Mini-Incision Bankart Repair

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Contents

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Recurrent instability can lead to severe disability. The balance between stability and freedom of motion makes the glenohumeral joint vulnerable to injury. Treatment can be challenging. Historic surgical options have included staple capsulorrhaphy [1] and subscapularis advancement [2], but these procedures resulted in substantial restriction of external rotation and subsequent glenohumeral arthrosis [3–6]. Furthermore, the traditional limited operative indications failed to account for the growing awareness of subluxations as a source of symptomatic instability [7–10]. Surgical options today for anterior shoulder instability include capsular shift [11], capsulolabral repair [12], and transfer of the coracoid [13].

Minimally invasive techniques are desirable for faster postoperative rehabilitation and improved cosmesis. This chapter will focus on the mini-incision Bankart repair, including relevant anatomy, physical examination, radiologic features, indications, and surgical technique. Arthroscopic techniques for capsulolabral repair [14] and coracoid transfer [15] have been described as well, but are beyond the scope of this chapter. Some indications are overlapping, but mini-incision open Bankart repair is favored especially in cases of young collision and overhead athletes, revision cases, and in cases with a sizable glenoid fracture amenable to screw fixation [11, 16–21].

Anatomy and Biomechanics

The glenohumeral joint has the widest range of motion of any articulation in the human body. The small size and shallow nature of the glenoid relative to the humerus allow the shoulder to achieve this degree of motion, but this also predisposes the shoulder to instability if the soft tissue capsuloligamentous restraints or osseous architecture is disrupted [22, 23]. The rotator cuff, deltoid, and scapular stabilizers serve as dynamic restraints in normal shoulder biomechanics. These muscles counteract translational forces through compression of the humeral head into the glenoid cavity.

The three major glenohumeral ligaments plus the coracohumeral ligament function as static shoulder stabilizers, or “check-reins.” Turkel et al. [24] found that the contributions of these structures were position dependent. The superior glenohumeral ligament and coracohumeral ligament restrain anterior humeral head translation in 0° of abduction and external rotation. With increasing abduction to 45°, the middle glenohumeral ligament provides the primary anterior restraint. Finally, the inferior glenohumeral ligament (IGHL) tightens and becomes the prime anterior stabilizer at 90° of abduction and 90° of external rotation. Biomechanical study of the IGHL has demonstrated tensile failure at the glenoid insertion or in the midsubstance. Significant deformation, however, was observed in midsubstance even if the ultimate site of failure occurred at the insertion [25].

The glenoid labrum helps to deepen the socket of the glenohumeral joint and increases stability of the articulation. The anterior–inferior glenoid labrum, with its attachment of the anterior band of the IGHL, provides the primary restraint to anterior humeral translation when the arm is abducted to 90° and externally rotated. The Bankart injury is a disruption of this anterior–inferior labrum and IGHL [26]. In some cases, traumatic anterior dislocations may result in a fracture of the anterior–-inferior glenoid, which is equivalent to disruption of the IGHL, since the labroligamentous complex is usually attached to the bony piece. This is termed a bony Bankart injury, and X-ray examination may show a small fragment of bone along the inferior glenoid neck. This fracture can be either an avulsion injury with a large displaced fragment or an impaction injury produced by the humeral head crushing the anterior glenoid lip. This marginal impaction fracture may appear as “missing bone” without a separate fragment anterior and medial to the anterior glenoid rim.

A humeral avulsion of the glenohumeral ligament (HAGL) is a disruption of the glenohumeral ligamentous complex from the humeral neck instead of the more common inferior glenoid. With anterior dislocations, the capsule and glenohumeral ligaments are stretched, and this further increases the laxity of the joint. Commonly, a large pouch of loose capsule filled with synovial fluid will be seen on magnetic resonance imaging (MRI) in patients with instability of the shoulder.

Hill–Sachs lesions can occur after anterior dislocations. This is an impaction fracture on the posterosuperior humeral head as the head is compressed on the anterior margin of the glenoid. If large enough, these lesions can engage the anterior glenoid rim in external rotation, leading to instability. In essence, a large posterosuperior osteochondral humeral defect may allow the humeral head to "fall off" the glenoid as the defect engages the anterior rim of the glenoid; this is known as an engaging Hill–Sachs lesion.

Clinical Features

Patient History

Critical to the evaluation of glenohumeral instability is a careful history and physical examination. The position of the arm at the time of injury or circumstances that provoke symptoms will often indicate the direction of instability. Reproduction of a patient's symptoms in a position of abduction, external rotation, and extension suggests anterior instability. Flexion, internal rotation, and adduction, by contrast, would more likely point to posterior instability.

In determining the degree and etiology of instability, the history should ascertain whether the initial and any subsequent episodes of instability were elicited by high-energy trauma (such as violent twisting or a fall), minimal repeated trauma (such as throwing a ball), or no trauma (such as reaching for a high shelf). An initial dislocation resulting from a single traumatic episode will frequently produce a Bankart lesion. In contrast, capsular laxity and the absence of a Bankart lesion will often be found in those patients who suffer from an atraumatic first dislocation, especially in the setting of generalized multijoint laxity. Other patients with a history of recurrent traumatic dislocations may have attritional glenoid bone loss. The type of reduction required, such as reduction under sedation in the emergency room versus self-reduction, may also provide additional information about the extent of joint laxity.

A detailed record of prior treatment should also be obtained, including rehabilitative efforts and previous surgeries. Knowledge of failed interventions will help guide future treatment in the recurrent dislocator.

Acquired instability was described by Neer, in which cumulative enlargement of the capsule results from repetitive stress [27]. Overhead and throwing athletes may develop isolated shoulder laxity from overuse with no evidence of laxity in other joints. Or these patients may become symptomatic only after a frank dislocation following a single traumatic event, but years of microtrauma must be taken into account as well. This patient group demonstrates that multiple etiologies may contribute to instability and underscores the need for careful diagnosis and individualized treatment to address coexisting pathologic entities.

Patients must be carefully screened for signs of voluntary muscular control of their shoulder instability, as this may change the ultimate course of treatment. Patients may deliberately dislocate the shoulder for secondary gain. Biofeedback techniques and counseling may help those patients who sublux their shoulder through selective muscular activation [28]. Surgery is contraindicated in this scenario.

