurrence rates based on the type of immobilization. In a meta-analysis of randomized controlled trials evaluating immobilization in external rotation versus internal rotation after primary anterior shoulder instability in 632 patients, the authors found no significant difference in the recurrence rate, rate of compliance, and in the patient's own perceptions of their health-related quality of life.[263]

Outcomes of nonoperative treatment in patients with MDI have been reported by several authors. Burkhead and Rockwood initially reported a specific physical therapy program for patients with MDI.[33] Of the 66 patients diagnosed with MDI after an atraumatic subluxation, 53 (80%) had successful nonoperative treatment. Misamore et al. evaluated the long-term outcomes of patients with MDI treated with a nonoperative physical therapy regimen.[155] The mean age at presentation was 18.6 years and almost all of the patients participated in athletics. Of the initial 59 patients, 20 underwent surgery by the 2-year mark. Of the remaining 39 patients, 19 continued to complain of significant pain and 18 continued to experience significant instability. Patients were followed until the 7- to 10-year mark, at which 17 of the original 59 had a satisfactory outcome. They concluded a poor response to nonoperative treatment of MDI in this young, athletic population. Ide et al.[101] reported on 46 patients, mean age of 20 years old, with MDI who were treated with an 8-week shoulder-strengthening exercise program as well as an orthosis for scapular stabilization. They found improved outcome scores and improved mean peak torque of internal and external rotations. After a mean follow-up of 7 years, only 3/46 patients (6%) underwent surgical treatment.

Randomized studies are difficult to perform on this patient population as it is universally accepted that nonoperative methods should be the initial treatment in all MDI patients. Certain studies have looked at the outcome of surgically treated patients versus those who have solely undergone physical therapy[124]; however, there are inherent biases in these studies, and it is difficult to ascertain how the information can be applied to current practice.

OPERATIVE TREATMENT OF GLENOHUMERAL INSTABILITY

Early surgical stabilization after traumatic anterior shoulder instability injuries has been shown to reduce the frequency of recurrent instability and improve functional outcome in young individuals engaged in physical activities.[118,123] The overall goal of surgical treatment for anterior shoulder instability is to restore glenohumeral stability through either repair of the capsuloligamentous complex and/or enhanced stability through bony augmentation in cases of significant anterior glenoid deficiency.

Open Bankart repair was previously considered the gold standard for treatment of traumatic anterior shoulder instability with recurrence rates of typically less than 10%.[40,90,165,197] The advantages of open surgery include a more secure repair, a greater ability to reduce capsular redundancy, and achieving adequate tension of the capsuloligamentous complex, which may be challenging in chronic instability cases.[39] The known disadvantages of open Bankart repair include restriction of glenohumeral motion following surgery, particularly external rotation, which may lead to secondary arthritis and muscle weakness.[40,90,191,197,244]

As a result of the potential morbidity involved in open Bankart repair and improvement in implant and instrumentation, arthroscopic Bankart repair has supplanted open repair as the treatment of choice for most common anterior instability injuries.[177,276] Arthroscopic Bankart repairs are increasingly performed. An assessment of the 2004 to 2009 U.S. national insurance database showed that arthroscopic Bankart repairs accounted for 84% of shoulder stabilization surgeries.[276] Arthroscopic Bankart repair can minimize much of the morbidity associated with open surgery such as subscapularis weakness with possible rupture and arthrofibrosis. Modern techniques utilizing suture anchors and capsular plication have achieved recurrence rates similar to open repairs of 8% to 11% in selected patients. In addition to paying attention to the technical aspects of the arthroscopic repair, patient selection, including careful consideration of patient and injury characteristics (i.e., chronicity, number of dislocations, capsular insufficiency, and bony deficiencies), is paramount to achieving success with arthroscopic surgery.[22,73,130,180,209,254] It is important to remember that while arthroscopic Bankart repair is suitable for most patients with anterior instability, there are certain factors that should prompt consideration of an open or bony procedure.

ANTERIOR GLENOHUMERAL INSTABILITY

Indications/Contraindications

Operative Treatment of Anterior Glenohumeral Instability: INDICATIONS AND CONTRAINDICATIONS

Indications	Relative Contraindications
• Patients who have more than one shoulder subluxation or dislocation with anterior labral detachment (Bankart lesion) • Recurrent anterior shoulder instability despite adequate conservative treatment including physical therapy • Anterior locked dislocation with failed closed reduction under anesthesia will require open reduction • High-risk athletes (i.e., contact or overhead athletes) who sustain a traumatic first-time dislocation with document Bankart lesion on MRI (relative indication)	• Uncooperative or medically unstable patient including active seizure disorder • Presence of capsular deficiency or history of thermal capsulorrhaphy • Patients with primary collagen disorders (Ehlers–Danlos or Marfan syndrome) • Patients who have atraumatic shoulder instability and have evidence of ligamentous laxity on examination or patients who are voluntary dislocators • Patient with neurologic injury resulting in paralysis of the axillary or suprascapular nerve • Patients with recurrent instability in the setting of active infection or several posttraumatic arthritis

The importance of recognition and quantification of Hill–Sachs lesions and glenoid bone loss in treatment consideration for traumatic anterior shoulder instability and failed instability surgery is growing.[138,209] As a result, there is a resurgence of bony augmentation procedures such as coracoid transfer (Latarjet, Bristow) and autogenous or allogenic bone block procedures for treatment of anterior shoulder instability. In the following sections, we will discuss the operative treatment decision algorithm, operative approach and techniques, and outcomes of open and arthroscopic Bankart repair and bony augmentation for treatment of traumatic anterior instability.

There are many studies on the management of anterior shoulder instability in the adult patient population. However, a paucity of literature exists regarding shoulder dislocations in skeletally immature patients. The presence of open proximal humeral physis changes the management of these patients with primary shoulder dislocations. Recent literature shows a relatively low rate of recurrent instability after the primary dislocation compared with older literature. The authors recommended conservative management in this subset of patients after primary dislocation. Surgery should only be indicated after a prolonged trial of therapy or with recurrence of instability.[134]

Arthroscopic Anterior Labral (Bankart) Repair

Preoperative Planning

✔ Arthroscopic Anterior Labral (Bankart) Repair: PREOPERATIVE PLANNING CHECKLIST

OR table	❑ Regular OR table with rails that allows placement of the arm traction apparatus ❑ Beach chair table with arm holder
Position/positioning aids	❑ Lateral decubitus or beach chair
Equipment	❑ 30 and 70 degrees arthroscope ❑ 6- and 8-mm threaded cannulas ❑ Labral elevator and CoVator ❑ Curved passer (Mitek Ideal 45 degrees with Chia) ❑ Anchors loaded with sutures and labral tape ❑ Drill and drill guide (2.9-mm drill bit) ❑ Ring grasper and regular grasper

Both radiographs and advanced imaging should be obtained prior to surgery. MRA is both more sensitive and specific than MRI for the detection of anteroinferior labral tears. The amount of glenoid bone loss must be assessed prior to indication for arthroscopic Bankart repair. The critical bone loss that changes the indication from arthroscopic Bankart repair to a bone procedure is between 13.5% and 17.3% according to the literature. In the subset of patients who are at higher risk for recurrent instability (male, young, contact sports, etc.), a bone-based procedure at the primary surgery should be considered at the lower range of the critical defect size (13.5%), whereas in low-demand patients, 17.3% critical bone loss is the critical threshold between an arthroscopic procedure and an open bone procedure.

Positioning

The patient is set up either in the lateral decubitus or beach chair position depending on the surgeon's training and preference. In the lateral decubitus position, the patient is intubated and placed lateral on a bean bag. A pillow is placed under the leg to protect the common peroneal nerve. The operative extremity is prepped and placed in an arm holder with Coband to allow for traction. A balanced traction with 5 to 10 lb of weight is used with traction and lateral distraction (Fig. 34-30A). Additionally, a small bump can be placed underneath the axilla to help further distract the glenohumeral joint to allow for improved visualization. The beach chair set up starts with the patient intubated and a head holder is placed. A bump is placed underneath the body and the patient is sat up to approximately 70 to 80 degrees of flexion. The affected arm is placed in a spider arm holder, which allows for positioning throughout the case. As with the lateral decubitus position, a small bump can be

A, B

Figure 34-30. **A:** Lateral decubitus position for arthroscopic Bankart repair. Balance traction of the glenohumeral joint is obtained with both distraction and traction. Additionally, a small bump is placed under the axilla to help further distract the joint (*arrow*). **B:** Posterior viewing portal (*arrow*) and posterior lateral accessory portal (*circle*) used for drilling and placement of anchors for posterior labral repair. This portal must be in line or parallel with the spine of the scapula. **C:** Anterior inferior portal (*arrow*) used for suture passage and also drilling and anchor placement. Anterior superolateral accessory portal (*circle*) used for suture management and shuttling. This portal must be placed slightly under the lateral edge of the acromion so that it is spaced away from the anterior inferior portal.

placed underneath the axilla to help further distract the glenohumeral joint to allow for better visualization. The authors prefer the lateral decubitus position over the beach chair position for arthroscopic labral repair.

Surgical Approach

A posterior portal is placed approximately 2 cm below and 1 cm over from the posterior lateral edge of the acromion (Fig. 34-30B, *arrow*). The trochar is inserted toward the coracoid and in between the glenohumeral joint. A 30-degree scope is used to start the diagnostic arthroscopy. Complete evaluation of the glenohumeral joint is needed to identify any pathology to the labrum, cartilage, rotator cuff, humeral head, and other intra-articular structures within the glenohumeral joint. Two portals are established anteriorly with one as the working portal and the other as the drilling portal (Fig. 34-30C). The anterolateral portal is established with the assistance of a spinal needle and located within 1 cm of the anterolateral edge of the acromion (Fig. 34-30C, *circle*). This portal is right next to the anterior leading edge of the supraspinatus tendon over the biceps tendon. The anteroinferior or the 5:30 portal is also established with the assistance of a spinal needle placed right over the tendon of the subscapularis muscle and slightly above the glenoid fossa to allow for drilling and suture passing across the labrum (Fig. 34-30C, *arrow*). This portal must have a diameter with a large enough cannula (8 mm) to accommodate the curved passer. We prefer to use the metal passer that is 45 degrees which requires an 8-mm cannula. A right curved passer is used when the affected side is the right shoulder and vice versa. In the setting of associated posterior labral tear, the viewing is switched to the anterior portal and the working portal is posterior. It is essential that the accessory posterior lateral portal used for drilling and insertion of the anchor is in line with the spine of the scapula (Fig. 34-30B, *circle*). Otherwise, the anchor may penetrate the glenoid fossa.

Technique

✔ Arthroscopic Anterior Labral (Bankart) Repair: KEY SURGICAL STEPS

- ❑ Lateral decubitus or beach chair position
- ❑ Examination under anesthesia
- ❑ Establish posterior viewing portal
- ❑ Diagnostic scoping
- ❑ Establish anterolateral and anteroinferior portals
- ❑ Mobilize the anteroinferior capsulolabral off the glenoid rim
- ❑ Penetrate the capsule using a curved passer to allow shifting and mobilization of the capsulolabral complex
- ❑ Position first anchor low on the glenoid face and pass labral tape
- ❑ Cut the passed labral tape down to the rim of the glenoid
- ❑ The same steps are repeated with two to three additional passages of the passer, labral tape, and fixation of the Bankart lesion to the anterior glenoid rim
- ❑ Create a bumper at the end of the case that shows excellent shift of the anterior-inferior capsulolabral complex
- ❑ Insert scope into the anterolateral portal to evaluate the repair
- ❑ Place patient in a sling with abduction pillow
- ❑ Follow standard postoperative protocol

The lateral decubitus (Fig. 34-30A) or beach chair position is used. (The authors prefer lateral decubitus positioning due to the balanced traction placed on the affected extremity that allows better visualization to the anteroinferior labrum for repair.) Small bump underneath the axilla will help with visualization by joint distraction (Fig. 34-30A). Load and shift examination under anesthesia is performed to document humeral head translation (1+ is to the rim and back, 2+ past the rim and back, and 3+ is locked out past the rim). ROM in forward flexion, abduction, and external rotation is documented. Sulcus sign with the arm in neutral and external rotations is also recorded.

The posterior viewing portal is established with a no. 11 blade in the soft spot (usually ~2 cm down and ~1 cm over from the posterior lateral edge of the acromion; Fig. 34-30B). Diagnostic arthroscopy is performed to evaluate for labral tears, rotator cuff, biceps, cartilage, glenoid bone loss, bony Bankart lesions, and humeral head bone loss (Hill–Sachs lesion). A 30-degree scope is used for the procedure. However, if visualization is difficult, a 70-degree scope can be used in the posterior portal to better visualize the labrum for repair. Another option is to put the 30-degree scope into the anterolateral portal. The anterolateral portal is established with assistance of an 18-gauge spinal needle (~1 cm down from the anterolateral acromion). A posteriorly directed force on the humeral head can help with placement of this portal by posteriorly translating the humeral head and opening up the space anteriorly. A threaded cannula (6 mm) is inserted via a switching stick. This is the working portal (Fig. 34-30C, *circle*).

An anteroinferior portal is established with the assistance of an 18-gauge spinal needle just above the subscapularis muscle belly and slightly above the surface of the glenoid fossa (Fig. 34-30C, *arrow*). Alternatively, this portal position can be established with an inside-out technique. Another threaded cannula (8 mm) is inserted via a switching stick. An 8-mm cannula is used to allow for the passage of the curved passer. This is the suture passing and drilling portal for all anchors. A labral elevator or CoVator (Fig. 34-31A, *star*) is inserted into the anterolateral portal to mobilize the anteroinferior capsulolabral complex (Fig. 34-31A, *arrow*) off the glenoid rim. It is critical that the labrum is mobilized off the glenoid so that the subscapularis

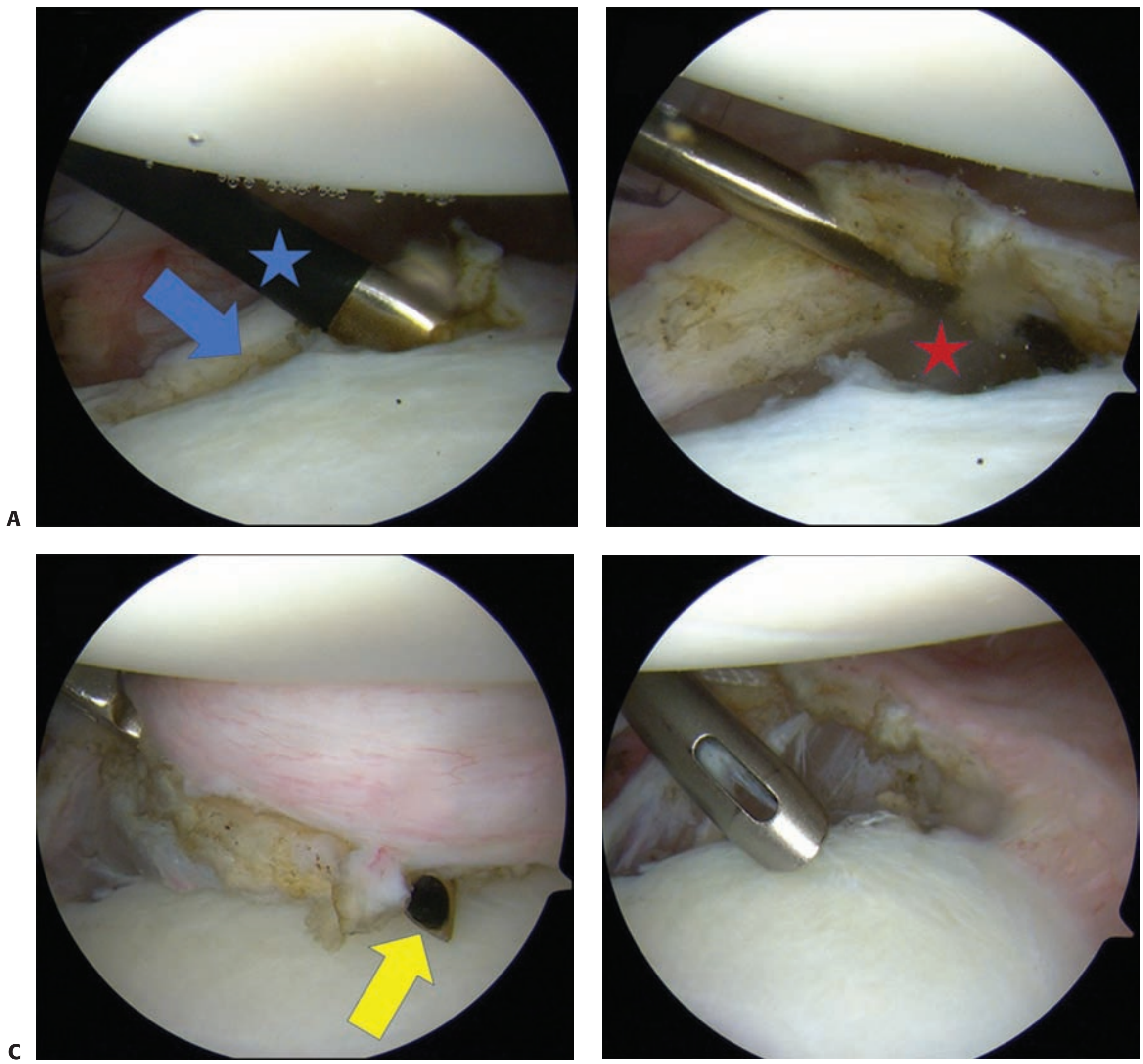
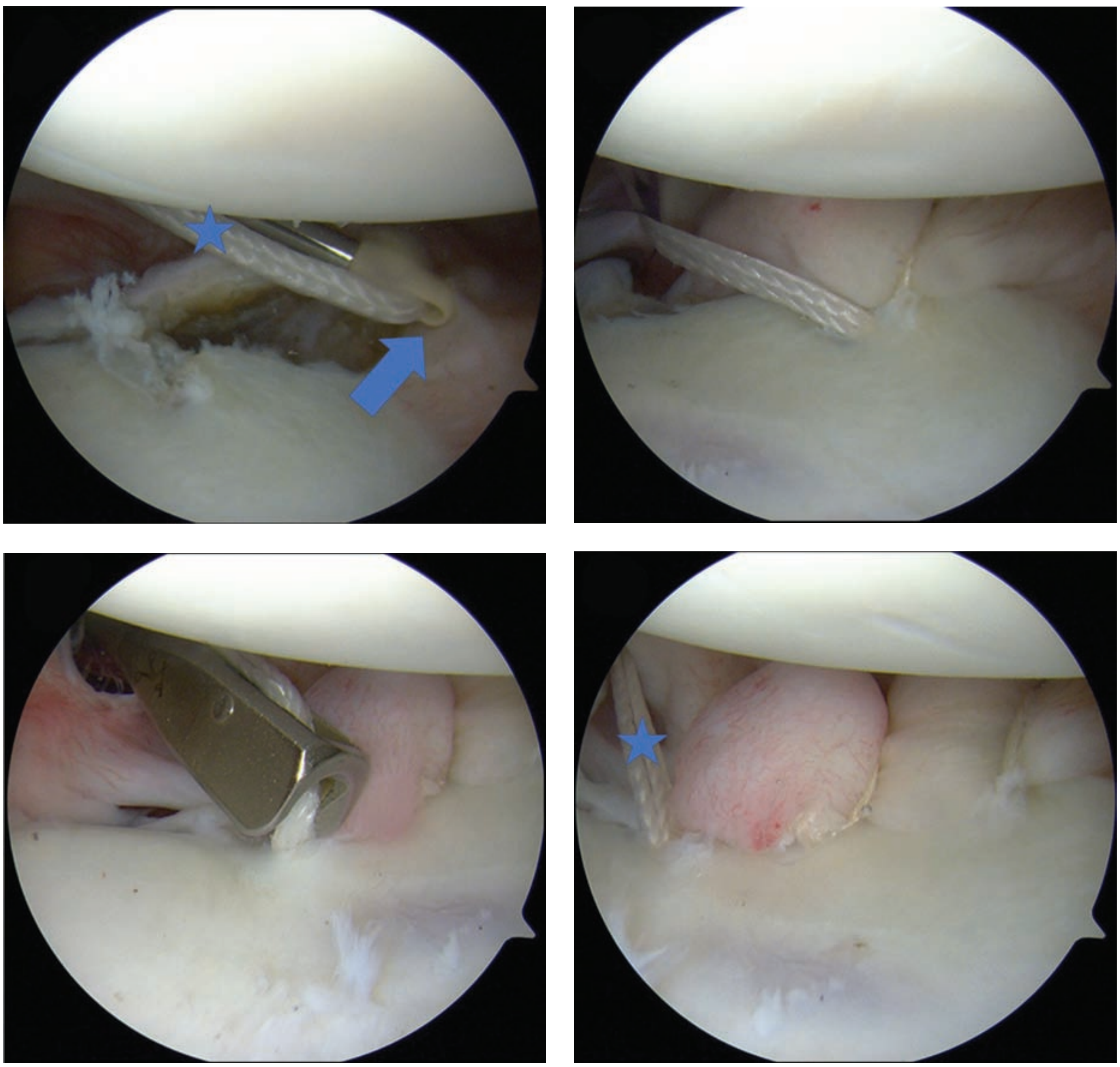


Figure 34-31. **A:** Anterior–inferior labral tear is identified (*arrow*) and the CoVator is used to mobilize the anterior–inferior labrum off the glenoid neck. **B:** The subscapularis muscle belly must be visualized (*star*) to confirm adequate shift of the capsulolabral complex will be obtained. **C:** A curved passer with a metal tipped suture shuttle (*arrow*) is used to shift the capsulolabral complex. **D:** The first anchor must be low on the anterior inferior glenoid rim.

muscle belly (Fig. 34-31B, *star*) is visualized below. This step will allow adequate shifting of the capsulolabral complex and reduce the anteroinferior capsular volume to stabilize the shoulder joint.

A curved passer is used from the anteroinferior cannula to penetrate the capsule ~1 cm distal and ~1 cm away from the glenoid rim (Fig. 34-31C, *arrow*) to allow shifting and mobilization of the capsulolabral complex. For the right shoulder, the right curve is used and vice versa. The authors prefer a metal-tipped passer to allow ease of passage through the soft tissue. Either knotless or knotted fixation repair of the Bankart lesion can be used. The authors prefer a knotless fixation using Labral Tape and Arthrex 2.9-mm pushlock anchors (Arthrex, Naples, FL). The first anchor position must be low on the glenoid face (Fig. 34-31D). The labral tape is shuttled across the labrum and both limbs are passed into the anteroinferior portal. They are loaded up onto a 2.9-mm pushlock anchor (Fig. 34-32A). Using the drill guide and a 2.9-mm drill, the first fixation is placed at the 5:30 position (right shoulder) or 6:30 position (left shoulder). It is essential that the first anchor position is low on the anterior glenoid face (Figs. 34-31D and 34-32B). A labral tape cutter is used to cut the tape down to the rim of the glenoid (Fig. 34-32C). The same steps are repeated with two to three additional passages of the passer, labral tape, and fixation to the anterior glenoid rim. The anchors are placed sequentially at the 4:30, 3:30, and 2:30 position or 7:30, 8:30, and 9:30 position as needed depending on the right or left shoulder, respectively. The authors prefer at least three anchors for arthroscopic Bankart repair. A bumper is created at the end



A

C

Figure 34-32. **A:** Labral tape (*star*) is shuttled across the labrum and loaded up onto a 2.9-mm pushlock anchor (*arrow*). **B:** The anchor is pushed locked onto the drill hole. **C:** A labral tape cutter is used to cut the suture flush to the glenoid rim. **D:** At least three anchors are used for the Bankart repair. In this patient, knotless technique is done with labral tape (*star*) and 2.9-mm pushlock anchors (Arthrex, Naples, FL). A bumper is created at the end of the repair.

of the case, which shows excellent shift of the anterior-inferior capsulolabral complex (Fig. 34-32D).