Other times, patients can demonstrate that placing their arm in a certain position will provoke dislocation, but then they have no control over the shoulder once so positioned; these patients are known as "positional voluntary" and are a separate entity from the "muscular voluntary" patients described above. By contrast, surgery may benefit patients with positional voluntary subluxation, if they cannot satisfactorily perform their activities of daily living or desired sports without putting the shoulder in an at-risk position.

Pain is a common but nonspecific symptom. Anterior shoulder pain may indicate anterior instability as well as other common disorders including subacromial impingement. Similarly, posterior shoulder pain may represent a range of pathology from instability to cervical spine disorders. The location of the pain in combination with certain arm positions or activities, however, may aid in diagnosis. Altered glenohumeral kinematics in throwers, for example, may result in posterior shoulder pain during late cocking ("internal impingement") [29]. Rowe and Zarins [10] described a phenomenon termed the "dead arm syndrome" in which paralyzing pain and loss of control of the extremity occur with abduction and external rotation of the shoulder. A similar phenomenon may be seen in patients with inferior subluxation when they carry heavy loads in the affected arm.

Finally, determining the patient's functional demands and level of impairment is important prior to formulating a therapeutic plan. The differing expectations of a sedentary patient with minimal functional loss versus the high-performance athlete with pain and apprehension may affect the type of prescribed treatment.

Physical Examination

A thorough physical examination is equally essential in making an accurate diagnosis and recommending the appropriate intervention. Both shoulders should be adequately exposed and examined for deformity, range of motion, strength, and laxity. Demonstration of scapular winging may accompany instability, particularly of the posterior type, and should be considered a potential cause of symptoms. Generalized ligamentous laxity may also contribute to instability and can be elicited with the ability to touch the thumb to the forearm and hyperextend the index metacarpophalangeal joint beyond 90° (Fig. 1). Incisional scars from previous instability repairs may be present.

Tenderness to palpation of the acromioclavicular joint should be sought and may represent the source of symptoms in a patient with a loose but stable shoulder. Pain along the glenohumeral joint line can be associated with instability but is a nonspecific finding.

Typically, there is full range of motion with the exception of guarding at the extremes as the shoulder approaches unstable positions. Clinical suspicion should be raised, however, in the patient older than 40 years of age who is unable to actively elevate the arm after a primary anterior dislocation. It has been shown that a high percentage of these patients will have rotator cuff tears with restoration of stability following repair [31]. Axillary nerve function should be assessed.

Various provocative tests can be used to reproduce the patient's symptoms and confirm the

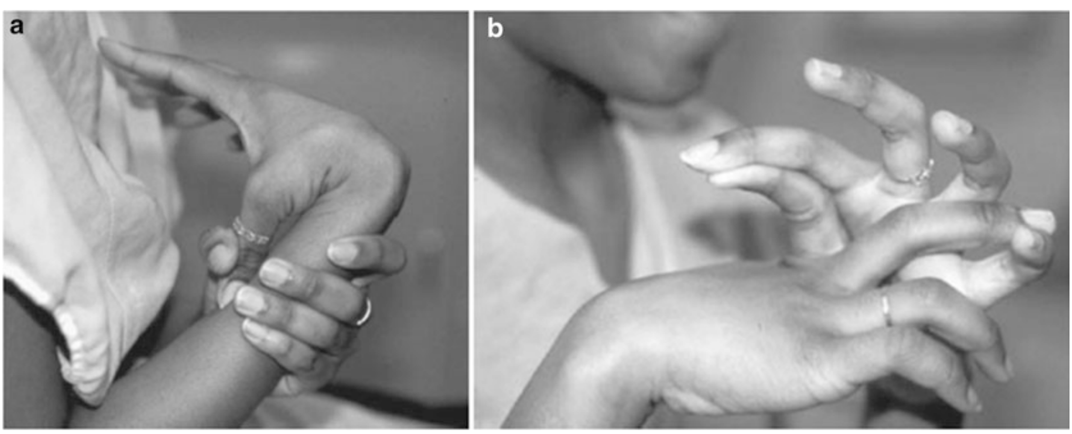

Fig. 1 Tests for generalized ligamentous laxity. (**a**) Thumb to forearm. (**b**) Index metacarpophalangeal joint hyperextension (From Lee and Flatow [31], with kind permission of Springer Science and Business Media, Inc.)

Fig. 2 Sulcus sign. Downward traction of the arm will create a gap between the acromion and the humeral head (From Lee and Flatow [30], with kind permission of Springer Science and Business Media, Inc.)

diagnosis. In order to minimize the effects of muscle guarding, these maneuvers should be performed first on the unaffected side and then in succession of increasing discomfort on the side of interest. The *sulcus test* evaluates inferior translation of the humeral head with the arm at the side and in external rotation [32] (Fig. 2). Significant findings would include an increased palpable gap between the acromion and humeral head compared with the opposite side that does not diminish in external rotation, signifying the presence of an incompetent rotator interval, as well as the presence of translation below the glenoid rim.

Laxity can be further evaluated by *anterior and posterior drawer* or *load-and-shift tests* [33] (Fig. 3). The proximal humerus is shifted in each direction while grasped between the thumb and index fingers. Alternatively, with the patient supine, the scapula is stabilized while the humeral head is axially loaded and translated anteriorly and posteriorly. Translation greater than the opposite shoulder or translation over the glenoid rim indicates significant laxity. The increased translation is considered pathologic only if it reproduces the patient's symptoms.

The *anterior apprehension test* is performed by externally rotating, abducting, and extending

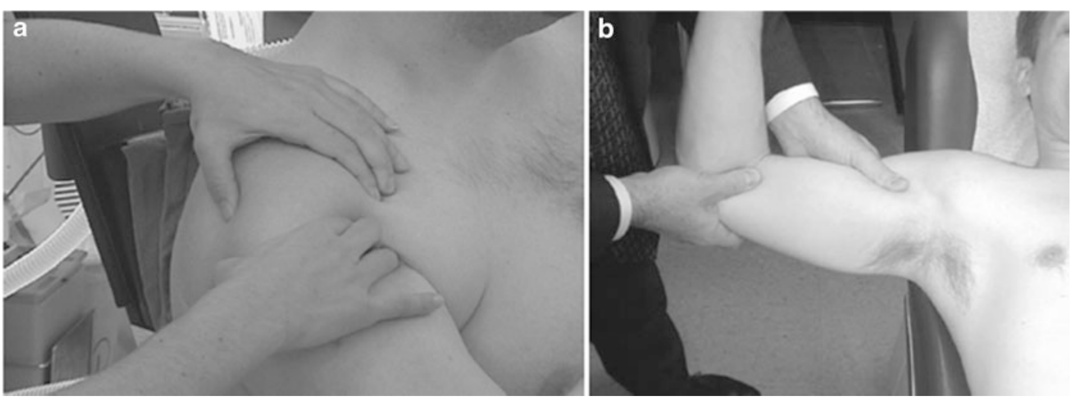

Fig. 3 (**a**) Anterior/posterior drawer: translation of the humeral head between the thumb and index finger and stabilization of the scapula with the other hand. (**b**) Load and shift: simultaneous axial loading and translation of the humeral head (From Lee and Flatow [30], with kind permission of Springer Science and Business Media, Inc.)

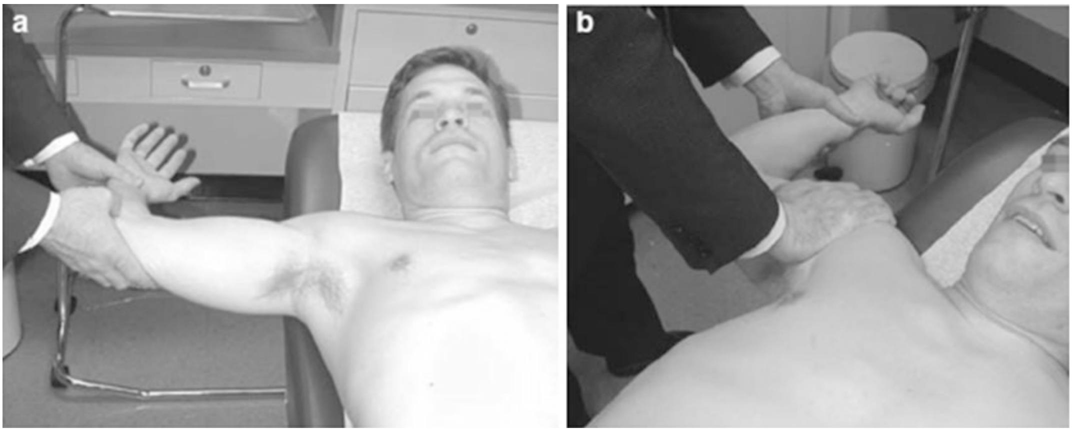

Fig. 4 (**a**) Apprehension test: abduction and external rotation will produce a sense of impending subluxation/dislocation with anterior glenohumeral instability. (**b**) Relocation test: posteriorly directed force on the humeral head will alleviate symptoms (From Lee and Flatow [30], with kind permission of Springer Science and Business Media, Inc.)

the affected shoulder while stabilizing the scapula or providing an anteriorly directed force to the humeral head with the other hand. Significant findings would include a sense of impending subluxation or dislocation, or guarding and resistance to further rotation secondary to apprehension [34] (Fig. 4). *Jobe's relocation test* is done in the supine position, usually accompanying the apprehension test. As symptoms are elicited with progressive external rotation, the examiner applies a posteriorly directed force to the humeral head. A positive test is signified by alleviation of symptoms with the posteriorly directed force [35] (Fig. 4).

Posterior instability can be elicited with the *posterior stress test*. As one hand stabilizes the scapula, a posteriorly directed axial force is applied to the arm with the shoulder in 90° of flexion and adduction and internal rotation. Unlike the anterior apprehension test, the posterior stress test will usually produce pain rather than true apprehension [36].

Radiographic Features

Although the history and physical examination are the key elements in the patient evaluation, a series of radiographic studies is helpful in confirming the diagnosis and defining associated pathology. Anteroposterior (AP) radiographs of the glenohumeral joint with the arm in internal and external rotation, a lateral view in the scapular plane (scapular Y view), and an axillary view (standard supine axillary or Velpeau axillary view) should be obtained in the initial evaluation. A *Hill–Sachs lesion* (posterosuperior impression fracture) of the humeral head is best seen on the AP radiograph in internal rotation (Fig. 5) or on specialized views such as the Stryker Notch view [37]. Fractures or erosions of the glenoid rim and subluxations can be best detected on an axillary or apical oblique view [38].

Computed tomography (CT) scans assist in further assessment of fractures and glenoid erosions or altered glenoid version [39, 40]. A 3D reconstruction of the glenoid *en face* with the humerus subtracted is best for assessing attritional glenoid bone loss. MRI and magnetic resonance (MR) arthrography can identify associated pathology of the labrum, glenohumeral ligaments, and the rotator cuff [41–43]. The addition of abduction and external rotation has been shown to increase the sensitivity of MR arthrography in delineating tears of the anterior labrum [44, 45]. More recent radiographic modalities such as dynamic MRI currently have no defined indications but

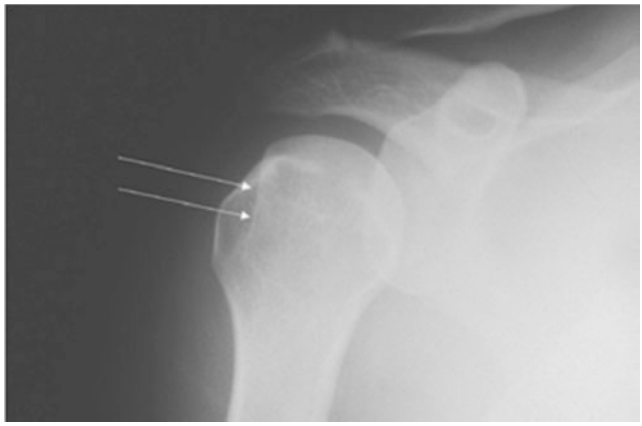

Fig. 5 Hill–Sachs lesion. An impaction fracture of the posterosuperior humeral head is associated with a previous anterior glenohumeral dislocation, and is depicted by the *small white arrows* on this internally rotated anteroposterior radiograph (From Lee and Flatow [30], with kind permission of Springer Science and Business Media, Inc.)

may become a useful adjunct in evaluating glenohumeral instability [46, 47].