An arthroscope is inserted to the anterolateral portal to evaluate the repair. Both the SLAP lesion and posterior labral tear must be addressed at this time if indicated. The patient is placed in a sling with an abduction pillow. Standard postoperative protocol is followed.

Open Anterior Labral (Bankart) Repair

Preoperative Planning

✔ Open Anterior Labral (Bankart) Repair: PREOPERATIVE PLANNING CHECKLIST

OR table	❑ Beach chair with arm holder
Equipment	❑ Open shoulder set ❑ Links shoulder retractor, anterior Bankart retractor ❑ Anchors with preloaded sutures ❑ Drill bits and drill guide specific to the anchors used ❑ Suture passer ❑ 4.5- to 5.5-mm anchor for the repair of the subscapularis tendon depending on either a tenotomy or a peel was performed.

Preoperative planning is the same as for arthroscopic anterior labral (Bankart) repair, described above.

Positioning

The patient is positioned upright in the beach chair position. An arm holder is placed to allow for different positioning and rotation of the shoulder throughout the case.

Surgical Approach

Either an anterior deltopectoral or mid-axillary crease approach is performed. With the anterior deltopectoral approach, a 5- to 6-cm incision is centered over the coracoid and extended down to the deltoid. For the mid-axillary crease approach (*green line*), the incision is centered over the coracoid to the axilla (Fig. 34-33A).

Technique

✔ Open Anterior Labral (Bankart) Repair: KEY SURGICAL STEPS

- ❑ Beach chair position with arm holder
- ❑ Examination under anesthesia
- ❑ Deltopectoral or mid-axillary crease approach
- ❑ Open the deltopectoral interval
- ❑ Superior half to two-thirds subscapularis tenotomy
- ❑ Separate the capsule from the subscapularis muscle belly
- ❑ "T" capsulotomy
- ❑ Expose and elevate the Bankart lesion off the glenoid rim
- ❑ Abraded the anterior glenoid rim with a burr
- ❑ Place 3-mm anchors on the anterior glenoid rim and suture
- ❑ Shift and repair capsule with the arm in 30 degrees of flexion and 30 degrees of external rotation
- ❑ Repair subscapularis tenotomy
- ❑ Close deltopectoral interval and skin
- ❑ Place patient a sling and abduction pillow

The patient is placed in the beach chair position with an arm holder to allow different arm positions throughout the case. Load and shift examination under anesthesia is performed to document humeral head translation. ROM and the sulcus

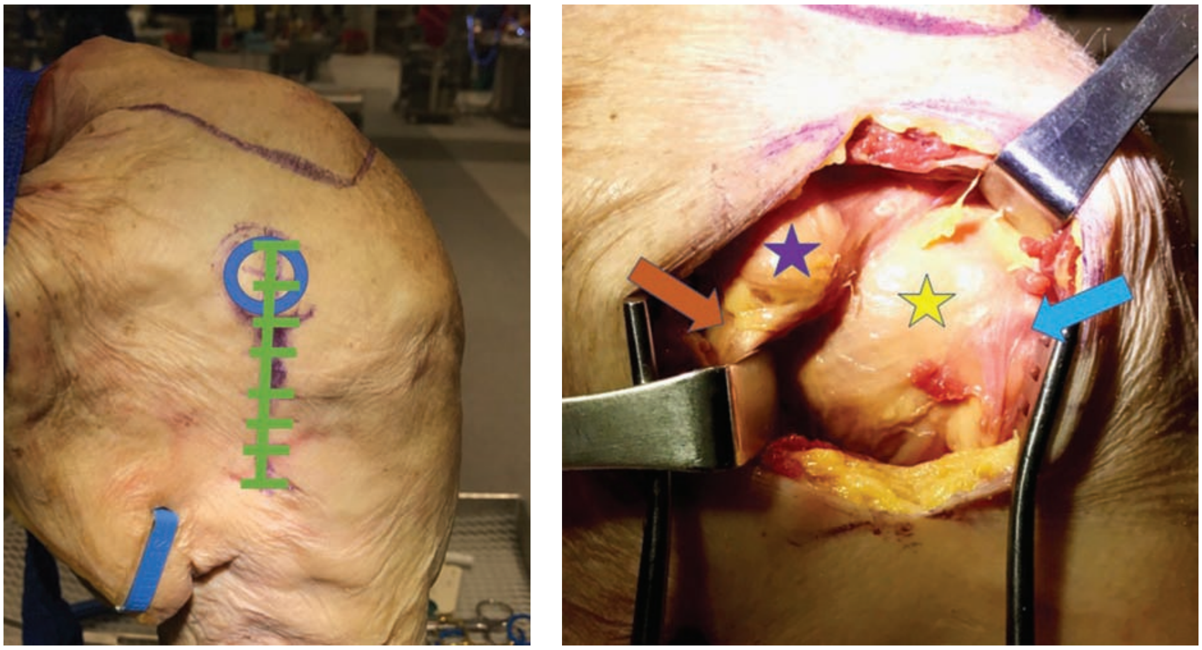
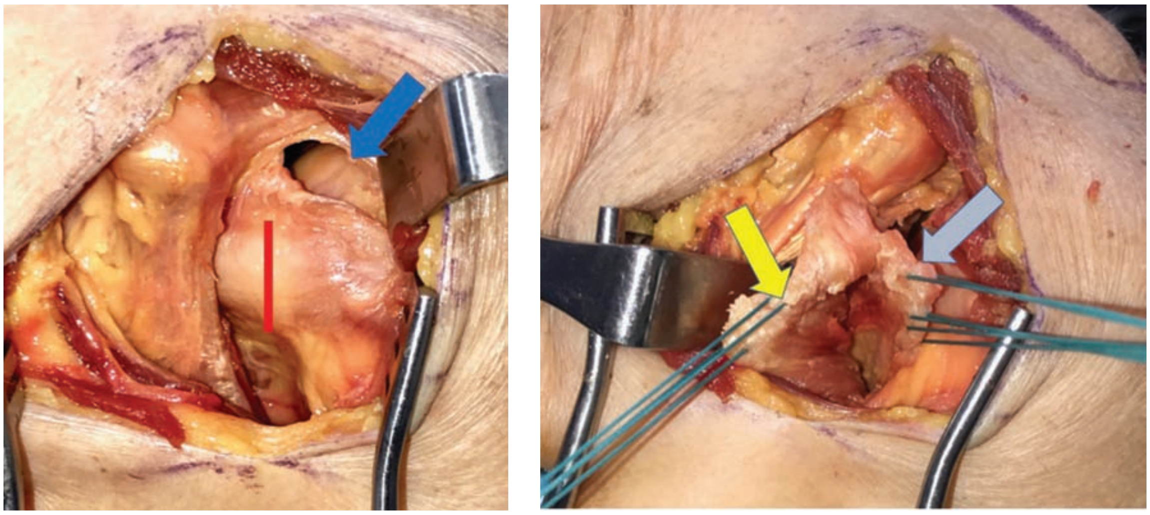

A B

Figure 34-33. A: Anterior approach to the shoulder with the incision centered over the coracoid and down to the axilla (*green line*). **B:** Deltopectoral approach performed with the cephalic vein retracted either medially or laterally. Retractors are placed between the deltoid and the conjoint tendon. The coracoid (*purple star*), conjoint tendon (*orange arrow*), lesser tuberosity (*yellow star*), and biceps tendon (*blue arrow*) are identified.



C D

Figure 34-33. (*Continued*) **C:** The rotator interval is split to help identify the top of the subscapularis tendon. Subscapularis tenotomy is performed 1 cm from the bicipital groove to leave a cuff of tissue for repair (*red line*). **D:** The subscapularis muscle belly (*yellow arrow*) is separated from the capsule (*gray arrow*).

sign are also recorded. A deltopectoral or mid-axillary crease approach is used.

For either surgical approach, the soft tissue is dissected down to identify the cephalic vein, which lies between the pectoralis major medially and deltoid laterally. The authors prefer retracting the vein laterally with the deltoid musculature. A linked shoulder retractor (Kolbel self-retractor) is placed to split the deltopectoral interval (Fig. 34-33B). The clavipectoral fascia is incised to expose the coracoid (Fig. 34-33B, *purple star*) and conjoint tendon (Fig. 34-33B, *orange arrow*). The linked retractor is repositioned between the conjoint tendon and the deltoid. Now, the biceps tendon is identified in the bicipital groove (Fig. 34-33B, *blue arrow*). The lesser tuberosity is medial to the groove (Fig. 34-33B, *yellow star*) and the greater tuberosity is lateral to the groove.

The authors prefer a superior half or two-thirds subscapularis tenotomy that is made 1 cm medial to the lesser tuberosity (Fig. 34-33C, *red line*) to allow for repair and separation of the capsule from the undersurface of the subscapularis muscle belly. The medial subscapularis tendon is tagged with no. 2 sutures. The rotator interval is also split to help identify the top of the subscapularis tendon (Fig. 34-33C, *blue arrow*). External rotation of the arm will help better expose the subscapularis tendon. With traction on the no. 2 sutures, using both Metzenbaum scissors and an elevator, the capsule (Fig 34-33D, *gray arrow*) is separated from the subscapularis (Fig 34-33D, *yellow arrow*) muscle belly. A lateral-based "T" capsulotomy is made 1 cm medial to the lesser tuberosity to allow for further shifting of the capsule after the Bankart repair. The medial and lateral leaflet of the capsule is tagged with sutures to facilitate exposure to the glenohumeral joint. An anterior glenoid neck retractor is placed to expose the Bankart lesion, and a humeral head retractor is placed in the glenohumeral joint to gently push the humeral head back to allow for a better exposure. The Bankart lesion is elevated off the glenoid rim with a soft tissue elevator. The anterior glenoid rim is superficially abraded with a burr. Anchors (3 mm) are placed on the anterior glenoid rim (Fig. 34-34A) at the 5:30 position (6:30 in left shoulder). Depending on the size of the tear, a minimum of three anchors should be used for the repair. The anterior glenoid neck retractor is removed and a suture passer is used to shuttle the no. 2 sutures from the anchor on the glenoid rim through the capsulolabral tissue (Fig. 34-34B) with horizontal mattress sutures (Fig. 34-34C). The same technique is repeated for the other anchors.

All the sutures are tied starting with the most inferior anchor. The capsule is shifted (*arrow*) and repaired using no. 0 sutures in interrupted fashion with the arm in 30 degrees of flexion and 30 degrees of external rotation (Fig. 34-35A). Subscapularis tenotomy is repaired back with no. 2 braided sutures in interrupted fashion (Fig. 34-35B). Deltopectoral interval is closed with running no. 2 sutures and skin closed with 3-0 Monocryl and Dermabond. The patient is placed in a sling and abduction pillow.

Open Latarjet Procedure

Preoperative Planning

✔ Open Latarjet Procedure:
PREOPERATIVE PLANNING CHECKLIST

OR table	❑ Beach chair
Position/ positioning aids	❑ Spider (Tenet Medical Engineering)
Equipment	❑ Kolbel linked retractor blades, anterior glenoid neck retractors, and humeral head retractor ❑ Steinmann pins ❑ Small frag set with 3.5- or 4.0-mm fully or partially threaded screws (we prefer the 5.0-mm partially threaded osteopenia screws for larger patients) ❑ 90-degree oscillating saw blade ❑ Large pineapple burr ❑ Curved osteotomes

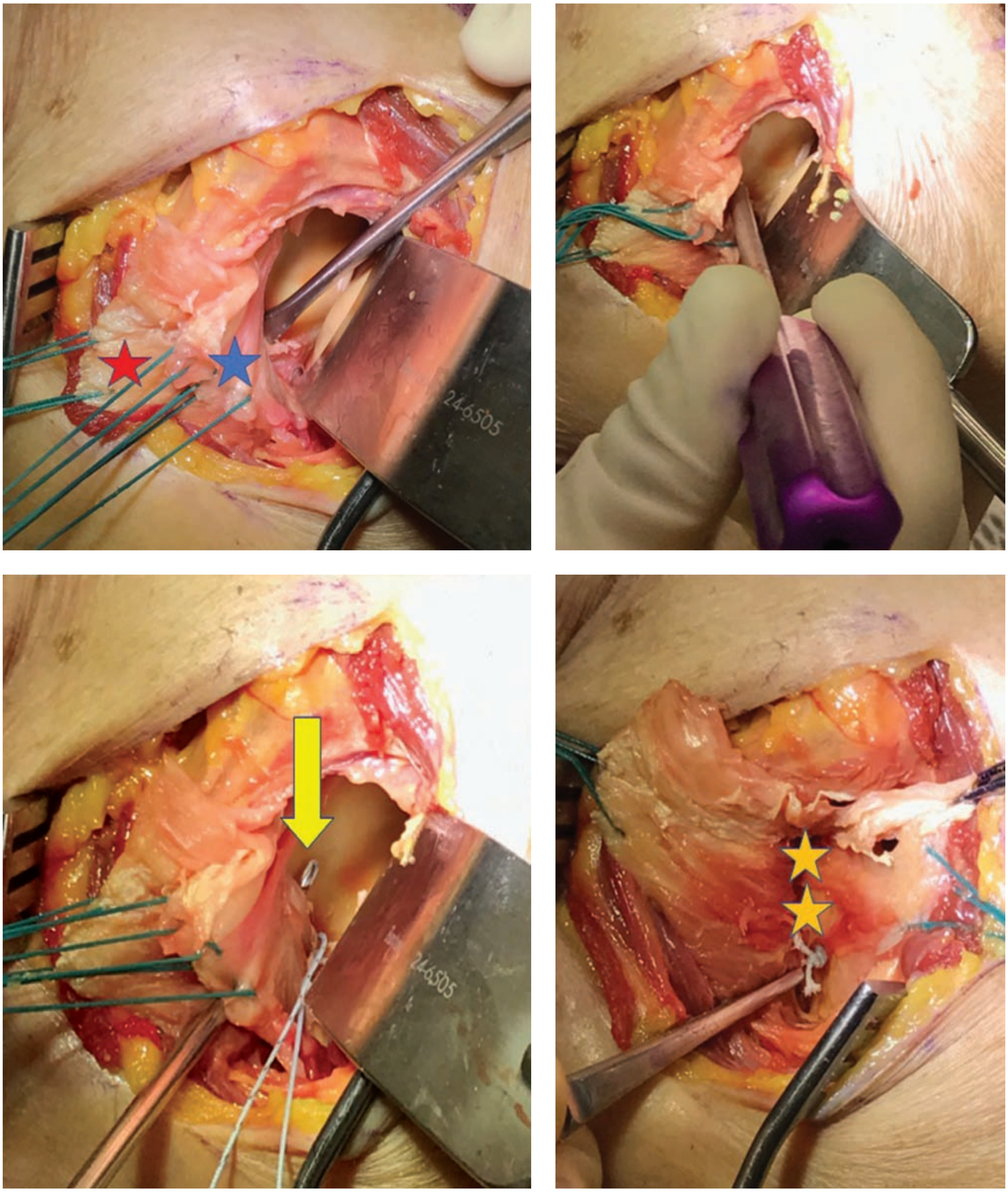


Figure 34-34. **A:** The anterior glenoid rim is elevated with an elevator to help mobilize the capsulolabral tissue. Subscapularis tendon (*red star*) and capsule (*blue star*) are tagged with no. 2 sutures. **B:** Anchors are placed on the anterior glenoid rim. **C:** Using a 90-degree suture passer (*yellow arrow*), horizontal mattress sutures are created with the sutures from the anchors. **D:** The sutures are tied down on the capsule anteriorly. At least three anchors are used for the open Bankart repair.

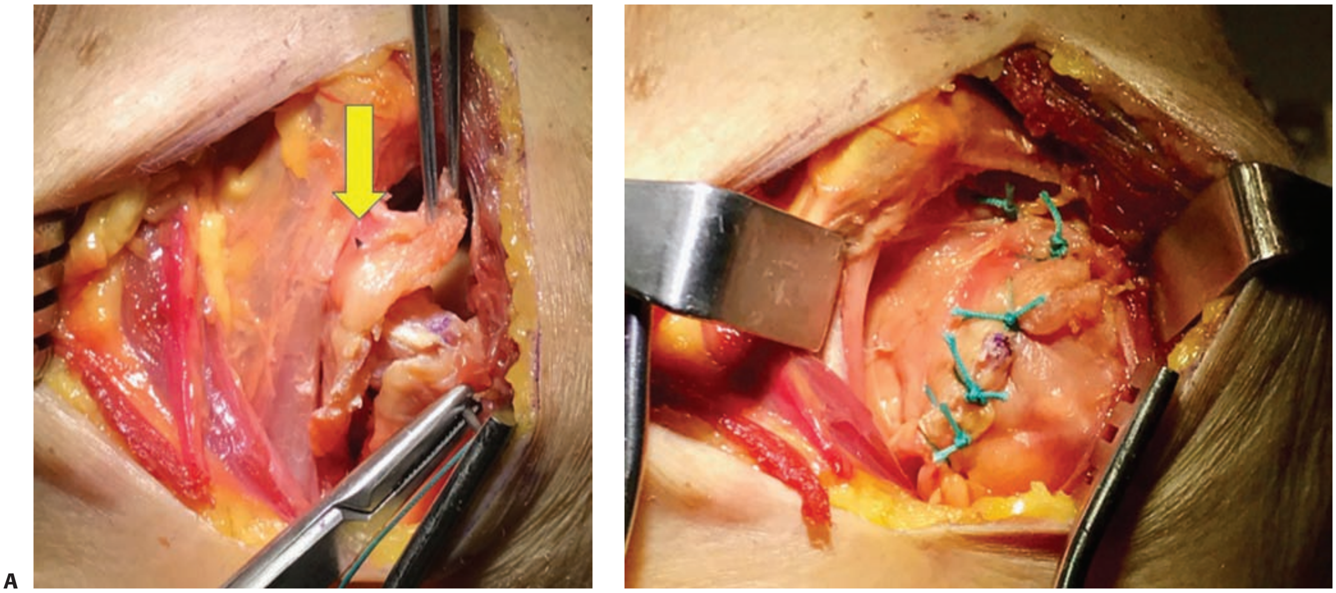


Figure 34-35. **A:** The anterior capsule and rotator interval is shifted up to decrease the capsule volume. **B:** The subscapularis tenotomy and the rotator interval is closed with no. 2 sutures in an interrupted fashion.

A CT scan with 3D reconstruction must be obtained to evaluate anterior glenoid bone loss. In high demand or contact sport patients, a critical bone loss of >13.5% resulted in unacceptable outcome and higher failure rates after arthroscopic Bankart repair in some studies.[209] Recently, Shin et al.,[211] in a similar study of both contact and noncontact athletes, reported 17.3% bone loss as the "Critical" value that led to surgical failure and recurrence of instability after arthroscopic repair. In the patient group with less than 17.3% bone loss, failure rate was 3.7% compared with a 42.9% failure rate in the group with over 17.3% bone loss. A critical bone loss greater than 13.5% to 17.3% is an indication for open Latarjet; however, the patient's activity level, type of sporting (contact vs. noncontact) events, and expectations also factors into the decision-making between arthroscopic repair and open bony reconstruction.

Positioning

The patient is positioned upright in the beach chair position. An arm holder is placed to allow for different positioning and rotation of the shoulder throughout the case.

Surgical Approach

A mid-axillary crease approach is used.

Technique

✔ Open Latarjet Procedure: KEY SURGICAL STEPS

- ❑ Beach chair position with arm holder
- ❑ Examination under anesthesia
- ❑ Mid-axillary crease approach
- ❑ Expose the coracoid and conjoint tendon
- ❑ Horizontal split of the subscapularis at the mid aspect of the muscle belly and tendon
- ❑ Peel the subscapularis muscle off the anterior capsule
- ❑ Retract the humeral head posteriorly
- ❑ Expose the labral tear and glenoid bone loss
- ❑ Protect the axillary nerve
- ❑ Release the pectoralis minor muscle from the medial coracoid and the conjoint tendon from the fascia
- ❑ Resect the coracoacromial (CA) ligament from the acromion and preserve the entire length
- ❑ Cut the coracoid at the base from a medial-to-lateral direction
- ❑ Expose and flatten the inferior surface of the coracoid in preparation to transfer to the anterior glenoid rim
- ❑ Drill two holes into the coracoid
- ❑ Expose the anterior glenoid neck
- ❑ Latten the anterior-inferior glenoid in preparation of the coracoid transfer
- ❑ Drill the first hole (2.7-mm drill bit) into the neck of the glenoid about 5 to 6 mm medial to the glenoid surface
- ❑ Fix the coracoid transfer with either a partially or a fully threaded screw to the first hole that was drilled into the neck of the glenoid
- ❑ Drill a second superior hole from the coracoid to the back of the glenoid rim and place another partially or fully threaded screw to complete the final fixation of the coracoid to the anterior glenoid rim
- ❑ Repair the CA ligament to the capsule
- ❑ Repair the subscapularis split
- ❑ Close the deltopectoral interval and keep the skin closed
- ❑ Place the patient in a sling and abduction pillow
- ❑ Follow standard postoperative protocol

The incision is centered over the coracoid to the axilla (Fig. 34-36A). Soft tissue is dissected down to identify the cephalic vein which lies between the pectoralis major medially and deltoid laterally. The authors prefer retracting the vein laterally with the deltoid musculature. A linked shoulder retractor (Kolbel self-retractor) is placed to retract the deltopectoral interval. The clavipectoral fascia is incised to expose the coracoid (*circle*) and conjoint (*arrow*) tendon (Fig. 34-36B). The biceps tendon is

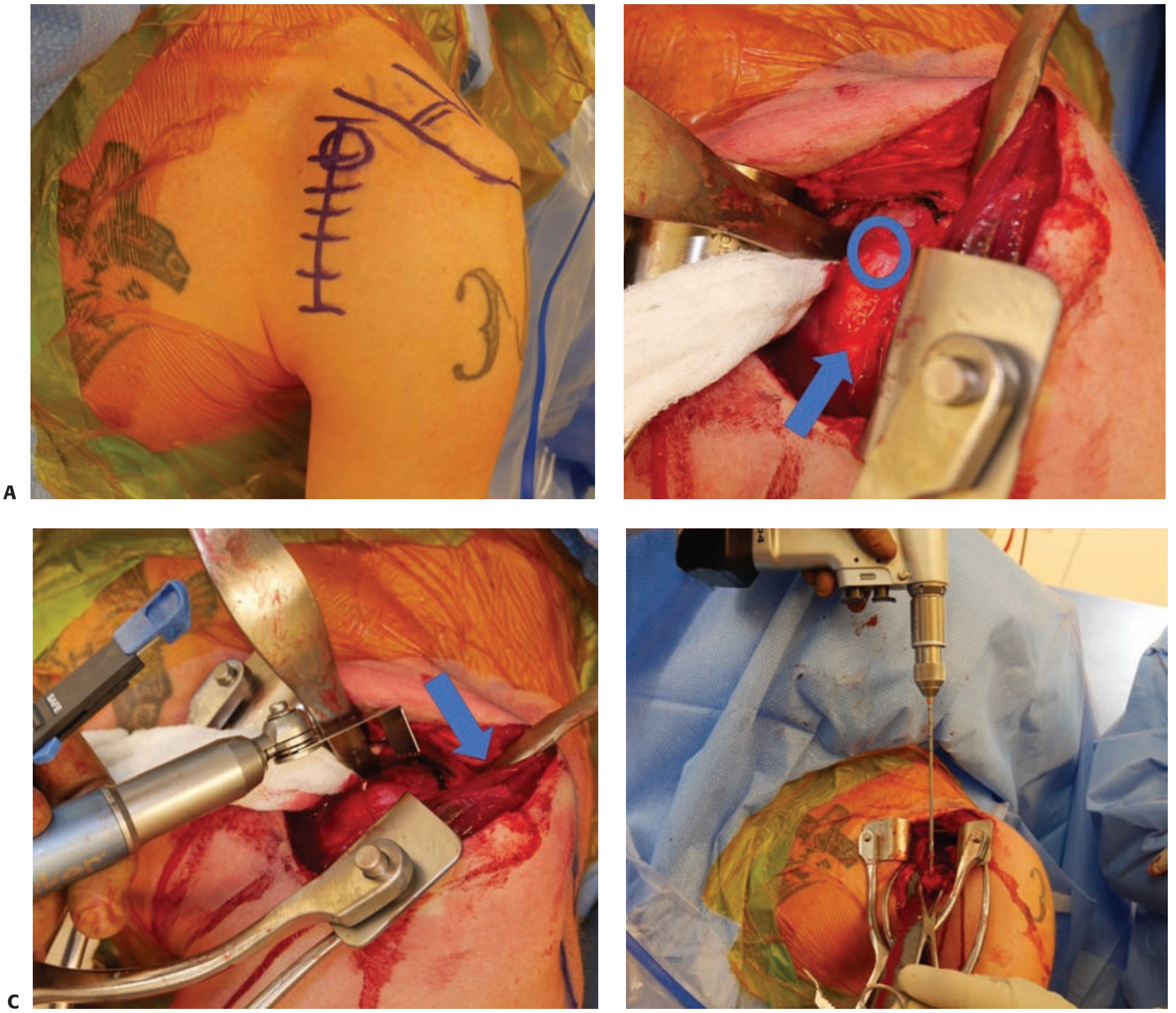


Figure 34-36. **A:** Standard approach to the shoulder is done with a mid-axillary crease incision centered over the coracoid. **B:** Deltopectoral approach is performed and the coracoid (*circle*) along with the conjoint tendon (*arrow*) is identified. The pectoralis minor is released from the medial aspect of the coracoid and the medial along with the lateral edge of the conjoint tendon is freed up. **C:** A 90-degree sagittal saw blade is used to harvest the coracoid at the base from the medial to lateral direction. At least 1.5 cm of the coracoid must be harvested for the procedure. **D:** The undersurface of the coracoid is flattened with a saw, and two holes are predrilled into the coracoid. The authors use 2.7-mm drill bits for the 5-mm partially threaded osteopenia screws (Smith and Nephew, Memphis, TN).

identified in the bicipital groove. The lesser tuberosity is medial to the groove and the greater tuberosity is lateral to the groove. External rotation of the arm will help better expose the subscapularis tendon. The authors prefer a horizontal split of the subscapularis at the mid aspect of the muscle belly and tendon. A Cobb elevator is used to peel off the muscle from the anterior capsule. A curved cobra retractor is placed inferiorly into the split to retract the subscapularis and a regular retractor is placed superiorly to further expose the anterior capsule. Posterior-directed force on the humerus will help subluxate the humeral head and better identify the joint line. A vertical capsulotomy is made at the glenohumeral joint with a no. 10 blade. A humeral head retractor is inserted into the glenohumeral joint through the capsulotomy to retract the humeral head posteriorly. Anterior glenoid neck retractor is used to expose the labral tear and glenoid bone loss. A curved cobra retractor is placed inferiorly to the glenoid rim to protect the axillary nerve. A Steinman pin is used superiorly to retract the subscapularis muscle.