Nonoperative Treatment

Immobilization is for comfort only. Studies by Hovelius and others have found no difference in recurrence rates from either the type or length of immobilization after dislocation [48–51].

Rehabilitation efforts are aimed at strengthening the dynamic stabilizers and regaining motion. Progressive resistive exercises of the rotator cuff, deltoid, and scapular stabilizers are recommended. Stress on the static restraints of the shoulder (i.e., capsuloligamentous structures) should be prevented in the immediate postinjury period by avoidance of vigorous stretching and provocative arm positions.

Some patients are more amenable to nonoperative treatment after dislocation than others, such as patients over age 40 who did not sustain a rotator cuff tear. The risk for subsequent dislocations is higher with earlier age of onset and with exposure to collision sports. For patients under age 40, Jakobsen and colleagues reported that up to 75 % of those treated nonoperatively reported unsatisfactory results at long-term follow-up because of recurrence, instability, and pain or stiffness; by contrast, 72 % of patients in the same randomized trial who underwent surgical stabilization instead reported good or excellent results [52]. Studies of patients younger than 20 years old and of collision athletes have found a recurrence rate as high as 90 % after a primary dislocation [48, 49, 53, 54]. Repeated instability episodes lead to dislocation arthropathy and early glenohumeral arthritis. Furthermore, there is evidence that delay in treatment until multiple dislocations occur can compromise final results of surgery [55].

Operative Treatment

Perthes [56] and Bankart [26] introduced the technique for repair of the capsule to the anterior glenoid without shortening of the overlying subscapularis. After modifications to the original description, repair of the avulsed capsule and labrum to the anteroinferior glenoid rim is commonly referred to today as the *Bankart repair*. Several capsulorrhaphy procedures have also been described to address concomitant capsular laxity and restore joint volume down to normal.

The inferior capsular shift was first introduced by Neer and Foster for multidirectional instability [32]. This procedure reduces capsular volume by retensioning capsular tissue on the side of greatest instability and reducing overall tissue redundancy. For anterior–inferior instability, we use a modified inferior capsular shift procedure, in essence a laterally based "T-shaped" capsulorrhaphy [11, 57].

The rationale behind this approach to instability is based on several factors. First, the capsule is shaped like a funnel with a broader insertion on the humeral side. Implementing a laterally based capsulotomy allows the tissue to be shifted a greater distance for reattachment to the broader lateral insertion. Second, following intraoperative assessment of the inferior pouch and capsular redundancy, the inferior shift procedure permits variable directions of capsular mobilization around the humeral neck to treat different aspects of capsular laxity. Third, use of a T-shaped capsulotomy permits independent tensioning of the capsule in the medial–lateral and superior–inferior directions. Medial–lateral tensioning is usually a secondary concern and, if overdone, may result in loss of external rotation. Fourth, a lateral capsular incision affords some protection to the axillary nerve, particularly during an inferior dissection as the nerve traverses under the inferior capsule. Finally, capsular tears/avulsions from the humeral insertion, although rare, are more readily identified and repaired with a laterally based incision.

The patient is placed in a beach chair position, although slightly more recumbent than when performing a rotator cuff repair. We use a regional interscalene catheter with general anesthesia. Examination under anesthesia should be performed prior to incision to confirm the direction and degree of instability. The key to a "mini-open" Bankart procedure is the use of a concealed anterior axillary incision starting approximately 3 cm below the tip of the coracoid and extending inferiorly for 7–8 cm into the axillary recess (Fig. 6). Supplemental local anesthetic is injected into the inferior aspect of the wound where thoracic cross-innervation prevents a complete block in this area. Full-thickness subcutaneous flaps are mobilized until the inferior aspect of the clavicle is palpated. The deltopectoral interval is then developed, taking the cephalic vein laterally with the deltoid. If needed, the upper 1–2 cm of the pectoralis major insertion may be released to gain further exposure. The clavipectoral fascia is then gently incised lateral to the strap muscles, which are gently retracted medially. A small, medially based wedge of the anterior fascicle of the coracoacromial ligament may be excised to increase visualization of the superior border of the subscapularis muscle, rotator interval, and anterior aspect of the subacromial space.

The upper and lower borders of the subscapularis are identified. The anterior humeral circumflex vessels are carefully isolated and ligated. Management of the subscapularis then proceeds in one of the following ways. The inferior third of the subscapularis muscle may be preserved in order to provide protection to the axillary nerve. This may be a reasonable option in true unidirectional instability cases; however, inadequate exposure of the inferior capsule may compromise the ability to correct any coexisting inferior laxity component. Another approach splits the subscapularis horizontally in line with its fibers at the junction of the superior two thirds and inferior one third. In this case, visualization of the glenoid and inferior capsule is more difficult, but motion is less restricted postoperatively since there is no tendon repair to protect. This approach may be useful in athletes who throw, in whom any restriction in external rotation postoperatively is undesirable [57]. For most cases, we prefer to detach the entire subscapularis tendon as a tenotomy starting 1 cm medial to its insertion on the lesser tuberosity, being careful not to stray too medially into the muscle fibers and compromise the subscapularis repair. Blunt elevation of the muscle belly from the capsule medially permits easier identification of the plane between the two structures.

Examination of the rotator interval is essential during dissection of the capsule and subscapularis. As one of the primary static stabilizers of the glenohumeral joint, the rotator interval can be an important component of recurrent anterior instability. We repair this if it is found to be widened, aware that overly tightening the gap will limit external rotation.

The arm is placed in adduction and external rotation to maximize the distance between the incision and axillary nerve, which should be palpated and protected throughout the procedure. The capsule is then incised laterally first with the vertical portion of the capsulotomy, placing traction sutures in the free edge.