The pectoralis minor muscle is released from the medial coracoid and the conjoint tendon is freed from the fascia. The CA ligament is resected from the acromion to preserve the entire length of the ligament. A 90-degree oscillating saw is used to cut the coracoid at the base from a medial-to-lateral direction (Fig. 34-36C, *blue arrow*). At least 1.5 to 2 cm of the coracoid must be harvested for the procedure. The soft tissues are dissected off the coracoid and the conjoint tendon is also

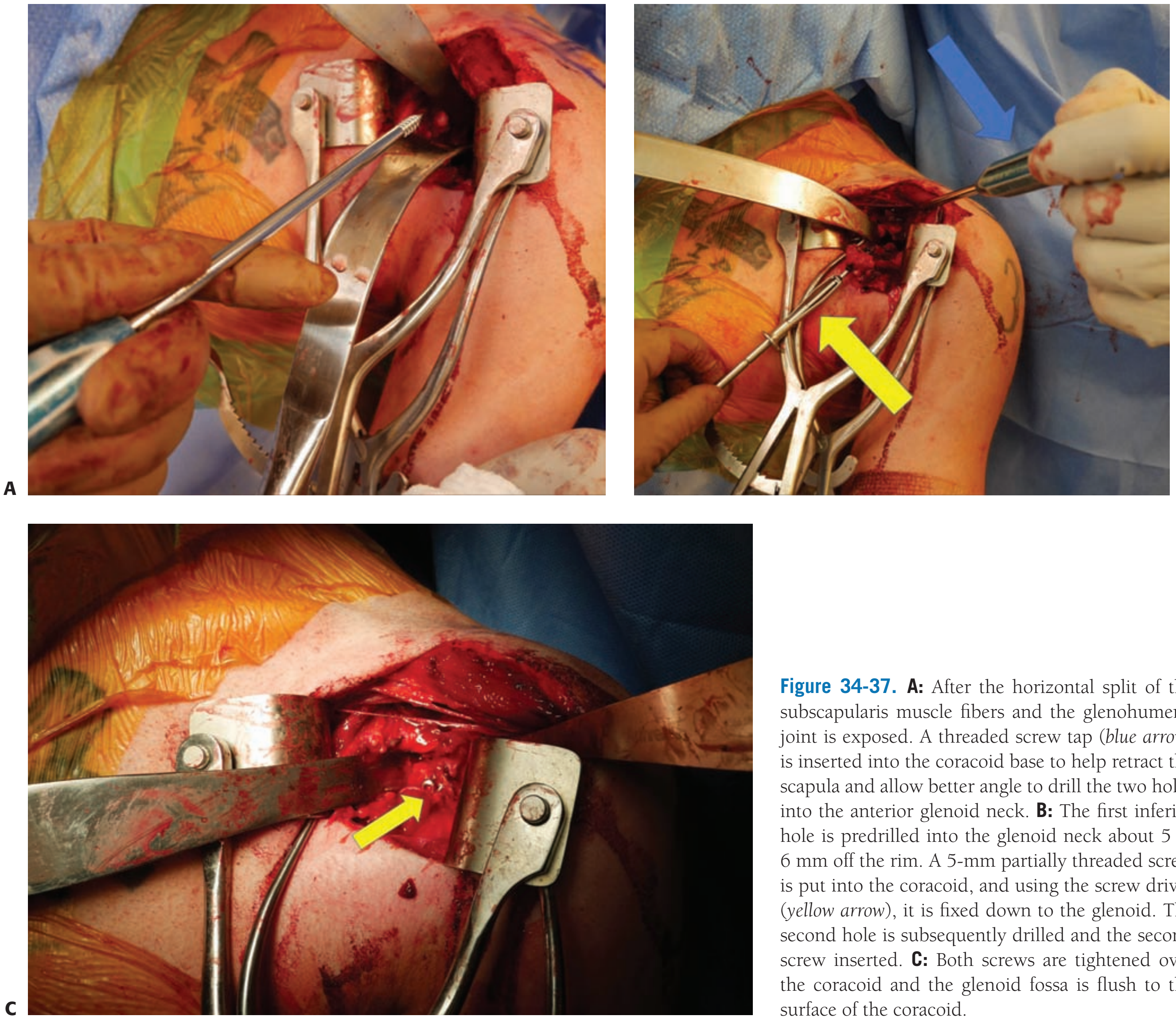


Figure 34-37. **A:** After the horizontal split of the subscapularis muscle fibers and the glenohumeral joint is exposed. A threaded screw tap (*blue arrow*) is inserted into the coracoid base to help retract the scapula and allow better angle to drill the two holes into the anterior glenoid neck. **B:** The first inferior hole is predrilled into the glenoid neck about 5 to 6 mm off the rim. A 5-mm partially threaded screw is put into the coracoid, and using the screw driver (*yellow arrow*), it is fixed down to the glenoid. The second hole is subsequently drilled and the second screw inserted. **C:** Both screws are tightened over the coracoid and the glenoid fossa is flush to the surface of the coracoid.

freed. Using a three-prong sharp grasper, the inferior surface of the coracoid is exposed. Using the same oscillating saw, the undersurface is flattened for preparation to transfer it to the anterior glenoid rim. Two evenly spaced holes are drilled into the coracoid with a 2.7-mm drill bit (Fig. 34-36D).

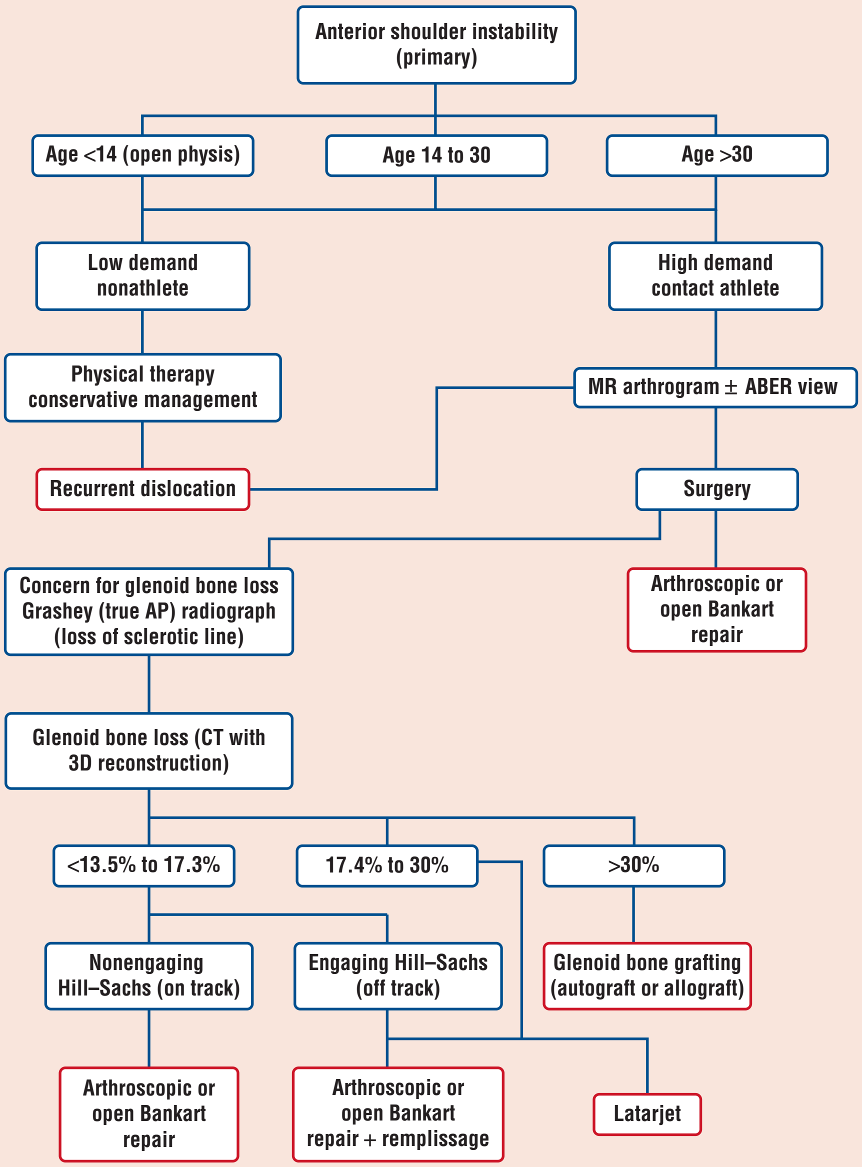
A humeral head retractor is placed in the glenohumeral joint to retract the humeral head. Curved cobra retractor is used inferiorly under the glenoid rim to retract the axillary nerve and subscapularis muscle. Anterior glenoid neck retractor is placed medial on the glenoid neck. A Steinmann pin is malleted into the glenoid fossa superiorly to retract the superior subscapularis muscle.

A large pineapple burr or curved osteotome is used to flatten the anterior-inferior glenoid for preparation of the coracoid transfer. It is crucial that this surface is flat to allow for full contact between the undersurface of the coracoid and the anterior glenoid rim. The first hole (2.7-mm drill bit) is drilled into the neck of the glenoid about 5 to 6 mm medial to the glenoid surface. The authors like to use a metal tap into the base of the coracoid to help externally rotate or retract the scapula (Fig. 34-37A). This maneuver will allow the drill hole to be parallel to the glenoid fossa.

A 30-mm partially threaded 5-mm osteopenia screw is placed into the inferior hole in the coracoid, and using a screw driver, the graft is placed on the anterior glenoid rim and the screw is used to hold the graft (Fig. 34-37B). Using the 2.7-mm drill bit, the second hole is drilled from the coracoid to the back of the glenoid rim. A depth gauge is used to measure the exact size of the screw length. Another partially threaded 5-mm screw is placed to complete the final fixation of the coracoid to the anterior glenoid rim (Fig. 34-37C). Alternatively, if the coracoid is small, two 3.5 fully threaded screws put in with lag-by technique can also be used for fixation.

The capsule to the CA ligament is repaired with 0 Vicryl sutures. The subscapularis split is also repaired with 0 Vicryl sutures in an interrupted fashion. Deltopectoral interval is closed with running no. 2 sutures and skin closed with 3-0 Monocryl and Dermabond. The patient is placed in a sling and abduction pillow. Standard postoperative protocol is utilized.

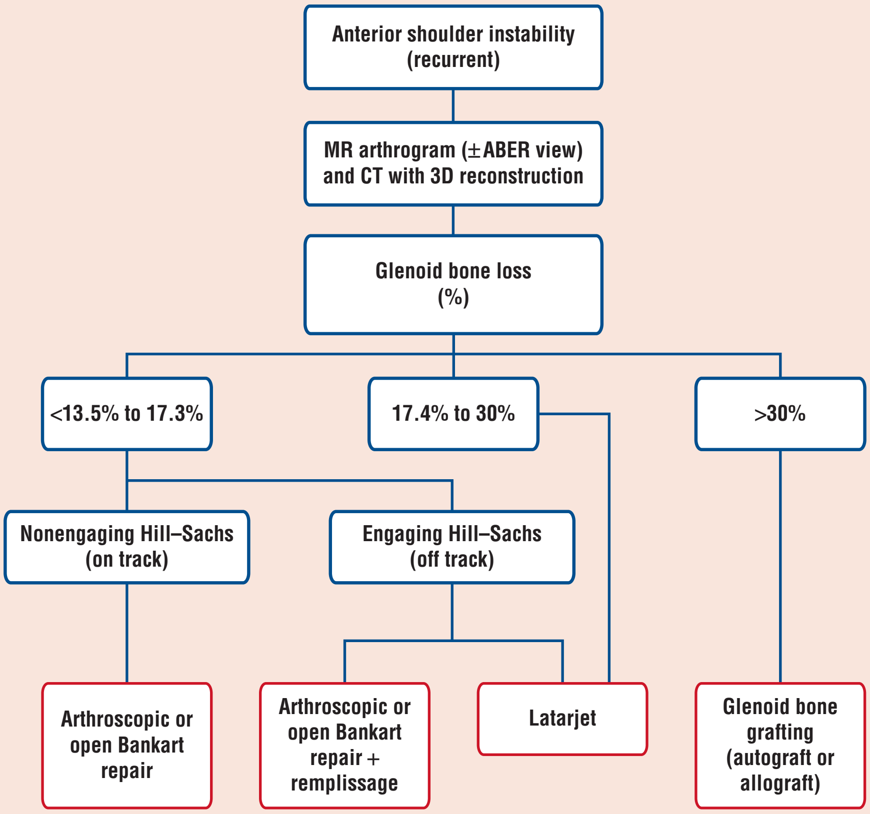
Authors' Preferred Treatment for Anterior Glenohumeral Instability (Algorithms 34-1 and 34-2)



Algorithm 34-1. Authors' preferred treatment for primary anterior shoulder instability.

For patients with anterior shoulder instability, the decision between conservative or surgical management is dependent on age, number of subluxations/dislocations, amount of glenoid bone loss, type of sports (contact vs. noncontact), and the patient's own expectations. Primary dislocation in patients under the age of 14 years is managed with physical therapy and rotator cuff and deltoid strengthening exercises. In patients aged 14 to 30 years who are active and play a high-demand or contact sports, MRA is recommended after the primary subluxation or dislocation event. If a Bankart lesion is detected on MRA, surgery is recommended to stabilize the shoulder and prevent recurrent instability that would result in damage to the intra-articular structures. If there is no Bankart lesion on the MRA, a trial of physical therapy and strengthening program is recommended. For patients in this age group who are of low demand and not athletes, the authors recommend a trial of conservative management with physical therapy. Furthermore, for primary instability in low-demand patients over the age of 30 years, physical therapy is also the treatment of choice.

Surgery should be indicated for any patients who have recurrence of instability after a trial of physical therapy. A CT scan with 3D reconstruction is critical to assess for anterior glenoid bone loss, the size of the Hill–Sachs lesion, and whether the shoulder is "on" or "off" track. A review of recent literature suggests that the "subcritical" to "critical" bone loss is between 13.5% and 17.3% glenoid bone loss.[209,211] The decision to use 13.5% or 17.3% as the cutoff



Algorithm 34-2. Authors' preferred treatment for recurrent anterior shoulder instability.

value between arthroscopic stabilization versus open Latarjet should be based on the patient's activity level, type of sports (collision vs. noncontact), and expectations. The best option for treatment is based on informing the patient both the risk and benefits of arthroscopic versus open bone procedure and a shared decision-making model. Thus, the authors suggest that in patients with <13.5% to 17.3% anterior glenoid bone loss and non–engaging Hill–Sachs (on-track) lesions, arthroscopic or open Bankart repair is indicated. In patients with <13.5% to 17.3% bone loss with an engaging Hill–Sachs (off-track) lesion, a remplissage procedure should be considered in addition to the arthroscopic or open Bankart repair. A Latarjet procedure can also be used in this setting to stabilize the shoulder. In patients with >17.3% but less than 30% bone loss, an open Latarjet procedure is recommended for the best outcome. An anterior glenoid bone grafting with either autograft (iliac crest) or allograft (distal tibia allograft) is indicated when the patient has >30% glenoid bone loss or has failed open Latarjet procedure. Both autograft and allograft have similar reported outcomes in the literature.

Postoperative Care

After arthroscopic or open Bankart repair or Latarjet procedure, the patient is placed in a sling with an abduction pillow for the first 4 to 6 weeks to protect the repair or reconstruction. Formal physical therapy is started 2 weeks after surgery. In phase I of the recovery, passive ROM in forward flexion is done with the patient in the supine position where the goal is flexion to 90 degrees and external rotation to 25 degrees. Elbow and wrist active and passive ROM is encouraged with modalities as needed for both pain and edema control. In phase II, between weeks 4 and 8, the patient will start to wean from their sling. Passive ROM is transitioned to active assisted ROM with a goal of 120 degrees in flexion. In phase III of the postoperative therapy, between weeks 8 and 14, the main goal is to restore full ROM in flexion and external rotation. Mild strengthening exercises are initiated around week 8 for the rotator cuff, deltoid, and scapula stabilizers. The patient should transition into active ROM with isokinetic training during this phase. In the final phase of the recovery process between weeks 14 and 18, the goal is to restore normal neuromuscular function with full ROM and strength. Sports-specific activity program is also incorporated into this phase. Full return to sports or high-demand job activities may begin around 5 to 6 months, and the patient must have similar ROM and strength compared with the contralateral shoulder.

Potential Pitfalls and Preventive Measures

Anterior Glenohumeral Instability:
SURGICAL PITFALLS AND PREVENTIONS

Pitfall	Prevention
Arthroscopic Bankart Repair	
• The lowest anchor position too high on the glenoid face is a risk factor for failure (needs to be 5 to 5:30 on the right shoulder and 6 to 6:30 on the left shoulder)	• Get the anteroinferior portal right above the subscapularis tendon in the low 5:30 position. • If the portal is high, a curved all-suture anchor with a curved guide can be used to get low on the glenoid rim. Alternatively, a trans-subscapularis percutaneous portal can be established for placement of the anchor at the most inferior position on the anterior glenoid.
• Glenoid rim anchor position on the glenoid neck or below the rim	• The glenoid drill holes and anchor fixation need to be on the rim or slightly on the glenoid face to allow for optimal shifting of the anteroinferior capsulolabral tissue.
• Loss of fixation with the anchor or glenoid rim fracture	• Use a bigger anchor in the same hole or alternatively; drill a separate hole in a difference location on the glenoid rim to avoid the perforated region.
• Inadequate capsulolabral shift resulting in persistent instability	• The capsulolabral tissue must be mobilized off the glenoid rim with either a CoVator or arthroscopic elevator to visualize the muscle belly of the subscapularis.
• Difficulty passing the anterior and lowest suture passers across the capsulolabral tissue	• Use a tissue grasper in the anterior lateral portal to help manipulate and shift the capsulolabral tissue to assist in the passing of the low inferior passer and suture. Alternatively, passage from the posterior portal using a suture lasso facing the opposite direction (i.e., left lasso for right shoulder) may facilitate passage at the most inferior position of the anterior labrum.
• Instrument crowding within the glenohumeral joint	• The anterior-inferior portal is right over the subscapularis tendon and the anterosuperior lateral portal is right underneath the anterior lateral edge of the acromion. Two threaded cannulas are inserted into the joint to allow suture passage.
• Difficulty with visualization of the anterior inferior labrum for mobilization and shifting/repair	• Use a 70-degree scope in the posterior portal instead of the 30-degree scope to help visualization. Alternatively, the 30-degree scope can be switched over to the anteriosuperior lateral portal to view and work through the anterior-inferior portal to mobilize. This is especially important for anterior labral periosteal sleeve avulsion (ALPSA) lesions where the labrum is scarred in medially on the glenoid neck.
Open Bankart Repair	
• Difficulty with visualization of the anterior inferior Bankart tear	• Either subscapularis peel or tenotomy can be used for the open Bankart procedure. The capsule must be separated away from the subscapularis tendon to allow for shift and repair with the Bankart lesion. Using an anterior Bankart retractor will help with the visualization.
• Overtightening of the capsule resulting in stiffness and loss of external rotation	• After the Bankart repair, if anterior capsular shift is desired, it must be done with the arm in 30 degrees of forward flexion and 30 degrees of external rotation to avoid overtightening and loss of motion.
• Humeral head cartilage damage from retraction	• Use retractors that are smooth or place sterile lap sponge around the retractor to minimize damage to the humeral head during this procedure.
Open Latarjet Procedure	
• Axillary nerve injury	• Place a curved smooth cobra retractor under the inferior glenoid rim to retract the axillary nerve away from the surgical site and avoid injury.
• Lack of exposure	• Medially place an anterior Bankart retractor, inferiorly place a smooth curved cobra retractor, superiorly use a 3-mm smooth pin to retract the subscapularis muscle belly, and a humeral head retractor in the glenohumeral joint.
• Coracoid too short	• Use 90-degree saw blade, cut from medial to lateral at the coracoid base to maximize the length, and complete the osteotomy with a curved osteotome.
• Screw too long	• Both fully threaded or partially threaded screws can be used for fixation. Typically, in most patients, a 30–32-mm screw will be the optimal length. If you are concerned that the screw length is too long, then after the graft is fixed down with the first screw, use a depth gauge to measure the second hole for the correct length.
• Difficulty with the glenoid drill angle and placement of the screws parallel to the glenoid face	• Place a threaded Steinman pin or arthroscopic threaded tap into the coracoid base harvest site. Use the pin or tap to retract the scapula body posterior to allow better angle to drill the glenoid so that the screws are in optimal position.
• Subscapularis tendon rupture	• Use a horizontal subscapularis split in the middle and then a vertical capsulotomy to get exposure. The subscapularis split will decrease the risk of subscapularis rupture or weakness compared with a tenotomy.

Outcomes

Open and Arthroscopic Bankart Repair

Arthroscopic Bankart repair is the current treatment of choice for most uncomplicated traumatic anterior instability injuries without other associated structural lesions such as significant humeral or glenoid bone loss or capsular injury (Table 34-4).[177,276] A large number of studies have looked at recurrence of shoulder instability after arthroscopic Bankart repair with varying degrees of instability. Recent reviews of the literature reported recurrence shoulder instability risk to be approximately 10.7% to 13.1% after arthroscopic Bankart repairs.[57,90] Notable risk factors for recurrent instability after arthroscopic stabilization include young age, a higher number of preoperative dislocations, significant bone loss from either the humeral head or glenoid, and inferior capsule hyperlaxity.[2,22,73,130,180,209,254]

A decrease in postoperative ROM can be expected following arthroscopic Bankart repair, particularly in external rotation both with the arm down at the side and in 90 degrees of abduction. A recent meta-analysis reported this to be 3 to 9 degrees with the arm at the side and 3.5 to 6 degrees with the arm in 90 degrees of abduction.[40] There is less effect on forward flexion after arthroscopic Bankart surgery (1 to 3 degrees).[40] Postoperative ROM after arthroscopic surgery is typically superior to that after open surgery, including open Bankart repairs.[21,40,90,244] This is an important factor of consideration, particularly for overhead throwing athletes.

Functional outcomes following arthroscopic anterior Bankart repair have been typically favorable (see Table 34-4). The ASES and the Rowe shoulder scores are frequently used for reporting outcomes following Bankart repair. While the ASES score focuses on pain level and functional ability both at work and leisure activity, the Rowe score is focused on shoulder stability, motion, and function. A long-term retrospective study of 180 patients 13 years after arthroscopic Bankart repair reported minimal shoulder pain (VAS 0.0 ± 1.7) and high Rowe (90.0 ± 20.5) and ASES (92.0 ± 17.0) scores after stabilization with an overall patient satisfaction of 92.3%.[1] A recent prospective longitudinal study demonstrated that significant improvements in patient satisfaction, functional outcomes, and quality of life can be expected up to 2 years after surgery.[201]

Similar to arthroscopic Bankart repairs, outcomes after open Bankart repair have been favorable for treatment of traumatic anterior shoulder instability (Table 34-5). Neviaser et al.[165] report on their series of 127 patients who underwent open Bankart repair. The authors reported a 1.6% recurrent dislocation/subluxation rate in their series at a mean follow-up of 17.1 years. Compared with the normal opposite shoulder, the operative shoulders had statistically significant loss of external rotation and internal rotation at final follow-up; however, the mean differences were small (4 degrees and 0.57 vertebral level, respectively).[165] The average final outcome scores were as follows: ASES, 93.5; Rowe 91.4; Western Ontario Shoulder Instability Index, 327.7.[165] Systematic reviews and meta-analyses of open Bankart versus arthroscopic Bankart repairs have typically favored open Bankart repair in terms of recurrence risk after surgical stabilization for anterior instability.[40,90,244] These recent literature syntheses, however, demonstrate that postoperative ROM after open repairs is typically inferior compared with arthroscopic repairs.[40,90,244]

Given the majority of patients treated for traumatic anterior shoulder instability are young active patients, return to sport after either arthroscopic or open surgical stabilization is an outcome of interest. The rates vary greatly for both arthroscopic and open Bankart repairs. Synthesizing the research in this area is challenging given the varying, and often lacking, data that stratify not just whether an individual was able to get back to playing a particular sport, but at what frequency and competition level before and after surgery. Ialenti et al.[100] performed a systematic review and meta-analysis on return to sport after open and arthroscopic Bankart repairs. The authors found a higher consistent rate of return to "same-level" of sport following arthroscopic Bankart repair (71%) versus open repair (66%). The authors reported that the numbers increase to 90.5% and 89%, respectively, if one considers return to sport to be defined as returning to "any level" of sport.

Bony Glenoid Augmentation (Latarjet Coracoid Transfers and Bone Block Procedures)

The importance of glenoid bone loss as well as the contribution of Hill–Sachs lesions in the outcomes of soft tissue Bankart repairs is increasingly being recognized.[138,209] Resurgence of bony reconstructive procedures such as coracoid transfers (Bristow-Latarjet) and bone block augmentation with autograft (Eden-Hybinette) or allograft is evident, to optimize outcomes in traumatic anterior shoulder instability, particularly in failed instability surgery scenarios. The redislocation rate after Latarjet procedure is typically lower than those reported for arthroscopic and open Bankart repairs (see Table 34-5).[6,21,194,279] An et al.[6] performed a meta-analysis of available studies on the rate of redislocation between Bankart repairs and Latarjet repairs and found a higher redislocation rate of 9.5% in Bankart repair versus 5.0% after Latarjet coracoid transfers. Longo et al.[140] reported a 9.8% recurrent instability rate (luxation or subluxation) in their systematic review of the literature. In addition to a lower redislocation rate, the Latarjet procedure may also be a more durable procedure for traumatic anterior instability. Zimmerman et al.[279] reported their experience on 360 patients who underwent arthroscopic Bankart repairs versus Latarjet coracoid transfers. While the Latarjet procedure resulted in lower redislocation compared with an arthroscopic Bankart repair (13% vs. 1%), the authors also noted that the arthroscopic Bankart repair continued to fail at a low but appreciable rate over the 6-year study period. This phenomenon was not seen in the Latarjet group, which led the authors to conclude that the Latarjet procedure may be a more reliable long-term surgery for anterior shoulder instability.

Functional outcomes following Latarjet have compared favorably to arthroscopic and open Bankart repairs (Table 34-6). Systematic reviews of Bankart repairs and Latarjet have demonstrated a range of Rowe scores from 79.3 to 87.9 versus 85.4 to 87.1, respectively. In terms of return to sport following Latarjet, the data is conflicting in terms of how it compares relative to Bankart repairs. Blonna et al.[21] evaluated a matching cohort of 60 patients who underwent arthroscopic Bankart

TABLE 34-4. Comparative Studies on Arthroscopic and Open Bankart Repairs

Author	Year	Mean Follow-Up (mo)	Rowe		Constant		UCLA		ASES		Recurrence	
			Arthroscopic	Open	Arthroscopic	Open	Arthroscopic	Open	Arthroscopic	Open	Arthroscopic	Open
Cole et al.[49]	2000	54	83	82					87	88	6 (16%)	2 (9%)
Karlsson et al.[113]	2001	28	93	89							9 (15%)	5 (10%)
Sperber et al.[222]	2001	24	100	98	100	95					7 (23%)	3 (12%)
Kim and Ha[118]	2002	39	92.7	90.4			33.1	30.6			2 (3.4%)	2 (6.7%)
Fabbriciani et al.[64]	2004	24	91	86.5	89.5	86.7					0 (0%)	0 (0%)
Hubbell et al.[99]	2004	60									9 (30%)	0 (0%)
Sperling et al.[223]	2005	77							87	98	0 (0%)	0 (0%)
Wang et al.[243]	2005	24					90	86			1 (5.6%)	4 (23.5%)
Bottoni et al.[25]	2006	32	91.6	86			94.4	90			1 (3.1%)	2 (6.9%)
Rhee et al.[190]	2006	72	87.4	88.7	86.5	86.8					4 (25%)	4 (12.5%)
Tjoumakaris et al.[232]	2006	42							90	90.3	1 (2%)	1 (4%)
Lützner et al.[142]	2009	31									9 (15%)	15 (8%)
Mahirogullari et al.[143]	2010	26.1	91.6 ± 13.3	90.2 ± 11.4							2 (5.9%)	1 (3.3%)
Zaffagnini et al.[275]	2012	164.4	85 ± 22.6	83.2 ± 24.2	86.3 ± 16.7	87.4 ± 14.1	26.4 ± 4.8	26.9 ± 4.2			6 (12.5%)	3 (9%)
Archetti Netto et al.[7]	2012	37.5							94.1	92	2 (11.8%)	0 (0%)
Mohtadi et al.[158]	2014	24							88.2	91.4	20 (23%)	9 (11%)
Uchiyama et al.[236]	2017	62	88.3 ± 18.2	94.0 ± 9.2			33.8 ± 2.1	33.3 ± 2.8			4 (27%)	0 (0%)

ASES, American Shoulder and Elbow Surgeon Self-Assessment Score; UCLA, University of California Los Angeles Shoulder Rating Scale.

TABLE 34-5. Clinical Outcomes After Open Bristow-Latarjet and Bone Block Augmentation With Autograft and Allograft

Author	Year	No. Patients	Type of Procedure	Mean Follow-Up	Outcomes	Recurrence Rate	Complication
Open Bristow-Latarjet or Modified Latarjet							
Hovelius et al.[96]	2004	113	Bristow-Latarjet	15.2 (14.3–20.8) yr	Rowe: 89.4 Excellent: 79 Good: 16 Fair: 12 Poor: 4	20/118 (17%)	
Burkhart et al.[32]	2007	102	Modified Latarjet	59 (32–108) mo	Constant: Postop: 94.4 Walch: Postop: 91.7	5/102 (4.9%)	Hematoma: 4.3% Loose screw: 4.3% Fibrous nonunion: 2.1%
de Beer and Roberts[55]	2010	55	Latarjet	59 mo	Constant: Postop: 94.4 Walch: 91.7	5/55 (9%)	
Neyton et al.[166]	2012	34	Latarjet	144 (68–237) mo	Rowe: Postop: 93 Walch: Postop: 86	0/34 (0%)	Hematoma: 2.7% Fracture of bone block: (8.9%)
Yang et al.[273]	2016	52	Modified Latarjet	3.5 yr	SANE: Postop: 83.6 WOSI: Postop: 384 Patient satisfaction: 86.6%	8/52 (15.4%)	13/52 (25%)
Open Glenoid Bone Block Augmentation							
Rahme et al.[187]	2003	87	Iliac crest autograft	29 (22–37) yr	Constant: Postop: 85	18/87 (21.8%)	
Warner et al.[250]	2006	11	Iliac crest autograft	33 (24–60) mo	Rowe: Preop: 28 Postop: 94		
Scheibel et al.[204]	2008	10	Iliac crest autograft	37.9 (24–49) mo	Constant: Postop: 88.3 Walch: 83.5	0/10 (0%)	None
Weng et al.[260]	2009	9	Femoral head allograft	4.5 yr	Rowe: Preop: 24 Postop: 84	2/9 (22.2%)	
Steffen and Hertel[224]	2013	48	Iliac crest autograft	9.2 (5–19) yr	Constant: Postop: 85	1/48 (2%)	
Mascarenhas et al.[146]	2014	10	Iliac crest allograft	48 mo	ASES: Preop: 64.3 Postop: 97.8 SST: Preop: 66.7 Postop: 100 WOSI: Postop: 93.8	0/10 (10%)	

WOSI, Western Ontario Shoulder Instability Index; ASES, American Shoulder and Elbow Surgeon Self-Assessment Score; SST, Simple Shoulder Test; SANE, Single Assessment Numeric Evaluation.

TABLE 34-6. Outcome Analysis: Arthroscopic Bankart, Open Bankart, and Latarjet[194]

	Dislocation (%)	Instability (%)	Rowe Score	Complication
Arthroscopic	15.1 (9.9–20.3)[a]	20.2 (11.7–28.7)	85.5 (80.1–90.8)	0.0 (–4.6 to 4.6)[a]
Open Bankart	7.7 (4.2–11.1)	20.8 (14.6–27.1)	87.1 (83.9–90.3)	4.3 (0.0–8.6)
Latarjet	2.7 (–0.3–5.8)[a]	14.8 (8.6–20.9)	87.9 (84.7–91.2)	10.6 (6.6–14.7)[a]

[a]Statistical significant ($P < 0.05$).

versus Latarjet procedures. At mean follow-up of 5.3 years, the authors reported better return to sport (SPORTS score: 8 vs. 6; *P* = 0.02), ROM in the throwing position (86 degrees vs. 79 degrees; *P* = 0.01), and better subjective perception of the shoulder (subjective shoulder value [SSV]: 86% vs. 75%; *P* = 0.02) in favor of the Bankart repair. A recent meta-analysis evaluating the available data on return to sport concluded that Latarjet and arthroscopic Bankart repairs had a similar return to sport at the same level following surgery (73% vs. 71%, respectively).[100] The data, however, did not stratify with respect to types of sports/athletes involved in the analyses (i.e., overhead versus nonoverhead sports). This may explain the underlying discrepancy on return to sport after Latarjet.

Management of Expected Adverse Outcomes and Unexpected Complications Related to Anterior Glenohumeral Instability

Anterior Glenohumeral Instability:
COMMON ADVERSE OUTCOMES AND COMPLICATIONS

- Recurrent anterior instability
- Postoperative stiffness
- Bone graft failure (Latarjet or bone block augmentation): graft fracture, lysis, nonunion
- Neurologic injury (musculocutaneous and axillary nerve)
- Glenohumeral arthrosis

The overall complication rate for arthroscopic Bankart surgery is low. Data from the American Board of Orthopaedic Surgery has shown that perioperative morbidity such as infection (0.2%) and neurologic injury (0.3%) is exceedingly low.[177] Comparatively, open procedures such as open Bankart and Latarjet procedures are associated with higher complication rates (open Bankart: 4.3%; open Latarjet: 10.6% to 15%; bone block: 17.6%).[24,140,194] Recurrent anterior instability after arthroscopic Bankart repair surgery is likely the most common adverse outcome after repair. Careful physical examination and assessment of imaging for underappreciated bone loss from either the glenoid or the humeral head is paramount for success in revision surgery. For scenarios where there is no critical bone loss, revision surgery with arthroscopic or open Bankart repair can be successful.[14,41,164] Neviaser et al.[164] reported their experience of 30 patients who had failed prior arthroscopic repair for anterior instability and underwent an open repair. None of the patients had bone loss on the glenoid or humeral side that was clinically significant. At an average of 10.2 years of follow-up, no patients had an apprehension sign, pain, or instability. Of 23 who played sports, 22 resumed after surgery. Outcomes scores were as follows: ASES, 89.44 (90% good/excellent); Rowe, 86.67 (93.3% good/excellent); Western Ontario Shoulder Instability Index, 476.26 (80% good/excellent). In cases where significant glenoid bone loss is present, revision with either Latarjet or bone block augmentation would be the treatment of choice. Schmid et al.[205] evaluated their group of 49 patients who had failed one or more instability repairs with associated glenoid rim deficiencies and underwent the Latarjet procedure. The authors reported no further dislocation in their series, and two patients with subluxation did not require further intervention. Forty-three shoulders (88%) were subjectively graded as excellent or good; three, fair; and three, poor. The mean SSV increased from 53% preoperatively to 79% at the time of follow-up (*P* < 0.001), and the Constant–Murley score remained high (80% preoperatively and 85% at the time of follow-up; *P* = 0.061).

Recurrent subluxation and dislocation after Latarjet occurs at a less frequent basis compared with Bankart repair.[21,90,279] Recurrent subluxation and dislocation after Latarjet is estimated to be approximately 5.8% and 2.9%, respectively.[76] In rare cases of frank dislocation, closed reduction and conservative management has yielded satisfactory outcomes.[279] Clinical scenarios of recurrent anterior shoulder instability after Latarjet or bone block augmentation are challenging. Positioning of the coracoid or bone block graft should be carefully evaluated as malposition has been associated with recurrent instability after these procedures.[71,94] Revision reconstruction with autograft or allograft bone block has been described and successful in this challenging subset of patients who failed a prior Latarjet procedure.[71,141,203,235]

Appropriate loss of ROM after Bankart repairs and open bone block procedures, including Latarjet procedures, is expected. Typical decrease in postoperative ROM can be expected following arthroscopic Bankart repair, particularly in external rotation both with the arm down at the side and in 90 degrees of abduction. A recent meta-analysis reported this to be 3 to 9 degrees with the arm at the side and 3.5 to 6 degrees with the arm in 90 degrees of abduction.[40] In terms of Latarjet procedures, An et al.[6] reported a mean loss of 11.5 degrees of external rotation in their systematic review of eight comparative studies. These ROM deficits are typically not to the extent that needs further surgical intervention and can be successfully managed with therapy and corticosteroid injections into the glenohumeral joint. In extreme cases, arthroscopic lysis of adhesions can be performed if conservative approaches have been exhausted. Incidence of secondary surgery for capsular release after Bankart surgery (0.5%) or open bony augmentation procedures is rare (0.7%).[6,18]

Bone graft complications with bone augmentation procedures can occur intraoperatively and postoperatively. Stable nonunion of a coracoid graft or bone block is a recognized complication of the bony glenoid augmentation procedures. The patients can have good functional results with an incidental finding of stable fibrous nonunion and may not require a reoperation.[18,79] In a recent systematic review by Griesser et al.[76] that included an analysis of 45 studies (1,904 shoulders) demonstrated 174 cases of nonunion or fibrous union, an overall nonunion rate of 9.1%. Mizuno et al.[157] in their cohort of 68 patients with a mean follow-up of 20 years reported a fibrous nonunion rate of 1.5% with no recurrence of instability. Dumont et al.[62] in their 5-year review of 62 patients reported that 1 patient (1.7%) required a reoperation as a result of graft nonunion. A recent study of failed Latarjet procedures reported that use of a single screw for graft fixation was associated with clinical failure.[71] Careful preparation of the coracoid graft and the anterior glenoid is therefore paramount, along with careful placement of two screws parallel to the glenoid face to minimize the risk of graft nonunion.

Graft osteolysis can occur after coracoid transfers and bone block procedures for anterior instability. A large systematic review of 45 studies on Latarjet procedures reported graft osteolysis to be approximately 3.2%.[76] In a CT analysis study of 26 patients, Di Giacomo et al.[61] found a higher mean of 59.5% osteolysis of the coracoid graft. However, this extensive osteolysis was not found to be of any great clinical significance in terms of recurrence of instability. The osteolysis was most commonly seen in the superficial part of the proximal coracoid, while the deep portion of the distal region of the graft was the least involved in osteolysis and exhibited the best rates of bone healing.[79] If the osteolysis results in implant problems such as the screws becoming prominent, this can be managed with removal of the screws. In the rare case where coracoid graft osteolysis results in recurrence of instability, this can be managed with revision to an autograft or allograft bone block reconstruction.[71,141,203,235]

Incidence of neurologic injury after anterior instability repair varies depending on the surgical technique. Arthroscopic approaches have an exceedingly low rate of neurologic injury (0.2%) versus open procedures such as Latarjet (1.8%) with the musculocutaneous and axillary nerve at the greatest risk.[76,177] Fortunately, most of the neurologic injuries reported were transient in nature with the majority of patients recovering without further sequelae.[58,76] One suggested treatment protocol if a neurologic injury is recognized in follow-up includes a CT scan of the shoulder to evaluate for correct screw placement and graft positioning in bone augmentation procedures.[79] If there is no radiologic abnormality noted, the patient is followed at 6 weeks and 3 months. If no improvement is noted at the 3 months' follow-up, an EMG is obtained to evaluate the extent of the injury. At 6 months' follow-up, if no recovery is noted, the patient is referred to a specialist in brachial plexus injuries. Consultation of a brachial plexus injury specialist should also occur earlier in the postoperative care to help manage these challenging cases.

Postsurgical osteoarthritis after arthroscopic or open Bankart repairs has not been studied extensively. A recent systematic review noted that radiographic evident osteoarthritis was seen in 45.9% (range 24.4 to 67.4) and 45.1% (29.8 to 58.4) of patients after arthroscopic or open Bankart repairs, respectively. Arthrosis after bone augmentation procedures, such as Latarjet, has been estimated to be 42.0% (29.3 to 54.8). The development of osteoarthritis after instability surgery, however, is likely at least partly due to the recurrent instability events itself. Hovelius et al.[91] reported an 11% rate of mild osteoarthritis and 9% rate of moderate osteoarthritis 10 years after primary shoulder dislocation. At 25-years follow-up, Hovelius et al.[93] reported that the prevalence of severe arthritis in their cohort of patients was similar between those who had been treated without surgery and those who were surgically stabilized. In the case of Latarjet and bone block augmentation procedures, aberrant graft positioning, especially with intra-articular hardware, has been implicated as a cause of postsurgical arthrosis.[4,95,114,157] Accurate intraoperative graft placement to ensure that the graft is congruent with the joint articular surface and to avoid lateralization of the graft minimizes this potential complication.

POSTERIOR GLENOHUMERAL INSTABILITY

Indications/Contraindications

Persistent pain and instability refractory to conservative management consisting of activity modification and a rotator cuff strengthening protocol are the primary indications for the treatment of posterior shoulder instability. Locked posterior shoulder fracture dislocations require surgical treatment. Contraindications include an inability to be compliant with postoperative restrictions, an uncontrolled seizure disorder, an inability to participate in postoperative rehabilitation, or medical comorbidities preventing safe surgical treatment.

Arthroscopic Posterior Labral (Bankart) Repair

Preoperative Planning

✔ Arthroscopic Posterior Labral (Bankart) Repair: PREOPERATIVE PLANNING CHECKLIST

OR table	❑ Regular OR table with rails that allows placement of the arm traction apparatus ❑ Beach chair table with arm holder
Position/ positioning aids	❑ Lateral decubitus or beach chair ❑ Bean bag or peg board to stabilize the patient
Equipment	❑ 30-degree arthroscope ❑ 6–8-mm diameter threaded cannulas ❑ Labral elevator or CoVator ❑ Disposable and nondisposable curved and straight labral suture passers ❑ Suture anchors (knotless or knotted) with percutaneous insertion instruments ❑ Drill and drill guide (2.9-mm drill bit) ❑ Arthroscopic suture and tissue graspers

Plain radiographs including an axillary radiograph should be obtained. Advanced imaging including a CT scan with 3D reconstruction is useful for evaluating bone loss, dysplasia, and fractures. Bone loss from attritional, chronic instability may require consideration for a bone augmentation procedure. While there are no established parameters for determining when a soft tissue versus a bony reconstructive procedure should be used, one can draw upon similar guidelines established for anterior glenoid bone loss. Greater than 20% to 25% bone loss from the posterior glenoid is an indication for a glenoid reconstructive procedure with bone, either autograft iliac crest or distal tibial osteoarticular allograft. Ten to 20% bone loss may also require consideration for bone grafting of the glenoid depending on other factors such as soft tissue labral and capsular deficiency, decentering of the humeral head, and prior failed instability surgery. MRA evaluation is necessary for preoperative planning as it is more sensitive and specific for identification of subtle labral and capsular pathology than MRI.

Positioning

The surgery can be performed in either the lateral decubitus or beach chair position, depending on the surgeon's training and comfort. In the lateral decubitus position, the patient is intubated and positioned lateral on a bean bag or peg board. Care must be taken to ensure there is no pressure over the fibular head to avoid pressure injury to the common peroneal nerve. The operative arm is prepped and secured in a mechanical arm holder. A variety of distraction devices/arm holders are available. A device that allows for a combination of longitudinal and lateral distraction is helpful for optimizing visualization and working space in the posterior shoulder. Additionally, a small sterile bump can be placed in the axilla of the operative arm to further distract the glenohumeral joint to allow for improved visualization.

For the beach chair setup (Fig. 34-38A), the hips and knee are flexed to 60 degrees and the head is secured in neutral in a padded head holder. Similarly, the operative arm is secured in an arm holder which enables stable arm positioning and a small bump is fashioned for axillary placement and distraction of the glenohumeral joint. In this position, external rotation of the arm to 30 degrees will help open up the posterior capsule, room for suture passing and provides anchor fixation of the labrum (Fig. 34-38B).