At this point, the extent of capsular dissection and mobilization depends on the components of instability identified preoperatively. Unidirectional anterior instability will only require dissection of the anterior capsule. Bidirectional

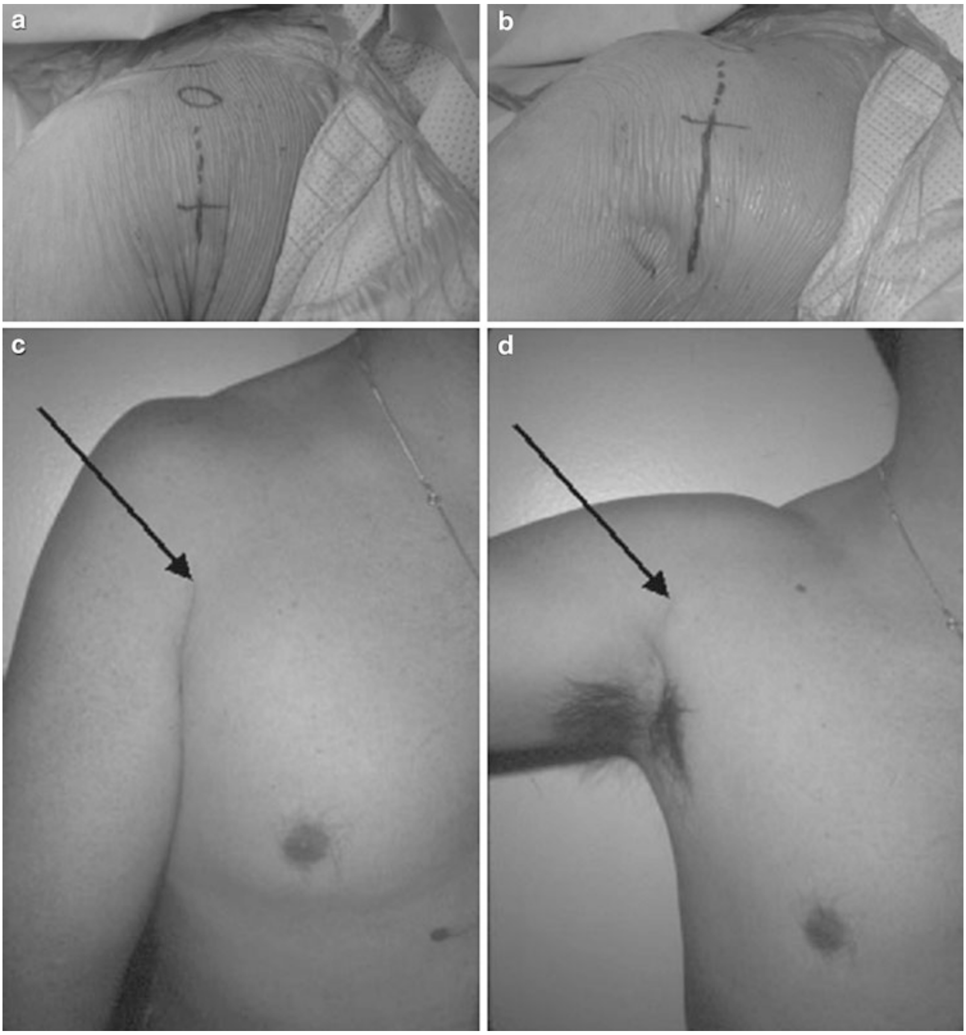

Fig. 6 Concealed axillary incision. (**a**) Arm at the side and (**b**) Arm in abduction. The *circle* indicates the coracoid process. The *solid line* indicates the true concealed incision; if needed for more exposure, the *dashed line* indicates extension toward the coracoid. (**c**) and (**d**) Healed axillary incision. *Black arrows* indicate the superior extent of the incision (From Lee and Flatow [30], with kind permission of Springer Science and Business Media, Inc.)

anterior–inferior instability will require the addition of inferior capsular mobilization to eliminate the enlarged capsule. In these cases, the shoulder is gradually flexed and externally rotated to facilitate sharp dissection of the anterior and inferior capsule off of the humeral neck. A finger can be placed in the inferior recess to assess the amount of redundant capsule and the adequacy of the shift. As more of the capsule is mobilized and upward traction is placed on the sutures, the volume of the pouch will reduce and push the finger out, indicating an adequate shift.

If there is minimal inferior instability, an inferior shift may be unnecessary, and the horizontal portion of the capsulotomy can be omitted. If there is significant inferior capsular redundancy, the horizontal limb of the T-shaped capsulotomy is made between the inferior and middle glenohumeral ligaments. A Fukuda retractor is then placed to visualize the glenoid (Fig. 7). If

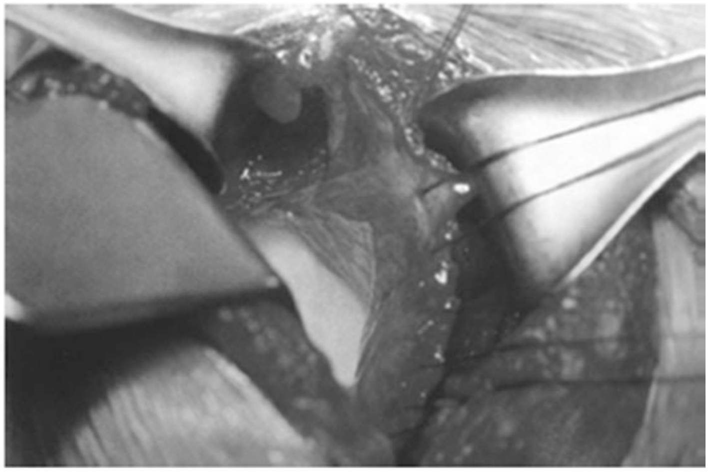

Fig. 7 Vertical capsulotomy with traction sutures in the free edge. A Fukuda retractor is placed, allowing inspection of the glenoid. (From Lee and Flatow [30], with kind permission of Springer Science and Business Media, Inc.)

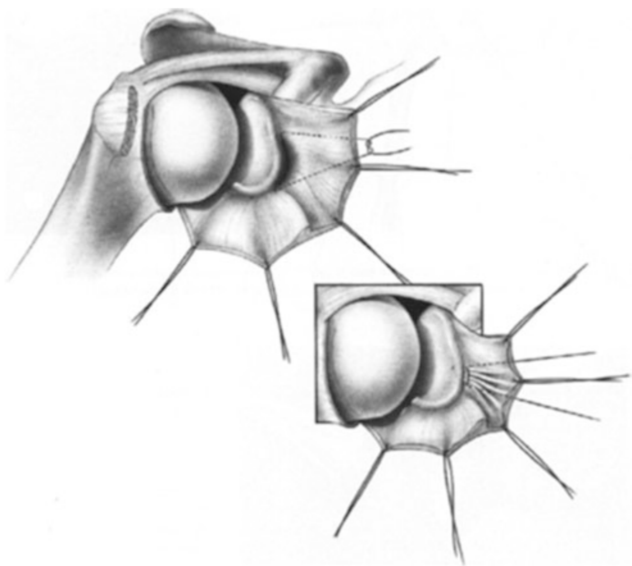

Fig. 8 A barrel stitch may be used medially to bunch up capsular tissue for later repair at the glenoid rim; the imbricated tissue helps to compensate for a deficient labrum (From Post et al. [58])

the capsule is thin and redundant medially, a "barrel" stitch can be used to imbricate the capsule for later repair (Fig. 8).