Technique

✔ Arthroscopic Posterior Labral (Bankart) Repair: KEY SURGICAL STEPS

- ❑ Lateral decubitus or beach chair
- ❑ Examination under anesthesia
- ❑ Establish standard posterior viewing portal
- ❑ Diagnostic arthroscopy
- ❑ Establish anterior lateral superior and anterior inferior portals
- ❑ Either knotted anchor of knotless anchors with labral tape can be used
- ❑ Place 2–4 anchors to repair the labrum back on the glenoid labrum
- ❑ Patient is placed in a sling with external rotation pillow. Standard postoperative protocol is followed

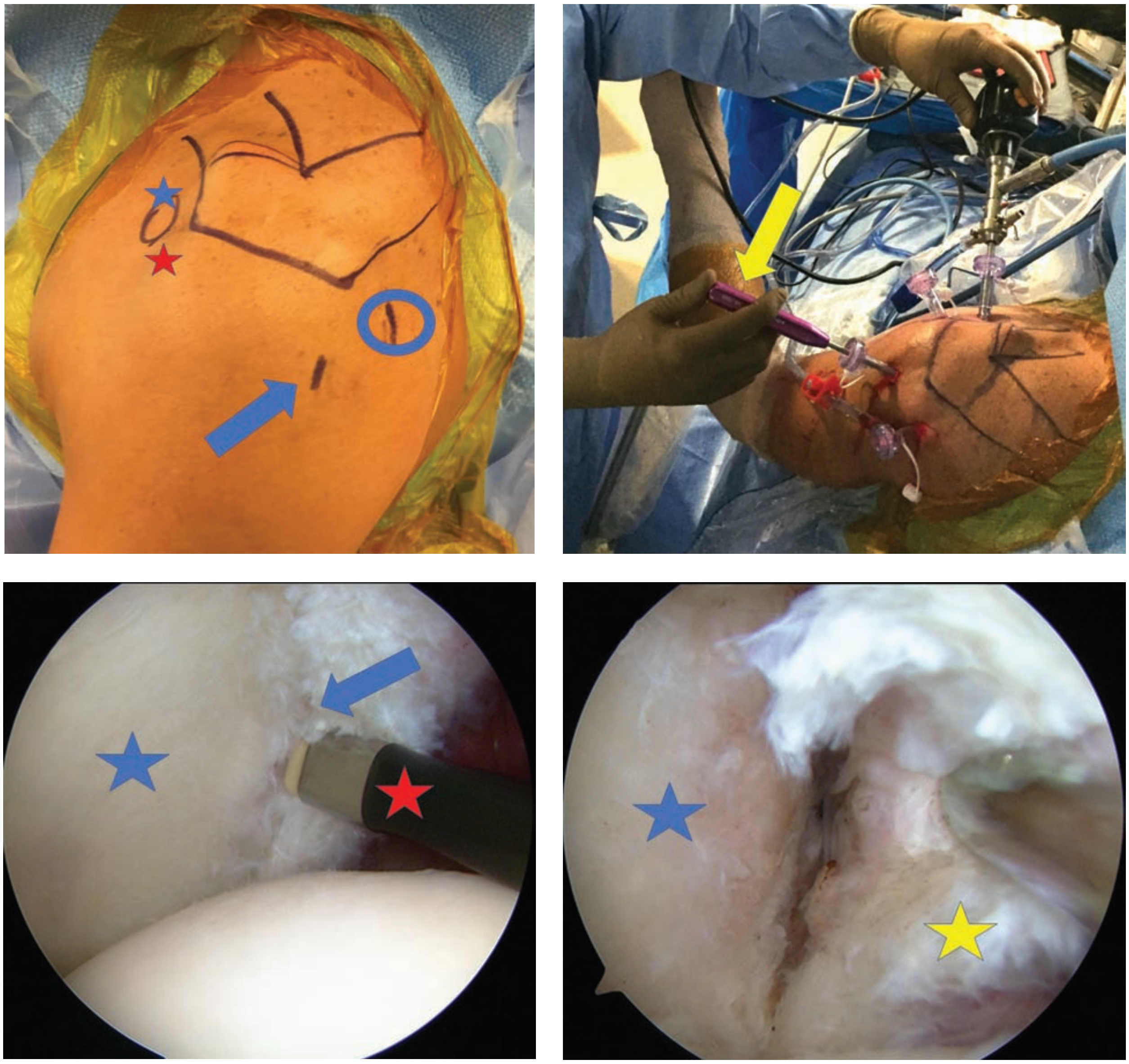
The lateral decubitus or beach chair position is used. A sterile bump composed of several sterile towels rolled up and wrapped with a Coban is placed underneath the axilla and will help with visualization by joint distraction. (This can be done in both positions.) Load and shift test under anesthesia verifies the direction of instability. Establish a standard posterior viewing portal approximately 1 cm inferior and 2 cm medial to the posterolateral acromion. Do not change this portal placement to improve angle for anchor insertion. A poorly placed portal will impair visualization and suture passage. Instead, use percutaneous anchor insertion techniques through another accessory posterior lateral portal that is in line with the scapular spine.

The trocar and arthroscopic sheath are directed toward the coracoid process in line with the glenohumeral joint (Fig. 34-38A,B). Diagnostic arthroscopy is performed to evaluate for labral tears, rotator cuff, biceps, cartilage, glenoid bone loss, bony Bankart lesions, and humeral head lesions (reverse Hill–Sachs lesion). A 30-degree arthroscope is used for visualization. Rarely, a 70-degree arthroscope can be used in the posterior portal to better visualize the labrum for repair. Another option is to put the 30-degree scope into the anterolateral portal. Two anterior rotator interval portals—anterolateral superior and anterior inferior portals—are then established using an 18-gauge spinal needle for localization. Disposable, threaded plastic cannulas are placed and a 6-mm superior viewing portal and an 8-mm anterior and inferior working portal are used. Care must be taken to separate the cannulas so there is a bridge of tissue between the two cannulas that allows for room to maneuver instruments. Also, the incisions must not be so large as to allow the cannulas to inadvertently pull out while passing instruments through them during surgery.

Once the two portals are established in the rotator interval, the viewing arthroscope is inserted in the 6-mm anterior portal while the working portal for the elevator is the anterior superolateral portal and a 3rd cannula (8 mm) is placed into location of the previously established posterior viewing portal (Fig. 34-38B). A diagnostic arthroscopy is performed and the extent of the posterior labral tear is evaluated. The previously established posterior viewing portal is parallel to the glenoid and is optimal for passing capsulolabral sutures and curved passers but may not allow for accurate placement of suture anchors at an appropriate insertion location and angle into the glenoid. Therefore, a percutaneous posterolateral accessory portal for anchor placement is necessary, especially for 5- to 7-o'clock posterior inferior anchors (Fig. 34-39). It is essential that this portal is in line with the spine of the scapula. Otherwise, there is a risk of the anchor penetrating the glenoid fossa.

Double-loaded suture anchors should be used, as they are biomechanically superior to single-loaded anchors. Knotless anchors with labral tape can also be used but are limited to one labral tape per anchor (Fig. 34-40). Depending on the pathology encountered, a capsular shift may be a desirable goal. The capsular shift/tightening is performed by passing the suture through a fold of tissue that includes the stretched or damaged posterior-inferior glenohumeral ligament and the adjacent torn posterior labrum. If a double-loaded suture anchor is used, either two simple stitches can be used or a combination mattress and simple suture configuration can be performed. The anchors should be placed on the face of the glenoid 1 to 2 mm from the edge of the intact glenoid which allows for restoration of the bumper effect of the labrum and ensures the anchors have a circumferential drill hole for stable fixation (Fig. 34-40C). Depending on the style of knotless anchor, the suture or labral tape may need to be passed first through the posterior capsulolabral complex followed by the insertion of the anchor, while traditional knotted anchors require placement of the anchor first followed by passage of sutures and knot tying.

Suture passage is achieved by either a shuttling technique or via direct passage with a penetrating suture passer such as a bird beak or curvilinear or corkscrew-style passer (see Fig. 34-39). The authors prefer a metal-tipped passer to ease the penetration through the soft tissue. For the right shoulder, posterior labral repair would require a left curved passer and vice versa. Positioning in the lateral position and use of a shuttling technique with the anteroinferior cannula is less technically demanding; however, the penetrating suture passers are effective in the beach chair position and can eliminate the need for any cannulas during surgery as well as the requirement for suture shuttling. The use of penetrating graspers without cannulas is more technically demanding but simplifies the equipment requirements and can enhance visualization. Knotted anchors require effective



A

C

Figure 34-38. **A:** Arthroscopic posterior labral repair in the beach chair position. Anterior portal (*blue star*) is used for viewing with the arthroscope, anterior lateral portal (*red star*) is the working portal for elevator and CoVator to facilitate elevation of the posterior labrum off the glenoid so that adequate capsulolabral shift is performed. Posterior working portal (*blue circle*) is used for suture shuttling devices. Typically, an 8-mm threaded cannula is used here to allow passing for these devices. Posterior lateral portal (*arrow*) is used for drilling and placement of anchors. This portal must be in line with the scapular spine so that the anchor does not penetrate the glenoid fossa. **B:** Arm is externally rotated 30 degrees to open up the posterior recess or space to allow suture passage and anchor placement. Arthroscopic drill guide is inserted into the posterior lateral accessory portal (*yellow arrow*). Camera is inserted into the anterior portal for viewing. **C:** Arthroscopic CoVator (*red star*) is inserted into the anterior lateral portal to help elevate the posterior labral tear (*blue arrow*) off the glenoid rim (*blue star*). **D:** The posterior labrum (*yellow star*) is elevated off the glenoid rim.

suture tying, and a variety of sliding locking knots with adequate loop security are available. Regardless of the style of knot used, three alternating half hitches should be tied to ensure adequate knot security is achieved. The post limb should always come from the labral/capsular side and not from the glenoid side so as to ensure the tied knots do not sit on the glenoid and create a nidus for humeral articular-sided wear and damage. Alternatively, using a knotless labral tape with pushlock anchors alleviates any risk of having knots on the glenoid surface (see Fig. 34-40). Depending on the severity and extent of the lesion, two to four anchors should be placed to allow for restoration of the labrum back to its anatomical position on the glenoid labrum. The patient is placed in a sling with external rotation pillow. Standard postoperative protocol is followed.

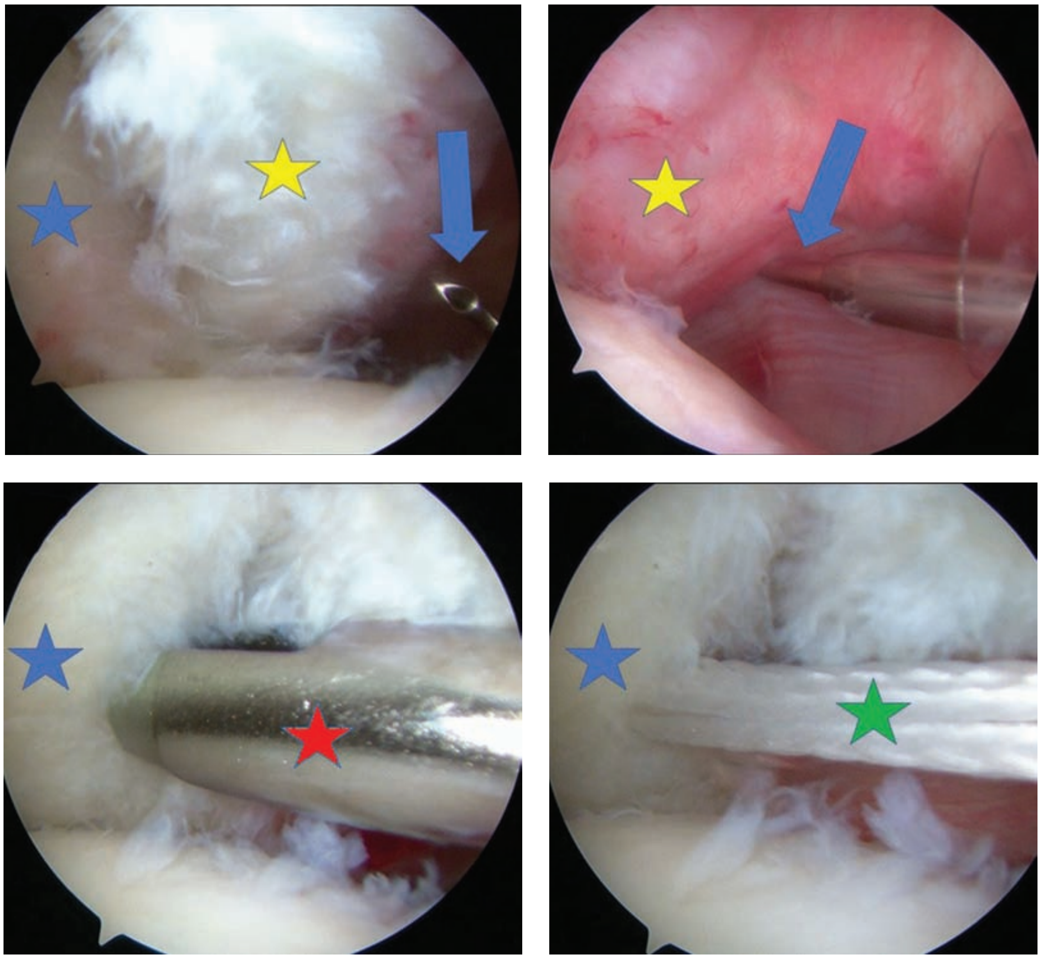

A
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Figure 34-39. **A** and **B:** Viewing from the anterior portal, a curved suture shuttle device (*blue arrow*) is inserted into the posterior 8-mm cannula to help in passing the labral tape into the capsulolabral tissue and posterior labral tear. **C:** Drill guide (*red star*) is inserted into the posterior lateral accessory portal. **D:** Pushlock anchor with labral tape (*green star*) is used to repair and shift the posterior capsulolabral complex back onto the glenoid rim. *Blue star*, glenoid; *yellow star*, labrum.

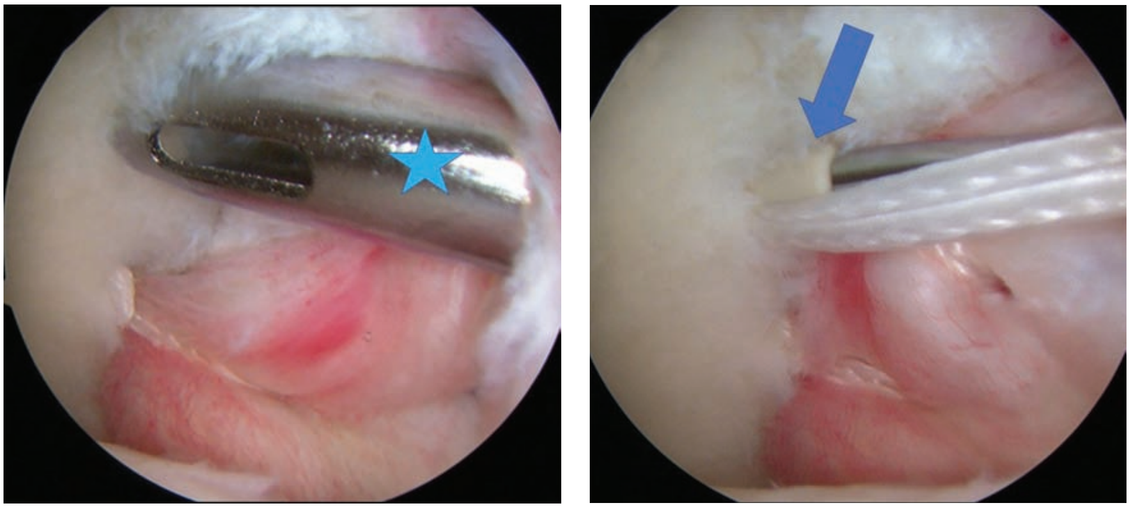
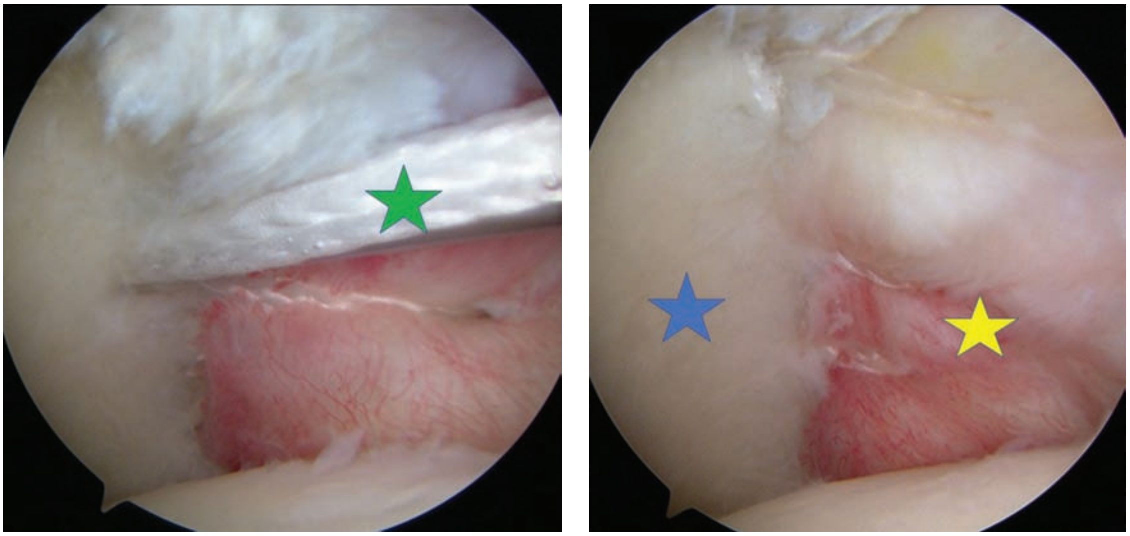

A

Figure 34-40. **A:** Arthroscope is inserted into the anterior portal for viewing with subsequent passing of the labral tape across the posterior labral tear and drill guide (*blue star*) is inserted up to repair the tear up the glenoid rim. **B:** Arthroscopic-inserted 2.9-mm pushlock anchors with labral tape (Arthrex, Naples, FL) are used to repair the tear (*blue arrow*).



C

Figure 34-40. (*Continued*) **C:** Pushlock anchor inserted with knotless fixation and labral tape (*green star*). **D:** Final repair construct with a total of four anchors in the posterior glenoid rim (*blue star*) with labral tape knotless fixation of the posterior labral tear (*yellow star*).

Open Posterior Labral (Bankart) Repair or Capsular Shift

Preoperative Planning

✔ Open Posterior Labral (Bankart) Repair or Capsular Shift:
PREOPERATIVE PLANNING CHECKLIST

OR table	❑ Lateral decubitus with arm holder or beach chair. The surgical area that is prepped must be medial enough to allow for the open posterior incision at the joint line. A bump can be placed under the scapula to help bump the posterior joint line up and allow for the open approach
Position/positioning aids	❑ Peg board or bean bag with axillary roll ❑ Beach chair position with spider arm holder (Tenet Medical)
Equipment	❑ Open shoulder set ❑ Linked Kobel shoulder retractor, anterior Bankart retractor ❑ Anchors with preloaded sutures ❑ Drill bits and drill guide specific to the anchors used ❑ Curved and straight suture passers ❑ 4.5–5.5-mm double-loaded anchor for the repair of the infraspinatus tendon ❑ 2.9- or 3.0-mm double-loaded suture anchors for capsulolabral repair

Similar to that for arthroscopic posterior labral repair.

Positioning

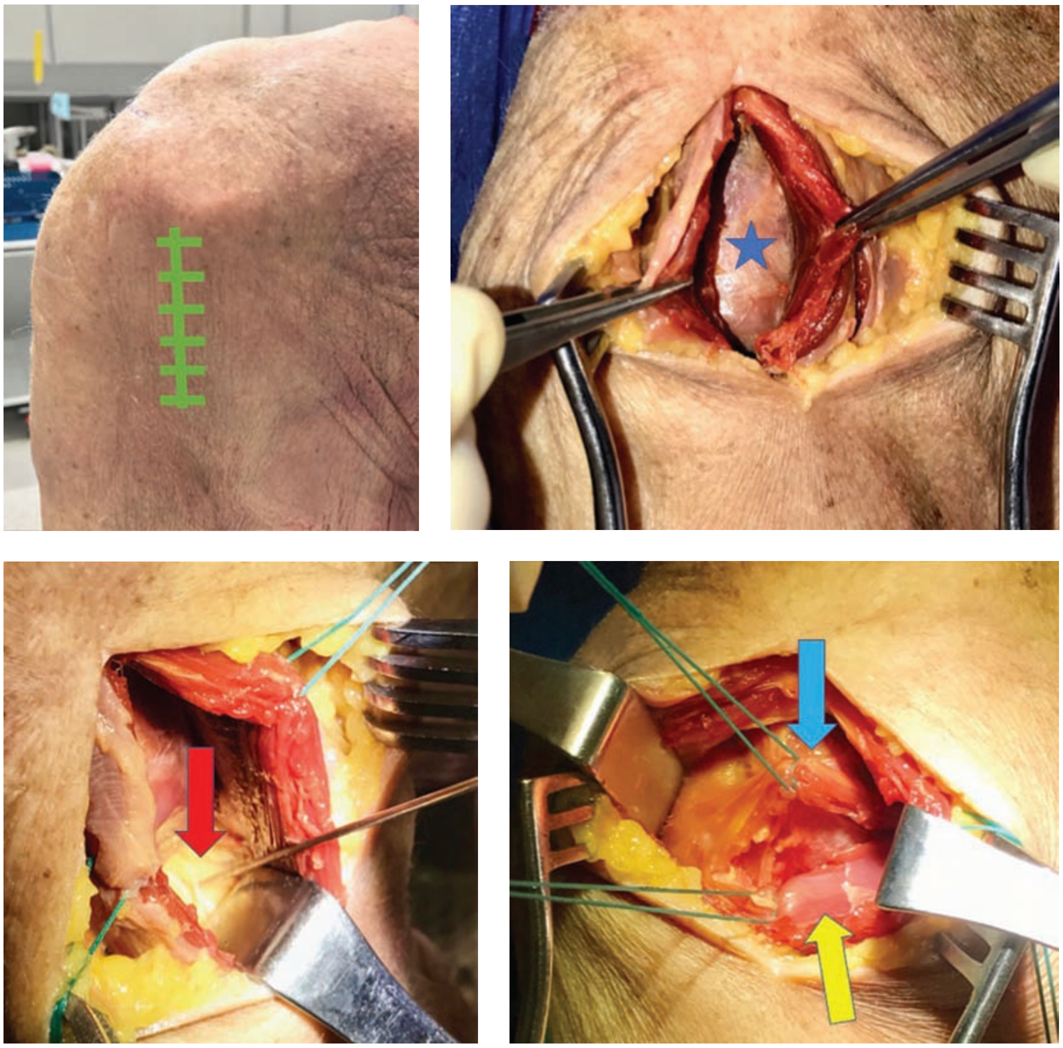
The patient is positioned in the lateral decubitus and an adjustable arm holder is used to allow adjustment of arm positioning during the case. Alternatively, the patient can also be positioned in the beach chair position with a bump underneath the spine with the medial border of the scapula draped (Fig. 34-41A).

Technique

✔ Open Posterior Labral (Bankart) Repair:
KEY SURGICAL STEPS

❑ Lateral decubitus position with arm holder or beach chair position with spider arm holder
❑ Posterior longitudinal incision centered over the posterior joint line and deltoid split
❑ Open the interval between the infraspinatus and teres minor
❑ Separate the capsule from the infraspinatus and teres minor muscles
❑ Horizontal capsulotomy or "T" capsulotomy
❑ Tag both leaflets with sutures
❑ Elevate the labral lesion off the glenoid rim and abrade the posterior glenoid rim superficially with a burr
❑ Place double-loaded suture anchors on the posterior glenoid rim along the extent of the tear
❑ Shuttle the sutures from the anchor on the glenoid rim through the capsulolabral tissue
❑ Shift the capsule and repair it using interrupted sutures
❑ Repair the infraspinatus teres minor
❑ Close the deltoid split and skin
❑ Place the patient in an external rotation sling

The patient is placed in the lateral decubitus position with arm holder to allow different arm positions throughout the case or beach chair position with spider arm holder. A longitudinal incision over the posterior shoulder extending from the posterolateral acromion to the level of the posterior axillary fold is performed (Fig. 34-41A, *green line*). The deltoid is split in-line with its fibers to the level of the posterior axillary fold (Fig. 34-41B). The incision must be lateral enough to access the insertion of the infraspinatus and teres minor (Fig. 34-41B, *star*). Two to three centimeters of the deltoid can be elevated off of the acromion to assist



A

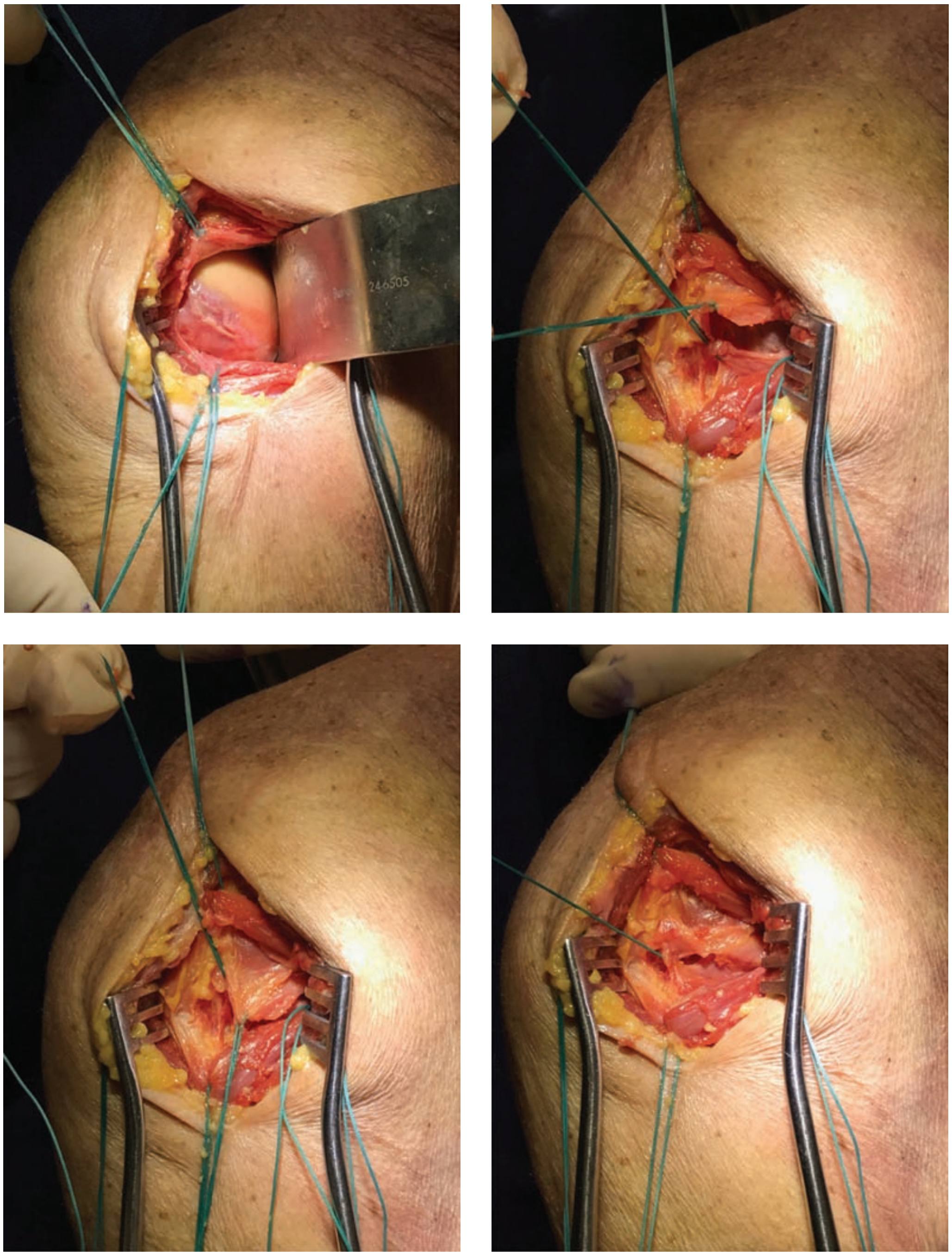
C

Figure 34-41. **A:** Open posterior Bankart or capsular shift procedure can be performed either in the lateral decubitus or in the beach chair position. This figure demonstrates the procedure in the beach chair position. Posterior open incision is centered over the posterior joint line. The surgical prep area must be medial so that the posterior glenohumeral joint is exposed. **B:** The deltoid fibers are split in line to expose the posterior rotator cuff musculature (*star*). **C:** The deltoid is tagged with no. 2 braided sutures with the spinal needle pointing to the posterior axillary nerve. **D:** The infraspinatus musculature (*blue arrow*) is split horizontally in line with the teres minor muscle (*yellow arrow*) to expose the posterior capsule and joint line.

in exposure. A shoulder linked retractor (Kolbel self-retractor) is placed to hold open the deltoid split. The axillary nerve and posterior circumflex artery are identified in the quadrangular space and protected (Fig. 34-41C). The interval between the infraspinatus and teres minor is opened and these tendons are partially elevated from their insertions laterally (Fig. 34-41D). The infraspinatus can be detached or partially elevated as can the teres minor to enhance exposure. Separation of the underlying capsule from the rotator cuff is important.

Scissors and a Cobb elevator are used to separate the capsule from the infraspinatus and teres minor muscles in a medial-to-lateral direction. A horizontal capsulotomy or "T" capsulotomy is performed from 1 cm lateral to the glenoid rim to the greater tuberosity to facilitate the capsular shift (Fig. 34-42A). Tagged sutures should be placed on each layer to aid in retraction and exposure (Fig. 34-42B). Homan retractors are placed over the superior and inferior glenoid rim and a humeral head retractor is placed in the glenohumeral joint to gently push the humeral head back to allow for optimal exposure (Fig. 34-42C).

The labral lesion is elevated off the glenoid rim with a soft tissue elevator. (A curved glenoid neck retractor can be placed, but great care must be taken not to damage or compress the suprascapular nerve as it passes through the spinoglenoid notch.) The posterior glenoid rim is superficially abraded with a burr. A 3-mm double-loaded suture anchors are placed on the posterior glenoid rim along the extent of the tear. Depending on the size of the tear, two to four suture anchors should be used for the repair. Either a free needle or a curve or straight suture passer is used to shuttle the sutures from the anchor

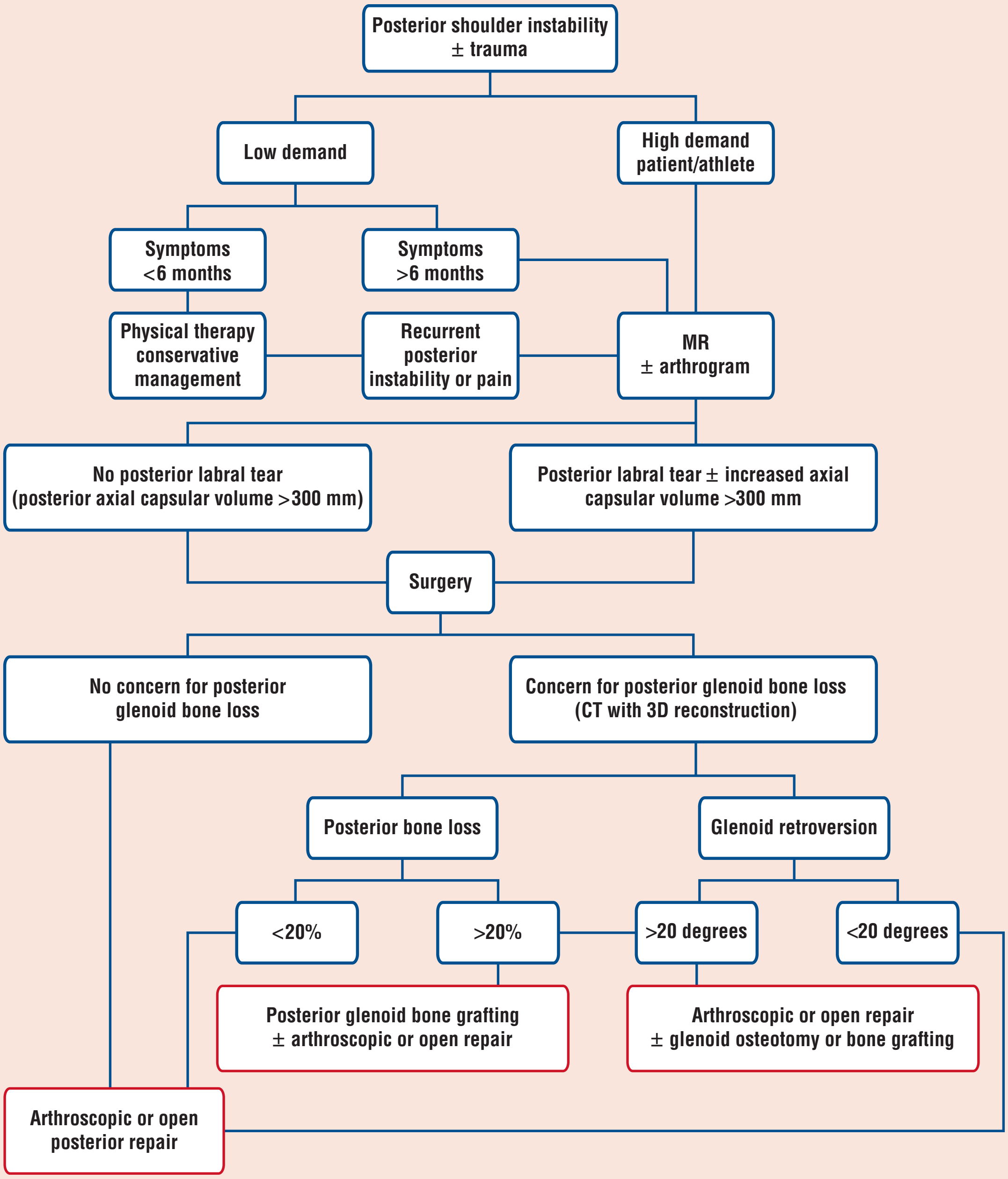


A I C I

Figure 34-42. **A:** Posterior "T" capsulotomy is performed with Fakuda inserted into the glenohumeral joint to allow exposure. Alternatively, a Bankart retractor can be inserted over the glenoid neck to expose the posterior labral tear for repair. **B:** Posterior capsulotomy is tagged with no. 2 braided sutures. **C:** Posterior capsular shift is performed and the capsule is sutured together in a pants-over-vest fashion. **D:** Final posterior capsular shift is seen here after suture repair.

on the glenoid rim through the capsulolabral tissue starting at the most inferior portion of the tear and continuing superiorly until the labral lesion is repaired. Following the labral repair, a repair of the capsular split is performed. A capsular shift can be performed as well by completing a "pants over vest" repair if capsular laxity or redundancy is part of the pathologic problem (Fig. 34-42C). A single 4.5- or 5.5-mm anchor is placed at the footprint of the infraspinatus/teres minor and is used to repair these tendons back to their anatomic insertions (Fig. 34-42D). The deltoid split is closed with running no. 2 sutures and skin is closed with 3-0 Monocryl and Dermabond. The patient is placed in an external rotation sling.

Authors' Preferred Treatment for Posterior Glenohumeral Instability (Algorithm 34-3)



Algorithm 34-3. Authors' preferred treatment for anterior shoulder instability with or without trauma.

Patients who present with symptoms of posterior shoulder instability should be grouped into either low demand/nonathletes or high demand/athletes. It is important for the physician to differentiate between symptoms of posterior apprehension, instability, or pain as these can help guide treatment options. In the low-demand group, symptoms less than 6 months should be addressed with conservative management with physical therapy focusing on ROM exercises and rotator cuff and deltoid musculature strengthening. For patients who present with longer than 6 months of duration of symptoms, advanced imaging should be obtained to evaluate for intra-articular injuries. If no posterior labral tear is detected on the MRI (with or without arthrogram), then physical therapy and conservative management is initiated. If there is no posterior labral tear but the posterior axial capsular volume is greater than 300 mm, or in patients with discrete posterior labral tear, surgery should be recommended.

In patients who present with glenoid retroversion or bone loss on CT images, the decision between arthroscopic repair and posterior bone block procedure is based on the critical amount for both retroversion and bone loss.

Arthroscopic or open repair is recommended with <20 degrees of glenoid retroversion and <20% of glenoid bone loss. In patients with >20 degrees of retroversion and >20% of bone loss, a posterior bone block procedure in addition to posterior labral repair is recommended which can be done arthroscopically or open. In the subset of patients with >20 degrees of retroversion and <20% of glenoid bone loss, both arthroscopic or open repair with and without block procedure should be considered based on the patient's activity level, presenting symptoms, and expectations. There is paucity of high-quality literature available to direct management of posterior shoulder instability, especially when deciding between arthroscopic and bone block procedures. The authors do prefer the arthroscopic technique over the open technique for posterior stabilization in the subset of patients with <20 degrees of retroversion and <20% of bone loss. In the patients with >20% of glenoid bone loss and >20 degrees of retroversion, the authors prefer open posterior glenoid bone grafting with iliac crest autograft and capsular labral repair with either arthroscopic technique or open technique depending on the patient, anatomy, and exposure.

Postoperative Care

The patient is placed in an external rotator immobilizer to protect the posterior repair for 6 weeks. Avoid forward flexion with the arm adducted across the midline in the acute phase after surgery. In phase I between 2 and 6 weeks, the patient stays in the ER immobilizer with elbow and wrist ROM and pendulums. In phase II between weeks 6 and 12, the patient will start passive ROM and progress to active ROM. The authors recommend starting the passive ROM in the supine position without pain. Limit internal rotation and adduction of the arm. Mild strengthening program is started around 10 to 12 weeks after surgery. In phase III between weeks 12 and 18, the patient progresses to full ROM and isokinetic strengthening. An activity-specific plyometrics program is also started along with sport-specific related programs. Return to sports or high-demand labor jobs typically takes 6 to 9 months after surgery.

Potential Pitfalls and Preventive Measures

Posterior Glenohumeral Instability:
SURGICAL PITFALLS AND PREVENTIONS

Pitfall	Prevention
• Aberrant portal placement	• Use a standard posterior lateral accessory arthroscopic portal established parallel to glenoid articular surface. The drill guide should be parallel to the spine of the scapula
• Poor angle for anchor insertion	• Use percutaneous technique and independent posterolateral portal
• Inability to visualize posterior-inferior labrum and capsule in beach chair position	• Use lateral position with axillary roll/bump • External rotation of the arm will help open the posterior capsule to allow space to work in the back to repair the labrum
• Difficulty with passing the suture	• If the posterior working portal is above the labral tear, use the curved guide that is opposite of the operative extremity (right curve for left shoulder and vice versa). If the posterior working portal is at the level of the labral tear, then use the 90-degree passer to assist in the shuttling of the sutures

Outcomes

Historically, posterior shoulder instability was treated with open repair, but with the advent of improved arthroscopic techniques, implants, and instrumentation, arthroscopic posterior capsulolabral repairs are increasingly common. The difficulty and added surgical morbidity of open repair further diminish its popularity in favor of arthroscopic techniques. A meta-analysis comparison of open versus arthroscopic posterior labral repairs found a 19% recurrence rate of posterior instability while the arthroscopic repair recurrence rate was 8%.[59] The largest series published includes 200 arthroscopic posterior labral repairs on athletes whom experienced a 90% return to play.[29] While glenoid dysplasia and increased glenoid retroversion have been identified as risk factors for the development of posterior shoulder instability,[69,174] the effect of increased retroversion and glenoid dysplasia does not appear to have an effect on outcomes.[28]

Kim et al.[119] evaluated the outcome after arthroscopic labral repair and posterior capsular shift in 27 patients with traumatic unidirectional recurrent posterior subluxation and reported that all patients were able to return to preinjury sport activities with little or no limitations. Shoulder function was graded as >90% of the preinjury level in 24/27 (89%) patients. The average pain score decreased from 4.5 points to 0.2 points postoperatively with no operative complications. Williams et al.[265] reported similar outcomes in 27 patients after arthroscopic posterior repair in patients with traumatic posterior shoulder instability. At a mean follow-up of 5.1 years, no patients demonstrated a ROM deficit. Symptoms of pain and instability were eliminated in 24/27 patients (89%) with two patients (8%) requiring additional surgery for recurrence of symptoms. In the athletic patient population, Bradley et al.[28] reported 89% of their patients were able to return to sports after arthroscopic posterior labral repair while only 67% of the patients were able to return to their preinjury sport levels. Despite the overall excellent functional outcomes and low failure rates reported in the literature, Radkowski et al.[186] found that throwing athletes were less likely to return to their preinjury level of sport (55%) compared with nonthrowing athletes (71%). DeLong et al.[59] in a systematic review and meta-analysis of clinical outcomes of posterior shoulder instability found that arthroscopic repair is shown to be an effective and reliable treatment for unidirectional posterior shoulder instability with respect to the outcome scores, patient satisfaction, and return to play. Furthermore, arthroscopic stabilization with suture anchors results in fewer recurrences and revisions than anchorless repair in high-demand athletes.

In the subset of patients who present with chronic posterior glenohumeral instability and critical bone loss of greater than 20% or failed arthroscopic or open posterior stabilization procedure, posterior bone-blocking procedure is considered the treatment of choice. This can be done with either allograft or autograft. Most of the studies in the literature are of Level IV evidence consisting of small case series. Barbier et al.[13] reported on the outcome of 8 patients after iliac crest bone block procedure and found satisfactory results in 80% of their cases; however, three of eight patients required revision surgery and several patients experienced limitation in external rotation of more than 20 degrees postoperatively. Sirveaux et al.[217] compared the outcome between iliac crest bone block and an acromial pediculated bone block in 18 patients and reported both procedures were effective in stabilizing the shoulder from recurrences in long-term follow-up. Less posttraumatic glenohumeral arthritis was noted when compared to bone block procedures for anterior shoulder instability. However, the authors recommended additional capsuloplasty when inferior laxity is associated with posterior instability. In the largest multicenter series of 66 patients with posterior shoulder instability and bone block procedures, the authors reported significant improvement in the Constant scores and Rowe scores after surgery. Additionally, pain scores were reduced and 85% of the patients were satisfied or very satisfied with the outcome.[47] Recently, several authors have reported on the outcome of arthroscopic posterior bone block procedure for posterior instability and found similar results compared with the open technique.[259] However, arthroscopic techniques are still evolving and long-term outcomes are not available at this time.

Management of Expected Adverse Outcomes and Unexpected Complications Related to Posterior Glenohumeral Instability

Posterior Glenohumeral Instability:
COMMON ADVERSE OUTCOMES AND COMPLICATIONS

- Recurrence of instability
- Persistent pain after surgery
- Posttraumatic arthritis
- Nerve injury (axillary)
- Stiffness or loss of motion
- Hardware irritation

The most common adverse outcome after posterior shoulder instability surgery is recurrent instability. A variety of factors must be evaluated for determining the cause of failure. Bone loss from the posterior glenoid, rotator cuff tears or insufficiency, arthritic changes, glenoid dysplasia, soft tissue deficiency, technical errors in surgical technique, postoperative secondary adhesive capsulitis, and neurologic injury are all known complications that can result from surgery to treat posterior glenohumeral instability.

Suspected bone loss should be evaluated with a 3D CT scan to determine the degree and severity of the defect. Treatment of bone loss with bony augmentation procedures can be considered. Rotator cuff insufficiency/tears can be identified on physical examination and are confirmed with MRI. Clinically relevant rotator cuff tears must be addressed with surgical repair. Technical errors resulting in failed surgery are numerous and include failure of anchor fixation resulting in recurrent labral tears and loose bodies, inadequate number of suture anchors, and errors in rehabilitation. Persistent pain from cartilage loss and arthritic changes are particularly challenging especially in the young patient, and salvage procedures such as glenohumeral arthrodesis or shoulder arthroplasty are possible but associated with unpredictable long term outcomes. Glenoid dysplasia treatment includes consideration for glenoid osteotomy or a posterior glenoid bone grafting procedure. Secondary adhesive capsulitis can be managed in a variety of ways depending on severity, duration of symptoms, and pain. Treatment options include glenohumeral cortisone injections, physical therapy with stretching exercises, and arthroscopic capsular release. Neurologic injuries, while rare, unfortunately have little potential for improvement but may be treated with nerve or muscle transfers.[38,207]

MULTIDIRECTIONAL GLENOHUMERAL INSTABILITY

Indications/Contraindications

Indications for operative management of multidirectional glenohumeral instability include patients with symptomatic recurrent instability who have undergone nonoperative strengthening for a period of 6 to 12 months. Patients who are voluntary dislocators or those with serious psychological or secondary gain issues are contraindicated. Operative treatment should only be discussed after the patient has demonstrated a failure to improve with a lengthy duration of nonoperative treatment to include either physical therapy or home-based exercises. While no specific duration exists that is evidence-based, however, most clinicians feel that 6 months to a year is needed prior to offering surgical intervention.

Common surgical techniques include either an open inferior capsular shift or arthroscopic capsular plication.[246] Thermal capsulorrhaphy is no longer recommended as it was found to be associated with a high rate of subsequent failure and linked to chondrolysis.[3,154] Surgical management by any means must be thoroughly discussed with the patient. A recent systematic review revealed, with only low-quality evidence, that surgery was superior to nonoperative management for only impairment-based outcome measures while nonoperative treatment was favored for most patient-based outcome measures.[245]

The inferior capsular shift was described by Neer and Foster in 1980 as a procedure that could be performed through either an anterior or posterior approach.[163] It has been further described with slight modifications,[5,9] but the basic tenets of the surgery remain the same. The surgery entails typically an anterior approach, accessing the capsule through a subscapularis tenotomy. The capsule can then be split and advanced in a pants-over-vest technique with subsequent fixation to decrease intra-articular volume. As arthroscopic equipment has improved throughout the years, so have the arthroscopic techniques to address glenohumeral joint stability. As such, arthroscopic management of MDI has become increasingly popular.[17,44,87,228]

Arthroscopic Capsular Plication

Preoperative Planning

Arthroscopic Capsular Plication: PREOPERATIVE PLANNING CHECKLIST

OR table	❑ Regular table is used for lateral decubitus position
Position/ positioning aids	❑ Bean bag is used to obtain lateral decubitus position ❑ Pneumatic arm holder to provide longitudinal traction and allow internal/external rotation of the shoulder ❑ Separate abduction paddle
Equipment	❑ 30- or 70-degree arthroscope ❑ 6- or 8-mm threaded cannulas ❑ Switching sticks ❑ Percutaneous insertion kit and double-loaded 2.4-mm suture anchors for use in anterior-inferior and posterior-inferior margin of glenoid. Alternatively, labral tape and knotless fixation with pushlock anchors can be used as well. ❑ If the labrum is intact, use alternate no. 1 absorbable polydioxanone (PDS) suture with suture anchors ❑ Knotless suture anchors (2.9-mm anchor with no. 2 high tensile strength suture, or looped suture, or suture tape) ❑ Arthroscopic rasp and liberator, CoVator ❑ Arthroscopic shaver
Other	❑ Suture passer with multiple angles usually needs at least a curve to the right, a curve to the left, and a straight passer for pan-capsular plication

Positioning

The patient is positioned in the lateral decubitus position with the operative extremity facing superiorly. Pillows are used between the knees, and the contralateral arm is positioned in forward flexion at the shoulder with the elbow flexed into a comfortable position. The neck is positioned in neutral. A bean bag, peg board, or commercially available positioning system is then utilized to secure the patient in the lateral position and then secure the patient to the table (Fig. 34-43A). A pneumatic arm holder or traction system is secured to either the anterior or posterior aspect of the bed, according to surgeon preference, and provides in-line traction. A separate paddle or abduction cable is placed about the operative arm to provide abduction. When this is completed, then the shoulder is prepped and draped to allow circumferential access.

Beach chair position and set up can also be used for this procedure. The patient is sat up to 60 to 70 degrees with all prominences well padded. An arm holder is used to assist in the arm positioning. A small bump can also be used to help distract the glenohumeral joint. An advantage of the beach chair position is that the arm can be positioned to help better expose the joint. Internal rotation will help open up the anterior capsule while external rotation will help open up the posterior capsule.