The anteroinferior glenoid labrum is then inspected. Effectiveness of a shift requires anchoring of the capsule to the glenoid. When the glenohumeral ligaments and labrum are avulsed from the glenoid bone, they must be reattached to the glenoid rim (Fig. 9). This can be accomplished with sutures through bone tunnels or with suture anchors. First the labrum is freed from adhesions medially and mobilized to the glenoid rim until a tension-free repair is possible. After the glenoid rim is roughened with a curette or high-speed burr, two to three bone tunnels are made adjacent to the articular surface and exiting inferomedially. Curved awls, angled curettes, and heavy towel clips may be used to create the tunnels. A small CurvTek device (Arthrotek, Warsaw, IN) may also be helpful in making the holes. Number 0 nonabsorbable braided sutures (e.g., Ethibond [Ethicon/Johnson & Johnson, Somerville, NJ]) are passed through the tunnels. Both limbs are then brought inside out through the labrum and tied on the outside of the capsule. Alternatively, suture anchors can be utilized, placing them

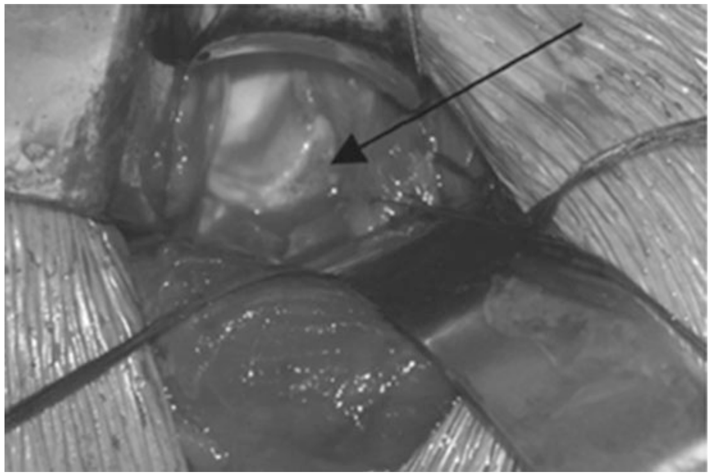

Fig. 9 Avulsion of the labroligamentous complex from the glenoid rim. The *solid black arrow* indicates the bare anteroinferior glenoid rim

adjacent to the articular margin with care not to insert them too medially and thereby lose the bumper effect of the repaired labrum to the glenoid rim.

Instead of simple labral detachment, patients may have bony Bankart fractures of the anteroinferior glenoid rim. The bony fragment nearly always remains attached to the labroligamentous structures. This fragment is often medialized and should be freed for mobilization to the glenoid rim for a tension-free repair. The fracture site is carefully debrided. Small bone fragments are repaired back to the glenoid with sutures through bone tunnels or suture anchors as described above. If the fragment is at least 1 cm wide, then screw fixation is preferred to suture fixation. These larger fragments are secured with one or two 3.5 mm partially threaded screws, countersinking the head of the screw within the bone.

Cases with attritional bone loss of larger than 25 % of the glenoid width without a reparable fragment should be identified preoperatively, as they should be treated with coracoid transfer or with allograft bone [13, 59]. Femoral head or tibial plafond allograft can be fashioned to reconstitute the glenoid rim. The technique for Latarjet will be described in another chapter, but the end result is transfer and fixation of the coracoid to the anteroinferior glenoid rim with two 3.5 mm cannulated screws and washers, carefully engaging the posterior cortex of the glenoid (Fig. 10).

After Bankart repair, attention is turned to inspecting the humeral head for an engaging Hill–Sachs lesion. If the Hill–Sachs lesion does not cause instability when the shoulder is taken through a full arc of passive motion, then the surgeon can proceed with the capsular shift. Otherwise, there are several options for achieving stability in the presence of an engaging Hill–Sachs lesion. First, the anterior portion of the capsular shift can be deliberately increased to restrict external rotation. This should be done with caution since, as previously mentioned, it can lead to glenohumeral arthrosis. Second, a size-matched humeral osteoarticular allograft or a corticocancellous iliac graft can be utilized to fill the defect. Third, a prosthetic implant may be utilized, such as a partial resurfacing metal cap. Finally, an internal rotation proximal humeral osteotomy can be performed, albeit with significant technical difficulty and potential morbidity, to shift the posterosuperior defect out of the arc of motion.

Next, a rotator interval closure is performed if indicated, with the arm in an adducted and externally rotated position, using two number 0 nonabsorbable braided sutures.

To perform the capsular shift, the arm is positioned in at least rotation, 45° of abduction, and 10° of flexion while securing the tissues for the capsular shift. Once any adherent soft tissues impeding excursion of the capsule are dissected from the capsule, the inferior flap should be shifted superiorly first and repaired to the lateral stump of capsule remaining on the humerus. Next, the superior flap is shifted to a more inferior position and repaired. A suture may be placed