Surgical Approach

Surface anatomy—including the lateral clavicle, the acromion and spine of the scapula, and the coracoid—is marked out on the skin prior to the start of the case. Standard arthroscopy portals are created which include a posterior initial viewing portal, an anterior-inferior portal just above the upper border of the subscapularis,

A

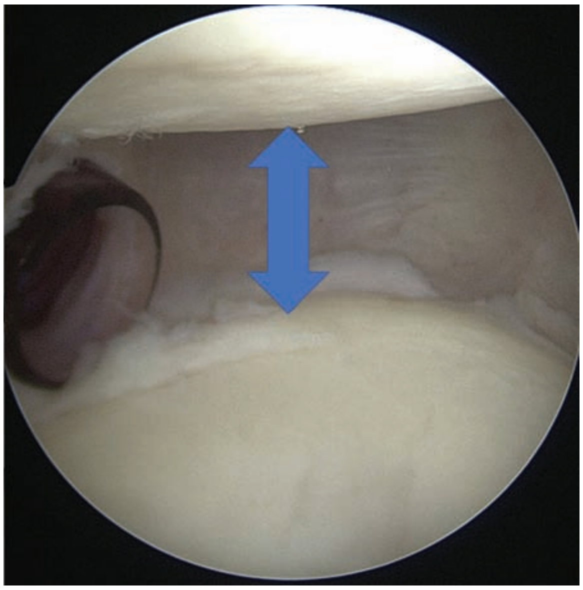


Figure 34-43. A: Lateral decubitus position for arthroscopic capsular plication or shift in a patient with multidirectional instability. **B:** Diagnostic arthroscopy indicates a positive "drive-through" sign (*blue arrow*) with capsular laxity and joint mobility.

and then a superior-lateral viewing portal. The camera is switched to the superior-lateral portal for most of the cases, and 6-mm cannulas are placed in the anterior and posterior portals. Typically, percutaneous portals are used to place the anterior-inferior and posterior-inferior anchors without the need for standard cannulas. The anterior inferior and posterior working portal may need an 8-mm threaded cannula for ease of passing the suture shuttling device. Depending on the company, some curved passers will go through a 6-mm cannula and others need 8-mm cannulas.

Technique

✔ Arthroscopic Capsular Plication: KEY SURGICAL STEPS

- ❑ Although lateral and beach chair positioning are possible, lateral position allows for greater distraction and traction of the glenohumeral joint and improved access to the inferior capsule
- ❑ Examination under anesthesia
- ❑ Ensure the location of neurovascular structures when placing percutaneous portals
- ❑ Both 6- and 8-mm threaded cannulas are used for this procedure
- ❑ Preparation of capsule with abrasion prior to placing sutures
- ❑ Glenoid rim preparation with a rasp or shaver prior to inserting suture anchors
- ❑ Place the inferior anchor low on the glenoid face
- ❑ For right shoulder, a "right" curved passer is used for anterior capsular shift and a "left" curved passer is used for the posterior capsular shift, and vice versa for the left shoulder
- ❑ Patient is placed in a sling with abduction pillow. Standard postoperative protocol is followed

The first step is to complete a diagnostic arthroscopy and evaluate all intra-articular structures, looking for sources of pathology that correlates with the history, physical examination, and imaging. The patulous inferior capsule can be noted as the joint is easily distracted (Fig. 34-43B, patulous inferior capsule with positive "drive through" sign). After documenting this, a curved rasp is used to abrade the inferior capsule in preparation for the plication until punctate bleeding is noted when the arthroscopy flow is temporarily stopped. If the inferior labrum is intact, then a liberator is used to prepare the edge of the glenoid for suture anchor insertion. If there is a labral tear, then the liberator or CoVator is used to completely free up the labral tissue until the musculature of the underlying rotator cuff can be visualized. Double-loaded anchors are placed at the 5 and 7 o'clock positions on the glenoid to grasp both bands of the IGHL.

Percutaneous drilling will allow the surgeon to place the anchor down to the very inferior position of the glenoid or 6 o'clock position (Fig. 34-44A). A suture passer is used to penetrate the capsule approximately 10 mm off of the labrum (Fig. 34-44B) and then again pass again under the labrum for the second suture to advance the capsular tissue (Fig. 34-44C). Sutures are tied, ensuring that the knot stack remains off of the cartilage surface (Fig. 34-44D). Final arthroscopic capsular shift can be seen in Figure 34-44D. The patulous capsule is shifted to decrease the capsular volume. Working superiorly, more anchors are placed in a similar fashion, although if the labrum is intact, sutures can be used without the need for anchors (PDS plication). Sutures can be of a permanent or absorbable material.

Open Anterior-Inferior Capsular Shift

Preoperative Planning

✔ Open Anterior-Inferior Capsular Shift: PREOPERATIVE PLANNING CHECKLIST

OR table	❑ Modified beach chair with 45 degrees of hip flexion
Position/ positioning aids	❑ Pneumatic arm holder can be utilized, but is not necessary, padded Mayo stand can be used to hold arm as well
Equipment	❑ Open shoulder retractors, including humeral head retractor, Koebel linked shoulder retractor ❑ Rasps/curettes to prepare site for suture anchor placement ❑ Suture anchors (double-loaded, high tensile strength sutures) ❑ No. 2 nonabsorbable high tensile strength sutures ❑ No. 1 absorbable PDS suture

Positioning

The patient is positioned in a modified beach chair position with approximately 45 degrees of hip flexion (Fig. 34-45). The head and neck are well secured and the contralateral arm is positioned comfortably on a support. An arm holder may be used, although it is not necessary. A padded Mayo stand can also be used to support the arm. The shoulder is prepped with surgical prep from the neck to the midline of the sternum to the nipple inferiorly, and the entire arm is prepped as well.

Surgical Approach

Surface anatomy to include the lateral clavicle, the acromion, and spine of the scapula and the coracoid are marked out on the skin prior to the start of the case. A 6-cm vertical incision beginning from the coracoid and extending to the axilla is used. Alternatively, a more traditional deltopectoral, oblique incision can also be used for this procedure (Fig. 34-46A).

Technique

✔ Open Anterior-Inferior Capsular Shift: KEY SURGICAL STEPS

- ❑ Beach chair position with arm holder
- ❑ Examination under anesthesia
- ❑ Vertical skin incision or standard deltopectoral approach
- ❑ Subscapularis tenotomy
- ❑ Close down anterior capsular redundancy using inside-out vertical mattress suture
- ❑ Alternatively, insert suture anchors on the humeral head to close the patulous capsule
- ❑ Ensure the arm is in adequate abduction (20 to 30 degrees) and external rotation (20 to 30 degrees) when repairing the inferior and superior limbs of the capsule so the joint is not overconstrained
- ❑ Close subscapularis tenotomy with interrupted sutures
- ❑ Patient is placed in a sling with abduction pillow
- ❑ Follow standard postoperative protocol

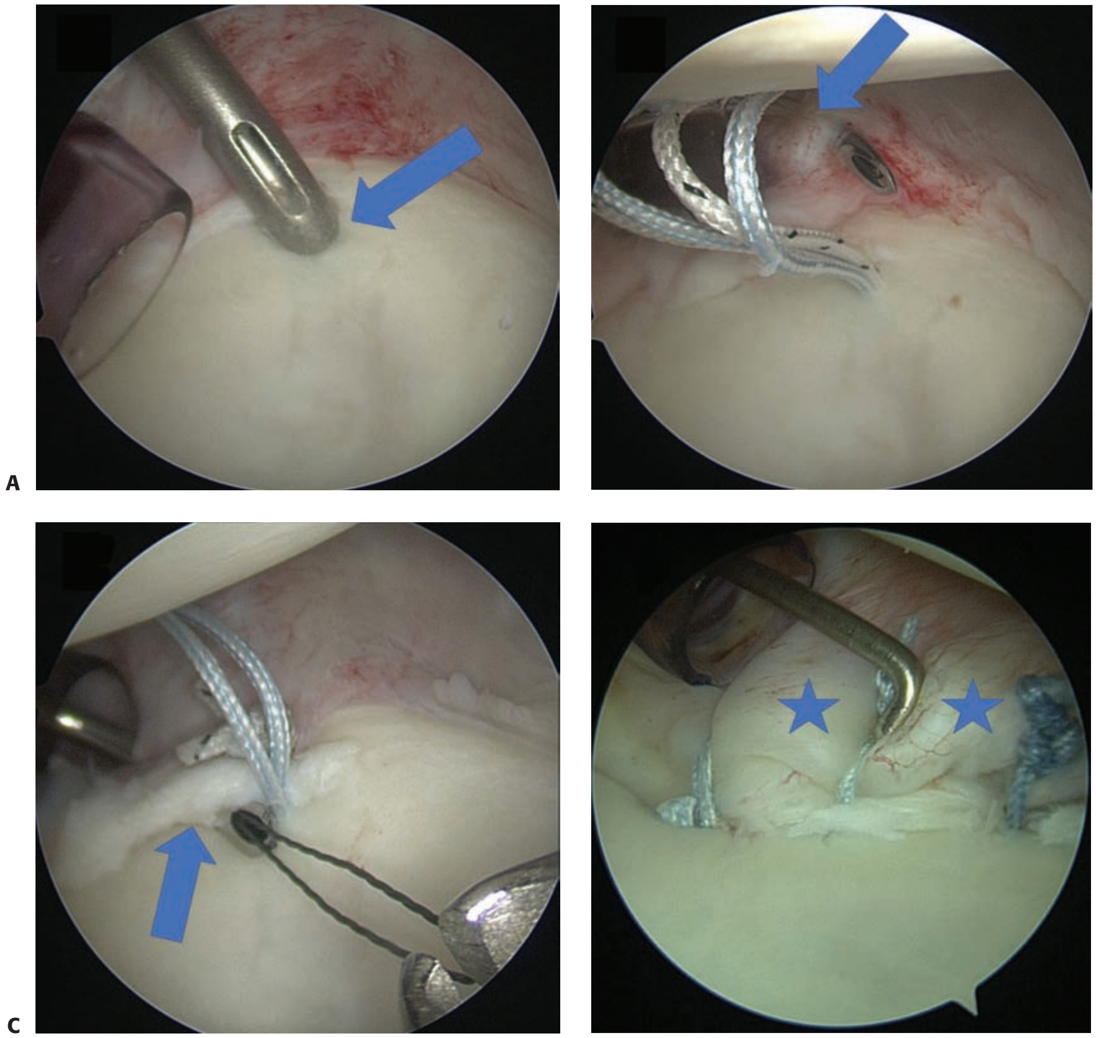


Figure 34-44. **A:** First anchor is placed percutaneously at the 6 o'clock position (*arrow*). **B:** Capsular plication is performed with the curved passer penetrating the redundant capsule to assist in the shuttling of the first suture from the anchor. **C:** The second pass is through the labrum and the second suture from the anchor is shuttled across. These sutures are tied using surgeon's knots. **D:** Final arthroscopic capsular plication/shift with three anchors. The patulous capsule is shifted (*star*) to decrease the capsular volume.

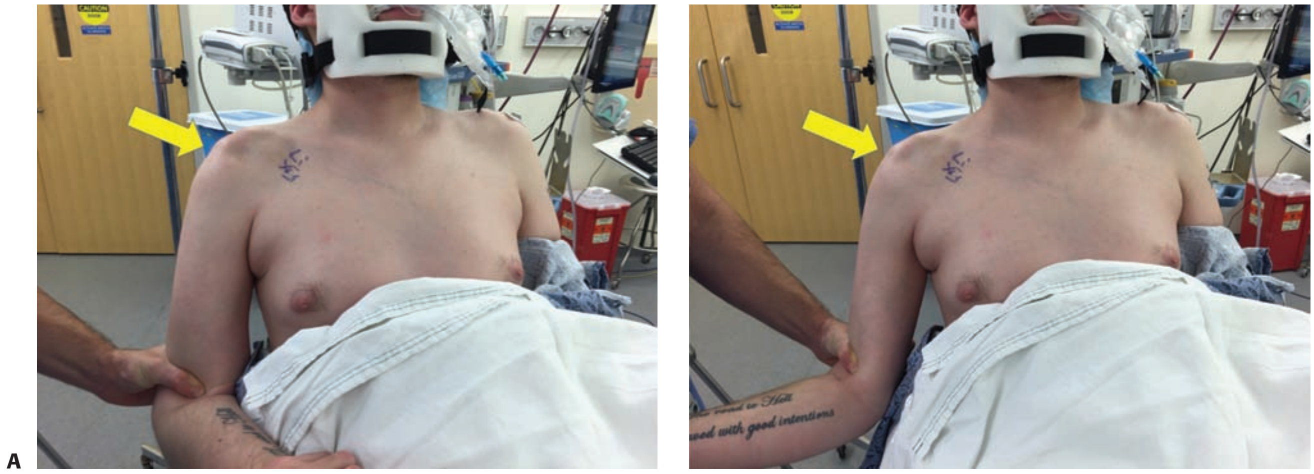
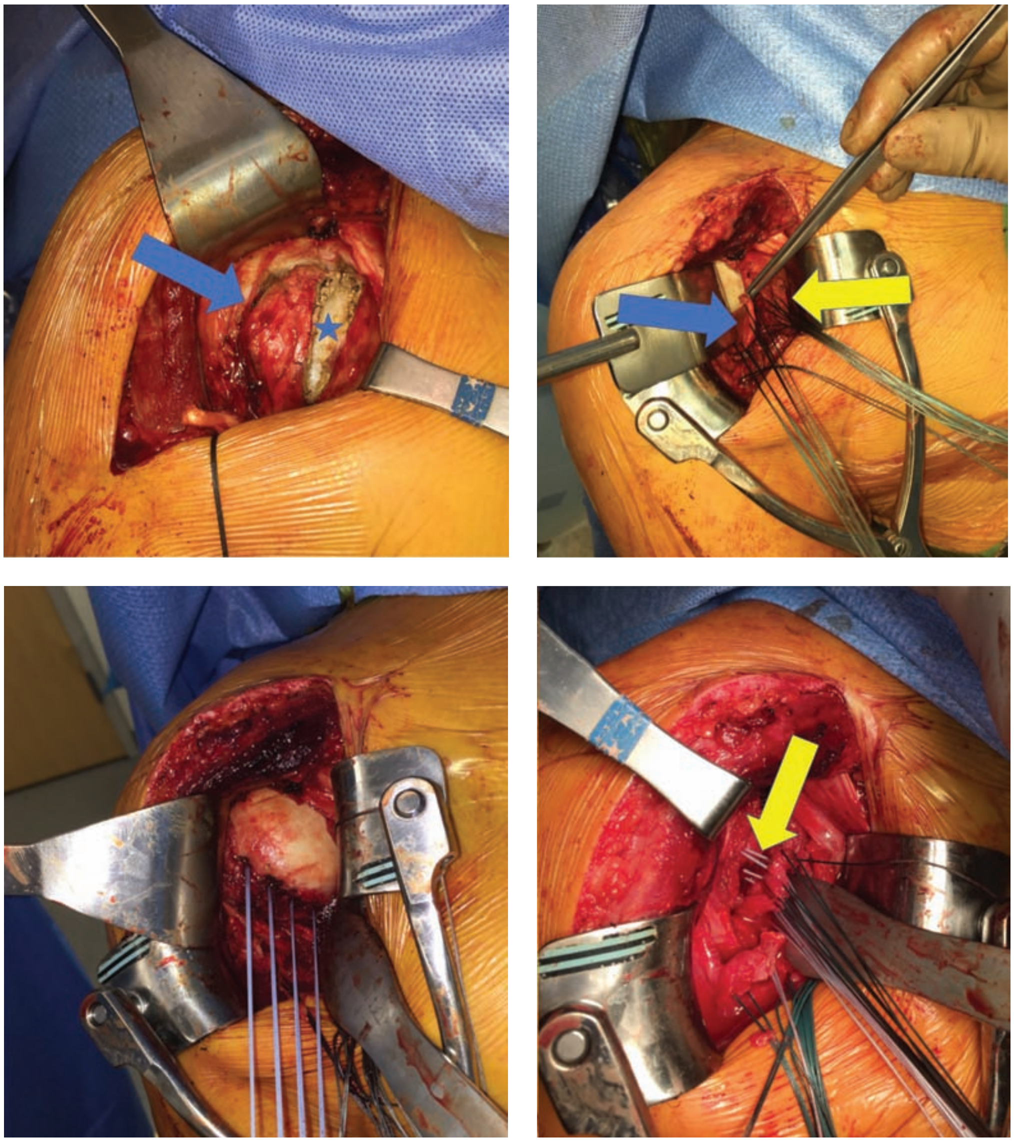


Figure 34-45. **A:** Open anterior capsular shift is performed in the beach chair position. A positive sulcus sign (*arrow*) is confirmed with the arm in neutral position and downward-directed force. **B:** With the arm in external rotation, the sulcus sign is still positive (*arrow*) with downward-directed force which indicates incompetency of the rotator interval.



A

C

Figure 34-46. **A:** Deltopectoral approach for open capsular shift. Bicipital groove is identified (*arrow*) and subscapularis tenotomy is performed 1 cm medial (*star*) to the tendon insertion to allow for repair at the end of the case. **B:** The capsule (*blue arrow*) is separated from the subscapularis muscle belly (*yellow arrow*) and tagged with sutures. Shoulder link retractors are used for the exposure. A Fakuda is inserted into the glenohumeral joint to help retract the humeral head posteriorly. A "T" capsulotomy is performed with either a small residual tissue from the humeral insertion or directly off the humeral insertion. **C:** Suture anchors with no. 2 braided sutures are inserted into the humeral head at the original insertion of the capsule to perform the shift. **D:** The sutures are passed into the capsule with 90-degree passers with the arm in abduction (20 to 30 degrees) and external rotation (20 to 30 degrees). It is essential to keep the arm in this position when tying down the sutures so that the shoulder is not constraint and to prevent stiffness.

The deltopectoral interval is identified and opened with the cephalic vein taken laterally. The pectoralis major tendon can be tenotomized at the upper 1 cm to ease visibility if needed and then repaired at the conclusion of the case. The clavipectoral fascia is incised just lateral to the muscle fibers of the conjoint tendon. The conjoint tendon is then retracted medially, taking care to not place undue strain on the underlying musculocutaneous nerve. Superior exposure can be improved by identifying and debriding the anterior-lateral aspect of the CA ligament. The bursa covering the subscapularis is then resected for better visualization. The upper and lower borders of the subscapularis are identified. The anterior humeral circumflex artery and two veins that accompany it (the three sisters) are identified.

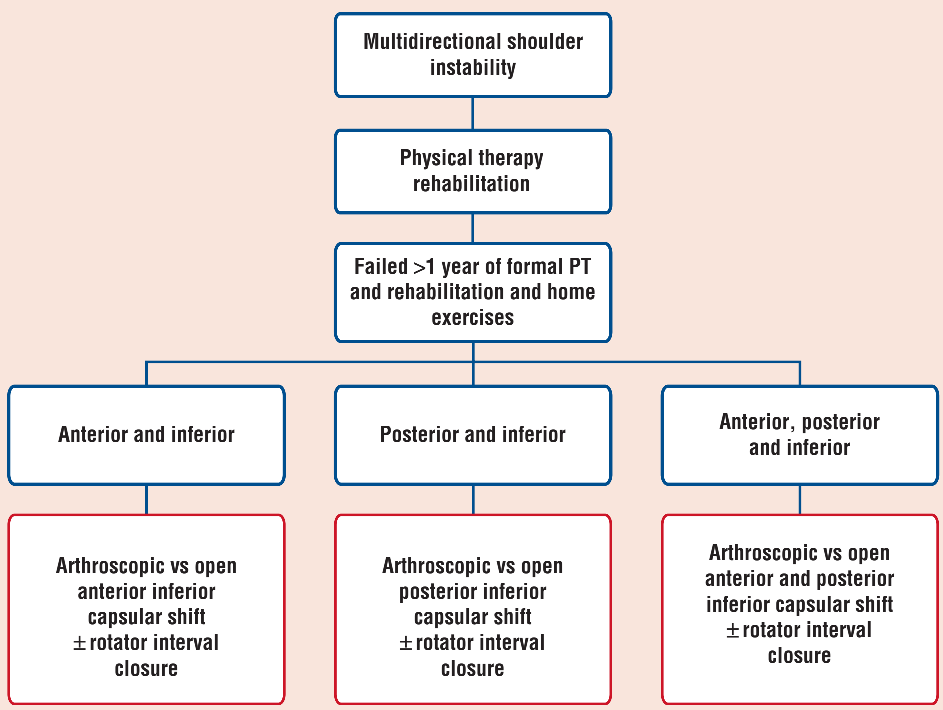
The subscapularis can then be tenotomized approximately 1 cm medial to its insertion (*star*), leaving an adequate cuff of tissue for later repair (Fig. 34-46A). The biceps tendon (Fig. 34-46A, *arrow*) is an excellent landmark to help identify the location of the subscapularis tendon. The subscapularis (Fig. 34-46B, *yellow arrow*) must then be dissected from the underlying capsule (Fig. 34-46B, *blue arrow*). This is most easily accomplished inferiorly, where there is more distinction between the two layers (Fig. 34-46B). Proximally, these structures can be blended into one layer. The subscapularis is then released completely and reflected medially, exposing the capsule.

The capsule is incised approximately 5 mm medial to the stump of the subscapularis, leaving enough tissue for eventual repair. Alternatively, the capsule can also be incised at the humeral insertion with a shift done later with suture anchors (Fig. 34-46C). The capsular incision begins superiorly and extends inferiorly. Tagging stitches are placed in the lateral edge to gain control of the tissue. Working inferiorly on the humeral neck, the arm is placed in progressive external rotation as the capsule is sharply released. At this point, the surgeon must judge the amount of inferior capsule to be released. Some advocate placing tension on the tagging suture with the surgeon's finger in the pouch to see if the pouch becomes obliterated with this motion. If so, the capsule has been adequately released.[9]

A humeral head retractor should be placed into the glenohumeral joint to retract the humerus posteriorly and inspect for an anterior labral tear. If a labral tear is present, it should be repaired with suture anchor fixation after preparing the anterior glenoid rim with a curette or rasp. The sutures from these anchors should be passed from inside the labrum to outside and then tied on the capsular side (see Open Bankart Repair technique). Crimping mattress stitches can be used to reduce anterior capsular redundancy by passing the sutures from outside the capsule to inside the joint in a vertical mattress fashion and then tying on the capsular side as well. The arm is then positioned into 20 to 30 degrees of abduction and 20 to 30 degrees of external rotation. A horizontal split is made in the capsule so that the final capsulotomy resembles a "T." Prior to performing the horizontal split, tagging stitches should be placed in both the superior and inferior limbs. The inferior limb is brought superiorly first and repaired back to the residual capsule or with suture anchors (Fig. 34-46C,D) and then the superior limb is repaired in a pants-over-vest fashion to the inferior capsule. If the patient exhibited a positive sulcus sign that persists in external rotation, then the rotator interval is also routinely closed with no. 2 braided suture fixation. The subscapularis is repaired with nonabsorbable no. 2 braided sutures, and the skin is closed in layers.

Rehabilitation is usually similar regardless of open and arthroscopic techniques and consists of sling immobilization for 6 to 8 weeks to protect the repair. Pendulum exercises are typically allowed after 7 to 10 days. Gentle passive ROM can begin after 2 weeks and are allowed to progress throughout the 6- to 8-week period. No aggressive stretching is allowed in the early period of rehabilitation, and strengthening against resistance is delayed until the 3- to 4-month mark. Many clinicians follow an even more conservative approach and delay the initiation of therapy until the 6- to 8-week mark, allowing only pendulums during that time.

Authors' Preferred Treatment for Multidirectional Glenohumeral Instability (Algorithm 34-4)



Algorithm 34-4. Authors' preferred treatment for multidirectional shoulder instability.

All patients are treated initially with a strengthening program designed to strengthen the rotator cuff musculature as well as improve scapular stabilization. Patients who continue to experience unacceptable instability are met with several times and counseled extensively on the inconsistent results of surgical treatment. They are counseled that some patients experience worsened pain after surgery and encouraged to weigh all alternatives seriously, including activity modification or even occupation modification. Patients who wish to undergo surgical intervention, and who are not voluntary dislocators and do not exhibit significant psychological or secondary gain issues, are indicated for surgery if they have failed despite one year of nonoperative treatment.

For patients with anterior and inferior instability, an arthroscopic or open anterior-inferior capsular shift with a rotator interval closure can be performed if they have a sulcus that persists in external rotation. For patients with posterior and inferior instability, operative treatment consists of an arthroscopic or open posterior-inferior capsular shift with a rotator interval closure for a sulcus that persists in external rotation. Finally, for patients with instability in all directions (anterior, posterior, and inferior), surgical treatment consists of an arthroscopic or open anterior/posterior with an inferior capsular shift with a rotator interval closure for a sulcus that persists in external rotation. Despite the known increased reduction in capsular volume with an open procedure over an arthroscopic one for MDI,[48] we prefer an arthroscopic approach as it offers a less severe complication profile as it is not necessary for the subscapularis to be taken down, repaired, and then heal.

We prefer an arthroscopic capsular plication performed in the lateral decubitus position as it offers unparalleled access to the inferior capsule compared with the beach chair position.

Patients have an examination performed while they are in the supine position after the induction of anesthesia so that both shoulders can be examined, and the results recorded.

Once the bean bag has been inflated around the patient, the patient and bean bag are moved until the head is as close to the posterior-superior corner of the table as possible. This prevents the surgeon from having to extend their arms while operating and makes the operation more ergonomic to perform. Two sets of seatbelts are used to secure the patient to the table and the ipsilateral leg is padded at the knee so the pneumatic arm holder cannot cause any inadvertent iatrogenic injury (see Fig. 34-43A). A pneumatic arm holder is secured to either the anterior or posterior aspect of the bed according to surgeon preference and provides in-line traction. A separate paddle is placed slightly inferior to the operative arm to provide abduction (see Fig. 34-43A). Care must be used to ensure that this is not placed too superiorly, which would limit access of instruments through the anterior-inferior portal during surgery. The paddle must also be placed at a height that allows it to provide a vector of force that is predominantly abduction; if this is placed too low, then it will inadvertently provide more anterior translation than abduction. Once this is completed, the shoulder is prepped with surgical prep from the neck to the midline of the sternum to the nipple inferiorly and the entire arm is prepped as well; no predrapes are utilized. A pneumatic arm holder is utilized to perform in-line traction and a separate abduction paddle is also used. The arm holder that we use can be covered with a sterile covering and can allow internal and external rotations of the shoulder.

Along with marking out all surface anatomy of the exposed shoulder girdle, we also recommend measuring an area of 5 to 7 cm lateral to the lateral edge of the acromion and marking out the likely site of the axillary nerve to prevent any cannulas being placed in this zone. We typically utilize a superior-lateral viewing portal, an anterior-inferior portal, and a posterior working portal, and also percutaneous portals that are not cannulated. We also commonly place an accessory posterior lateral portal which is approximately 2 cm inferior and 1 cm lateral to the posterolateral acromion.[35] The capsule is prepared with abrasion with either a rasp or lightly debriding with the shaver. A liberator is used to prepare the site of insertion and then a shaver is utilized to further prepare the edge of the glenoid. Suture anchors are then placed at the anterior-inferior and posterior-inferior margins of the glenoid (see Fig. 34-44A). A pinch of capsular tissue approximately 10 mm off the margin of the labrum is taken with a suture passer then passed under the labrum (see Fig. 34-45B), and knots are tied securing the capsule to the labrum (see Fig. 34-44C). We then prefer to work first posteriorly and then anteriorly, while viewing through a superolateral portal. If the labrum is intact, then a PDS suture is used to secure the capsule to the intact labrum directly superior to the anteroinferior and posteroinferior anchors and then alternated with suture anchor fixation working superiorly. This is able to be performed as an intact labrum provides similar fixation strength to a suture anchor.[185] We feel that this decreases the anchor burden as well as the nonabsorbable suture burden in the glenohumeral joint, and also complications such as abrasion to the cartilaginous surface. When working posteriorly, the arm is positioned in slight internal rotation, and when working anteriorly, the arm is repositioned in slight external rotation, so excessive tightening of the capsule is avoided.

Postoperative Care

Patients are placed in a standard shoulder immobilizer. In the first 6 weeks, there is limited physical therapy and the patients are allowed to come out of the immobilizer for elbow, wrist, and hand motion. No active motion of the shoulder is allowed. Pendulum exercises are permitted, and passive forward flexion and external rotation to neutral are allowed to begin after 4 weeks within a painless ROM. Active ROM may begin at the 6-week mark, and then patients can progress to a strengthening program at around 3 months. Aggressive passive stretching is avoided throughout the first 6 months. Return to athletics is permitted when patients have achieved painless ROM and have attained necessary rotator cuff strength and scapular stability. This is typically at the 6- to 8-month mark depending on the activities to which the patients wish to return.

Potential Pitfalls and Preventive Measures

Multidirectional Glenohumeral Instability:
SURGICAL PITFALLS AND PREVENTIONS

Pitfall	Prevention
• Overly constraining the joint	• Limit capsular tissue penetration with suture passer to 1 cm, place shoulder in slight external rotation when securing sutures anteriorly and slight internal rotation when securing sutures posteriorly
• Suture abrasion to cartilage	• Limit the number of nonabsorbable sutures by using plication stitches with PDS or similar absorbable suture between anchors
• Iatrogenic damage to cartilage from instruments	• Use of longitudinal traction and abduction should create a large intra-articular volume due to patulous capsule. Also, a small bump can be used under the axilla to help with joint distraction
• Inability to obtain insertion anchor below the 5 or 7 o'clock position for the anchors	• Use of percutaneous portals will allow access to inferior glenoid for instrumentation, and care should be taken to avoid neurovascular structures

Outcomes

Arthroscopic Procedures

Duncan and Savoie[63] were one of the first to report their outcomes on an arthroscopic modification of the open inferior capsular shift that had been previously described by Altcheck et al.[5] They performed this procedure on 10 patients with MDI and assessed them at 1 to 3 years follow-up. All patients reported satisfactory outcomes. Two patients had a follow-up surgery to remove symptomatic sutures. The senior author (FHS) later reported on a series of 25 patients with MDI also treated with arthroscopic capsular shift after an average of 5 years. They found that 21 (88%) of patients met the criteria for a satisfactory results and concluded that results of arthroscopic management of MDI could be considered comparable to open treatment even after 5 years.[233]

Results of 50 patients with MDI who had failed nonoperative methods and treated with arthroscopic capsular plication were reviewed at an average of 2 years.[267] They found that of the 43 patients available to report outcome scores, 41 had good or excellent results. Patients with a higher Beighton score demonstrated less improvement and 2 patients demonstrated recurrent instability. Gartsman et al. reported on their series of 47 patients at an average age of 30 years and almost 3 years of follow-up after arthroscopic treatment of MDI.[70] Multiple outcome scores were compared preoperatively and postoperatively. No patients were rated as good to excellent preoperatively; however, 44 of 47 (94%) were rated as such postoperatively. One patient underwent a revision procedure.

Open Procedures

Bigliani et al.[20] reported on the outcomes of 68 shoulders in 63 athletic patients treated with an open anterior-inferior capsular shift procedure. Good to excellent results were achieved in 94% of the patients and 75% were able to return to their previous level of athletic competition. Postoperative dislocation occurred in only 2 patients. Adolescents with Ehlers–Danlos syndrome presenting with MDI were assessed after undergoing an open inferior capsular shift after a follow-up of 7.5 years.[239] Out of 15 patients with 18 procedures, 13 (87%) reported improvements in pain and stability and were satisfied with the procedure with 9 (64%) patients able to return to sport.

Management of Expected Adverse Outcomes and Unexpected Complications Related to Multidirectional Glenohumeral Instability

Multidirectional Glenohumeral Instability:
COMMON ADVERSE OUTCOMES AND COMPLICATIONS

- Tightness due to over-constrained joint or postoperative stiffness
- Recurrent instability
- Pain
- Chondrolysis

The most frequent complication associated with surgery for MDI is incomplete resolution of pain and/or instability. Multiple previous studies reported in this chapter have demonstrated that a certain percentage of patients have always failed treatment, regardless of which treatment was chosen. Revision surgery remains a possibility for these patients,[23] but reports on outcomes are scarce and it is difficult to counsel the patient on expectations following a revision surgery.

When thermal capsulorrhaphy was performed routinely, along with poor operative results,[65,154] there were multiple significant complications reported, including postoperative chondrolysis[50,199,274] as well as injury to the axillary nerve.[75,258]

SUMMARY, CONTROVERSIES, AND FUTURE DIRECTIONS RELATED TO GLENOHUMERAL INSTABILITY

ANTERIOR GLENOHUMERAL INSTABILITY

Advances with new repair and reconstruction techniques and understanding the importance and interaction of bipolar bone loss (humeral head and glenoid), along with adjuvant procedures (i.e., remplissage or infraspinatus capsulotenodesis), will help improve outcomes when managing shoulder instability. In areas of arthroscopic surgery, advances in surgical techniques have allowed bony augmentation procedures, such as Latarjet and bone block augmentation, to be performed more reliably and safely via arthroscopic techniques.[74,145,277,278] Similar to Bankart repairs, arthroscopic surgery in bony augmentation procedures may offer decreased perioperative morbidity, particularly as instrumentation allows the surgery to be performed efficiently.

While glenoid bone loss has received the vast majority of attention over the last 5 years, studies that are focused on the consequences of humeral head bone loss and the concept of glenoid tracking of Hill–Sachs lesions popularized by Yamamoto et al.[271] are emerging. Certain locations of the Hill–Sachs lesion coupled with glenoid attritional loss that may be subcritical (less than 20%) may predispose Bankart repairs (especially those done arthroscopically) to failure. As a result, arthroscopic techniques, including infraspinatus capsulotenodesis or remplissage, have emerged to deal with Hill–Sachs lesions. Hartzler et al.[85] evaluated the glenoid tracking concept following Bankart repair with and without remplissage of the Hill–Sachs lesions in a bipolar cadaveric model where a less-than-critical 15% glenoid defect was created along with Hill–Sachs lesions that either engaged (off-track) or did not engage (on-track) with the 90 degrees of external rotation. The authors found that the addition of remplissage was necessary in addition to a standard Bankart repair to prevent engagement in all shoulders with off-track Hill–Sachs lesions.[85] Arthroscopic adjuvants such as remplissage may decrease the risk of recurrent instability after arthroscopic Bankart repair. Early clinical studies on remplissage have been favorable in terms reduction of recurrence of anterior instability relative to standard Bankart repairs.[42,43,125,152] Other arthroscopic approaches to addressing the Hill–Sachs lesion and augmenting a standard Bankart repair have been described.[188,261] It remains to be seen if these arthroscopic adjuvant procedures will decrease the recurrence risk in the long term.

The definition of "subcritical" or "critical" bone loss has changed in the literature in recent years. This concept is essential for the decision between arthroscopic repair or an open bone block procedure. Shaha et al.[209] found that over 13.5% bone loss was defined as the "subcritical" bone loss that resulted in higher failure rates as defined by poor WOSI scores after arthroscopic repair even in the setting of no recurrence of instability. Subsequent studies have found that over 17.3% bone loss was the "critical" value in which arthroscopic repair resulted in 47% failure rate as defined by recurrence of instability.[211] Future prospective studies should focus on the true critical bone loss value that will help predict outcome and guide the decision between arthroscopic or bone block procedures in patients with anterior glenohumeral instability and glenoid bone loss.

POSTERIOR GLENOHUMERAL INSTABILITY

Recognition of symptomatic posterior shoulder instability is increasing with the advent of improved imaging protocols and clarification of imaging and physical examination characteristics. Arthroscopic techniques continue to evolve with the advent of percutaneous and knotless anchors. Future investigation focused on the optimal treatment for patients with failed posterior instability surgery and those with primary symptomatic posterior shoulder instability in the setting of glenoid dysplasia is needed. Controversy regarding surgical treatment for glenoid dysplasia includes use of glenoid osteotomy versus primary arthroscopic repair versus bone blocks versus congruent bone augmentation techniques. Additional controversy regarding choice of graft including allograft distal tibia and autograft iliac crest is also unresolved. Additionally, current recommendations for management of posterior glenoid bone loss treatment are based on anterior shoulder instability protocols, but with deficient clinical evidence.

MULTIDIRECTIONAL INSTABILITY

MDI is a very complex problem that, despite many advances over the last few decades, is still not well understood. While the mainstay of initial treatment is a nonoperative strengthening program, much controversy exists over when to offer surgical treatment and what type of surgical treatment to perform. Multiple surgical techniques exist, both open and arthroscopic; however, none are deemed to be superior to the others and each has a specific complication profile that must be acknowledged. Although all surgeons agree that the rotator interval is a key anatomic structure involved in the pathology of MDI, there remains controversy on when to address the interval with surgical closure.[171] When surgical treatment is performed, most surgeons agree that patients require 6 to 8 weeks of postoperative immobilization.

Annotated References

Reference	Annotation
Aboalata M, Plath JE, Seppel G, et al. Results of arthroscopic Bankart repair for anterior-inferior shoulder instability at 13-year follow-up. *Am J Sports Med.* 2017;45(4):782–787.	This was a long-term follow-up of a total of 143 shoulders with anterior-inferior shoulder instability that underwent an arthroscopic Bankart repair with a minimum of 10-year follow-up. The overall redislocation rate was 18%. Concomitant SLAP repair had no effect on clinical outcome. Redislocation rate was significantly affected by the patient's age and duration of postoperative rehabilitation. The redislocation rate tended to be higher if the patient had more than 1 dislocation preoperatively. Significant dislocation arthropathy was observed in 12% of patients in this series, and degenerative changes were correlated with the number of preoperative dislocations, patient age, and number of anchors used for the repair. The overall patient satisfaction rate was 92%, and return to the preinjury sport level was 50%.

Annotated References

Reference	Annotation
Arciero RA, Wheeler JH, Ryan JB, et al. Arthroscopic Bankart repair versus nonoperative treatment for acute, initial anterior shoulder dislocations. *Am J Sports Med.* 1994;22(5):589–594.	This was one of the original clinical prospective studies comparing the outcome of arthroscopic Bankart repair with nonoperative treatment for the acute, initial anterior shoulder dislocation in an active military population. A total of 36 athletes were included and separated into two groups; group 1 was immobilized for 1 month followed by rehabilitation, group 2 had arthroscopic Bankart repair. There was 80% recurrence rate in group 1 and 7 of the 12 patients had surgery for shoulder stabilization. In group 2, the recurrence rate was 14%. The authors concluded that arthroscopic Bankart repair significantly reduced the recurrence rate in young athletes who sustained an acute, initial anterior dislocation of the shoulder.
Baker CL, Mascarenhas R, Kline AJ, et al. Arthroscopic treatment of multidirectional shoulder instability in athletes: a retrospective analysis of 2- to 5-year clinical outcomes. *Am J Sports Med.* 2009:37(9):1712–1720.	There are few reports of outcomes after arthroscopic treatment for multidirectional shoulder instability in athletes. This is one of the largest studies in the literature reporting the 2- and 5-year outcomes in 43 shoulders with MDI and arthroscopic fixation. The mean postoperative ASES scores was 91 out of 100, the mean Western Ontario Shoulder Instability percentage was 91 out of 100, and 86% were able to return to their sports with little or no limitation. The authors concluded that arthroscopic treatment can provide an effective method for symptomatic MDI in an athletic patient population.
Bradeley JP, McClincy MP, Arner JW, et al. Arthroscopic casulolabral reconstruction for posterior instability of the shoulder: a prospective study of 200 shoulders. *Am J Sports Med.* 2013;41(9):2005–2014.	The largest prospective study on the outcome after arthroscopic posterior labral repair for posterior instability. The authors followed 200 shoulders prospectively with a mean of 36 months of follow-up. They found the ASES scores increased from 45.9 to 85.1 and significant improvements in stability, pain, and function. There was no difference in the outcome comparing contact athletes with noncontact athletes. Patients who had repair with anchors did significantly better than the patients who had anchorless fixation. The authors concluded that arthroscopic capsulolabral reconstruction is an effective, reliable treatment for symptomatic unidirectional recurrent posterior glenohumeral instability in an athletic population.
Eichinger JK, Galvin JW, Grassbaugh JA, et al. Glenoid dysplasia: pathophysiology, diagnosis, and management. *J Bone Joint Surg Am.* 2016;98(11):958–968.	This review article reported the pathophysiology, diagnosis, and management of patients who present with posterior shoulder instability in the setting of glenoid dysplasia. A comprehensive literature review on the outcomes of arthroscopic, open, and posterior bone block procedure is reported in the article. Indications for arthroscopic versus open procedure is also discussed based on the available evidence in the literature.
Galvin JW, Parada SA, Li X, et al. Critical findings of magnetic resonance arthrograms in posterior shoulder instability compared with an age-matched controlled cohort. *Am J Sports Med.* 2016;44(12):3222–3229.	The authors aimed to identify the prevalence and severity of associated radiographic parameters found on magnetic resonance arthrograms in patients with arthroscopically confirmed isolated posterior labral tears and symptomatic recurrent posterior shoulder instability compared with an age-matched cohort of patients without posterior instability. The authors found that the presence of glenoid retroversion, glenoid dysplasia, and increased axial posterior capsular cross-sectional area were significantly associated with patients with posterior labral tears and symptomatic posterior instability.
Hartzler RU, Bui CN, Jeong WK, et al. Remplissage of an off-track Hill-Sachs lesion is necessary to restore biomechanical glenohumeral joint stability in a bipolar bone loss model. *Arthroscopy.* 2016;32(12):2466–2476.	The objective of this cadaveric study was to validate the glenoid track concept in a cadaveric bipolar bone loss model and to test whether "on-track" and "off-track" lesions can be stabilized with Bankart repair (BR) with or without Hill–Sachs remplissage (HSR). The authors found that, for on-track lesions, engagement occurred with translation testing in one shoulder (12.5%) at end-range rotation. After BR, engagement was prevented for this shoulder. For off-track lesions, engagement with translation testing occurred in 8 shoulders (100%) at end-range rotation and in 6 (75%) at mid-range rotation. After BR, engagement was only prevented in 4 of 6 engaging shoulders (67%) at mid-range rotation but was prevented in zero of 8 (0%) at end-range rotation. Adding remplissage prevented engagement in all 14 engaging shoulders with off-track lesions (100%).

Annotated References

Reference	Annotation
	The authors concluded that this biomechanical study provided evidence to aid in surgical decision-making by examining the effects of bipolar bone loss and consideration of remplissage in cases of "off-track" Hill–Sachs lesions in glenoids with subcritical (15%) anterior bone loss.
Hovelius L, Augustini BG, Fredin H, et al. Primary anterior dislocation of the shoulder in young patients: a ten-year prospective study. *J Bone Joint Surg Am*. 1996;78(11):1677–1684.	This was a prospective study on 247 primary anterior dislocations of the shoulder followed for 10 years in a multicenter study. At the 10-year follow-up evaluation, 52% had no additional dislocation. Recurrent dislocation necessitating operative treatment occurred in 23% of the shoulders. Radiographs that demonstrated an evident Hill–Sachs lesion was associated with a significantly worse prognosis with regard to recurrence than was no evident lesion ($P < 0.04$). At 10-year follow-up, 11% had mild and 9% had moderate or severe arthropathy after dislocation.
Hovelius L, Saeboe M. Neer Award 2008: arthropathy after primary anterior shoulder dislocation—223 shoulders prospectively followed up for twenty-five years. *J Shoulder Elbow Surg*. 2009;18(3):339–347.	This was a prospective multicenter study that included 257 shoulders in 255 patients (age, 12–40 years) with a first-time anterior shoulder dislocation. After 25 years, radiographic imaging was performed in 223 shoulders (97%). Only 44% of shoulders were normal radiographically at 25 years after a primary shoulder dislocation. Arthropathy was mild in 29%, moderate in 9%, and severe in 17% of the shoulders. Of the shoulders without a recurrence, 18% had moderate/severe arthropathy. Other factors that correlated with moderate/severe arthropathy were age >25 years at primary dislocation and primary dislocation caused by high-energy sports activity. Shoulders that had not recurred had less arthropathy than shoulders classified as recurrent or stabilized over time. Sixty-two surgically stabilized shoulders had less arthropathy than those that became stable over time. The authors concluded that age at primary dislocation, recurrence, high-energy sports, and alcohol abuse were factors associated with the development of arthropathy.
Li X, Ma R, Nielsen NM, et al. Management of shoulder instability in the skeletally immature patient. *J Am Acad Orthop Surg*. 2013;21(9): 529–537.	There are many studies on the management of anterior shoulder instability in the adult patient population. However, a paucity of literature exists regarding shoulder dislocations in skeletally immature patients. The presence of open proximal humeral physis changes the management of these patients with primary shoulder dislocations. A comprehensive literature review of recent literature shows a relatively low rate of recurrent instability after the primary dislocation compared with older literature. The authors recommended conservative management in this subset of patients after primary dislocation. Surgery should only be indicated after a prolonged trial of therapy or with recurrence of instability.
Shaha JS, Cook JB, Song DJ, et al. Redefining "critical" bone loss in shoulder instability: functional outcomes worsen with "subcritical" bone loss. *Am J Sports Med*. 2015;43(7):1719–1725.	The objective of this study was to evaluate the effects of subcritical bone loss (below the 20%–25% range) on outcomes and redislocation rates after an isolated arthroscopic Bankart repair for anterior shoulder instability. The authors reported results of 73 shoulders that underwent isolated anterior arthroscopic labral repair at a single military institution. The cohort was divided into quartiles based on bone loss. Quartile 1 had a mean bone loss of 2.8%, quartile 2 had 10.4%, quartile 3 had 16.1%, and quartile 4 had 24.5%. The mean WOSI score and SANE scores worsened as bone loss increased in each quartile. The WOSI score increased to rates consistent with a poor clinical outcome between quartiles 2 and 3 (bone loss, 13.5%). There was an overall failure rate of 12.3%. The percentage of glenoid bone loss was significantly higher among those repairs that failed versus those that remained stable (24.7% vs. 12.8%, $P < 0.01$). There was a significant increase in failure ($P < 0.05$) between quartiles 1, 2, and 3 (7.3%) compared with quartile 4 (27.8%). The authors concluded that bone loss above 13.5% led to a clinically significant decrease in WOSI scores consistent with an unacceptable outcome even if patients did not sustain a recurrence of their shoulder instability.

Annotated References

Reference	Annotation
Shin SJ, Kim RG, Jeon YS, et al. Critical value of anterior glenoid bone loss that leads to recurrent glenohumeral instability after arthroscopic Bankart repair. *Am J Sports Med*. 2017;45(9):1975–1981.	This study evaluated the critical value of glenoid bone loss that leads to recurrence of instability or failures. A total of 169 patients after arthroscopic repair for anterior shoulder instability were included. They were divided into two groups of critical bone loss. The authors found that the critical value was 17.3%. In patients with <17.3% bone loss, the failure rate was 3.7% compared to patients with >17.3% bone loss which was 42.9%. The author concluded that in the patients with >17.3% glenoid bone loss, an arthroscopic repair will result in unacceptable failure rates, and thus an open anterior bone block procedure is recommended.
Yamamoto N, Itoi E, Abe H, et al. 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(5):649–656.	The authors conducted a cadaveric study ($n = 9$) to clarify the size of Hill–Sachs lesion with the goal of quantifying what extent necessitates treatment of the Hill–Sachs lesion. The authors reported that with an increase in arm elevation, the glenoid contact shifted from the inferomedial to the superolateral portion of the posterior aspect of the humeral head, creating a zone of contact (glenoid track). The medial margin of the glenoid track was located 18.4 ± 2.5 mm medial from the footprint, which was equivalent to 84% ± 14% of the glenoid width. A Hill–Sachs lesion has a risk of engagement and dislocation (off-track lesion) if it extended medially over the medial margin of the glenoid track.

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