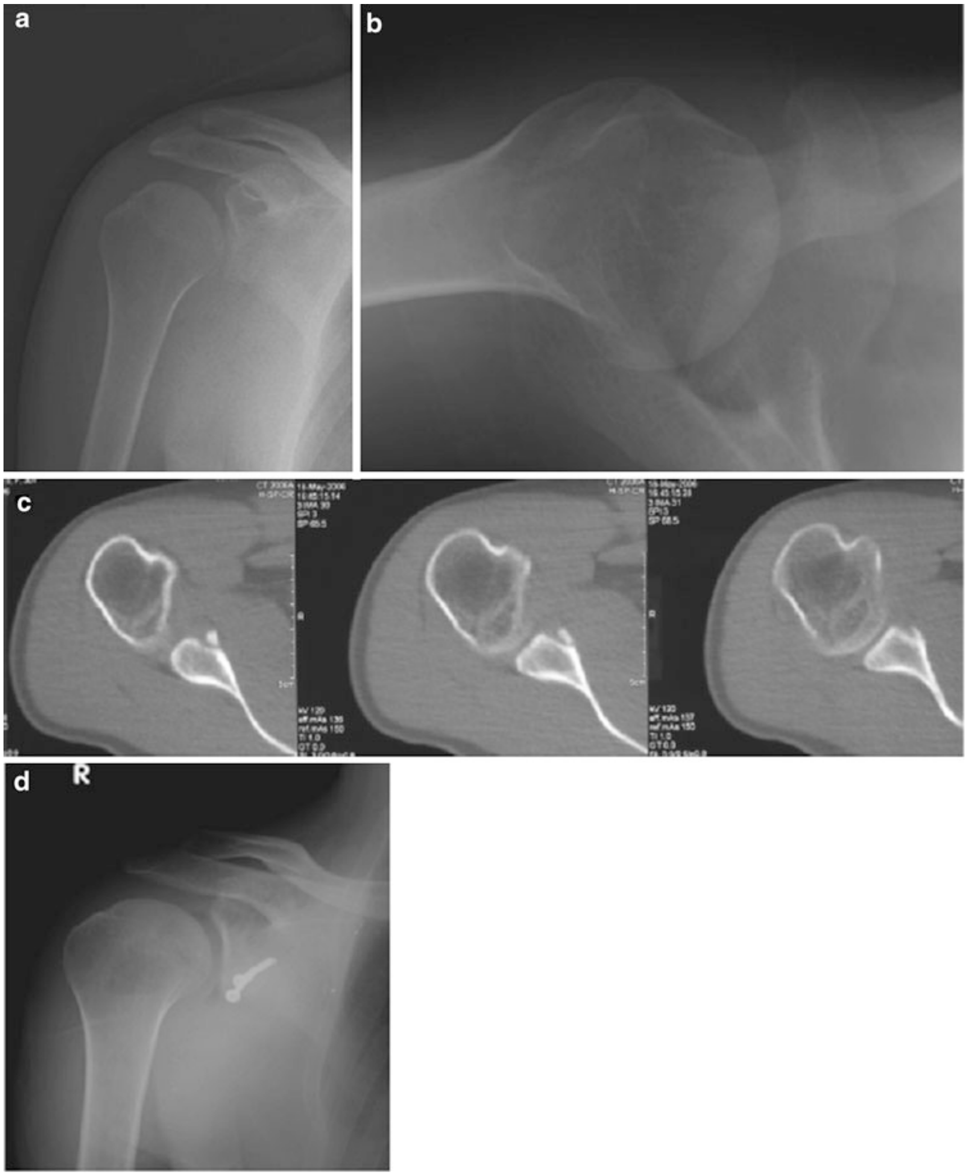

Fig. 10 Laterjet coracoid transfer for anteroinferior glenoid bone loss. (**a**) and (**b**) Preoperative radiographs. (**c**) Preoperative axial CT images. (**d**) Postoperative scapular anteroposterior radiograph with bone block and screws in place

medially to reinforce the area of overlap of the two flaps. The vertical capsulotomy is then closed with the desired amount of medial-to-lateral overlap. The subscapularis tenotomy is then repaired through bone tunnels in the lesser tuberosity and tendon-to-tendon sutures, followed by a layered closure.

Postoperative Care

The challenge following an instability procedure is to find the delicate balance between early gradual motion and maintenance of stability. In general, patients are protected in a sling for 6 weeks with immediate active hand, wrist, and elbow motion, and isometric shoulder exercises started at approximately 7–10 days. From 10 days to 2 weeks, gentle assisted motion is permitted with external rotation with a stick to 10° and elevation to 90°. From 2 to 4 weeks, motion is progressed to 30° of external rotation and 140° of elevation. From 4 to 6 weeks, external rotation to 40° and elevation to 160° are initiated in addition to light resistive exercises. Terminal elevation stretching and external rotation to 60° are permitted after 6 weeks. After 3 months, when the soft tissues have adequately healed, terminal external rotation stretches are allowed as well as gradual strengthening. Patients can expect a return to sport at 9–12 months postoperatively. These are broad guidelines that should be adapted to each individual case based on intraoperative findings and frequent postoperative exams. Repair quality, patient reliability, and future demands on the shoulder should dictate the progression of the rehabilitation program.

Results

Good results have been achieved with most open capsulorrhaphy techniques to treat anterior/anterior–inferior glenohumeral instability. Thomas and Matsen [60] reported 97 % good or excellent results in 63 shoulders with repair of the Bankart lesion and incising both the subscapularis and capsule. Pollock et al. reported 90 % successful results with an anterior–inferior capsular shift in 151 shoulders with a 5 % rate of recurrent instability. Bigliani et al. [11] studied 68 shoulders in athletes who underwent an anterior–inferior capsular shift with 94 % of patients with good or excellent results. Fifty-eight patients (92 %) returned to the major sports and 47 patients (75 %) returned at the same competitive level. In our series, 98 % of the patients were stable at an average follow-up of 6.5 years, with a high degree of patient satisfaction. The average loss of external rotation was 4°, and the average Rowe score was 96 [61].

Choice of Mini-Incision Versus Arthroscopic Repair

Best available data shows comparable results for arthroscopic and mini-incision open Bankart repair. However, there is some evidence that a certain subset of patients may require mini-open Bankart repair, such as young collision and overhead athletes, revision cases, and in cases with a sizable glenoid fracture amenable to screw fixation [20, 21, 52, 62, 63].

Advantages of arthroscopic repair include preservation of the subscapularis (although splitting the subscapularis in line with its fibers may also accomplish this), ability to thoroughly evaluate and visualize the entire glenohumeral joint, biceps, and labrum, and improved cosmesis [64, 65]. Cost differential is negligible if all procedures are done on an outpatient basis [66]. Disadvantages of an arthroscopic approach include difficulty mobilizing and securing large, medialized glenoid bone fragments and repairing capsular tears, especially humeral avulsions. A minimally invasive approach may be less helpful in some multidirectional cases where some degree of postoperative stiffness is desired. Open repair has been advocated for patients with extremely large Hill–Sachs requiring grafting or mini-surface replacement, collision athletes, and revision cases [16–19].

The authors utilize arthroscopic techniques for most cases in which only labral avulsion and capsular stretch need to be addressed. We will mobilize and repair small glenoid avulsion fragments arthroscopically, but when screw fixation of a bony Bankart fracture or bone grafting of the glenoid or Hill–Sachs lesion is required, a mini-incision open approach is employed. Finally, revision cases may be performed arthroscopically in many cases, especially when the failure is due to an unhealed or improperly medialized Bankart lesion, but an open approach is undertaken otherwise. Finally, an open approach is also employed if subscapularis deficiency already exists and requires extensive mobilization for repair or subcoracoid pectoralis transfer. Usually these procedures may be performed through the same concealed axillary, mini-incision approach as previously described.

References

1. Du Toit GT, Roux D. Recurrent dislocation of the shoulder: a twenty-four year study of the Johannesburg stapling operation. J Bone Joint Surg Am. 1956;38A:1–12.
2. Magnuson PB, Stack JK. Recurrent dislocation of the shoulder. JAMA. 1943;123:889–92.
3. Hawkins RJ, Angelo RL. Glenohumeral osteoarthrosis. A late complication of the Putti-Platt repair. J Bone Joint Surg Am. 1990;72(8):1193–7.
4. O'Driscoll SW, Evans DC. Long-term results of staple capsulorrhaphy for anterior instability of the shoulder. J Bone Joint Surg Am. 1993;75(2):249–58.
5. Samilson RL, Prieto V. Dislocation arthropathy of the shoulder. J Bone Joint Surg Am. 1983;65(4):456–60.
6. Young DC, Rockwood Jr CA. Complications of a failed Bristow procedure and their management. J Bone Joint Surg Am. 1991;73(7):969–81.
7. Blazina ME, Satzman JS. Recurrent anterior subluxation of the shoulder in athletics: a distinct entity. J Bone Joint Surg Am. 1969;51A(5):1037–8.
8. Garth Jr WP, Allman Jr FL, Armstrong WS. Occult anterior subluxations of the shoulder in noncontact sports. Am J Sports Med. 1987;15(6):579–85.
9. Hastings DE, Coughlin LP. Recurrent subluxation of the glenohumeral joint. Am J Sports Med. 1981;9 (6):352–5.
10. Rowe CR, Zarins B. Recurrent transient subluxation of the shoulder. J Bone Joint Surg Am. 1981;63 (6):863–72.
11. Bigliani LU, Kurzweil PR, Schwartzbach CC, Wolfe IN, Flatow EL. Inferior capsular shift procedure for anterior-inferior shoulder instability in athletes. Am J Sports Med. 1994;22(5):578–84.
12. Bankart ASB. The pathology and treatment of recurrent dislocation of the shoulder joint. Br J Surg. 1939;26:23–9.
13. Helfet AJ. Coracoid transplantation for recurring dislocation of the shoulder. J Bone Joint Surg Br. 1958;40B:198–202.
14. Morgan CD, Bordenstab AB. Arthroscopic Bankart suture repair: technique and early results. Arthroscopy. 1987;3(2):111–22.
15. Lafosse L, Lejeune E, Bouchard A, Kakuda C, Gobezie R, Kochhar T. The arthroscopic Latarjet procedure for the treatment of anterior shoulder instability. Arthroscopy. 2007;23(11):1242. e1–5.
16. Boileau P, Villalba M, Hery JY, Balg F, Ahrens P, Neyton L. Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. J Bone Joint Surg Am. 2006;88(8):1755–63.
17. Mazzocca AD, Brown Jr FM, Carreira DS, Hayden J, Romeo AA. Arthroscopic anterior shoulder stabilization of collision and contact athletes. Am J Sports Med. 2005;33(1):52–60.
18. Pagnani MJ, Dome DC. Surgical treatment of traumatic anterior shoulder instability in American football players. J Bone Joint Surg Am. 2002;84-A(5):711–5.
19. Rhee YG, Ha JH, Cho NS. Anterior shoulder stabilization in collision athletes: arthroscopic versus open Bankart repair. Am J Sports Med. 2006;34(6):979–85.
20. Neviaser AS, Benke MT, Neviaser RJ. Open Bankart repair for revision of failed prior stabilization: outcome analysis at a mean of more than 10 years. J Shoulder Elbow Surg. 2015;24(6):897–901.
21. Levine WN, Arroyo JS, Pollock RG, Flatow EL, Bigliani LU. Open revision stabilization surgery for recurrent anterior glenohumeral instability. Am J Sports Med. 2000;28(2):156–60.
22. Levine WN, Flatow EL. The pathophysiology of shoulder instability. Am J Sports Med. 2000;28 (6):910–7.
23. Wang VM, Flatow EL. Pathomechanics of acquired shoulder instability: a basic science perspective. J Shoulder Elbow Surg. 2005;14(1 Suppl S):2S–11.
24. Turkel SJ, Panio MW, Marshall JL, Girgis FG. Stabilizing mechanisms preventing anterior dislocation of the glenohumeral joint. J Bone Joint Surg Am. 1981;63(8):1208–17.
25. Bigliani LU, Pollock RG, Soslowsky LJ, Flatow EL, Pawluk RJ, Mow VC. Tensile properties of the inferior glenohumeral ligament. J Orthop Res. 1992;10 (2):187–97.
26. Bankart ASB. Recurrent or habitual dislocation of the shoulder joint. Br Med J. 1923;2:1132–5.
27. Neer II CS. Involuntary inferior and multidirectional instability of the shoulder: etiology, recognition, and treatment. Instr Course Lect. 1985;34:232–8.
28. Beall Jr MS, Diefenbach G, Allen A. Electromyographic biofeedback in the treatment of voluntary posterior instability of the shoulder. Am J Sports Med. 1987;15(2):175–8.
29. Davidson PA, Elattrache NS, Jobe CM, Jobe FW. Rotator cuff and posterior-superior glenoid labrum injury associated with increased glenohumeral motion: a new site of impingement. J Shoulder Elbow Surg. 1995;4(5):384–90.
30. Lee EW, Flatow EL. Mini-incision Bankart repair for shoulder instability. In: Scuderi G, Tria A, Berger R, editors. MIS techniques in orthopedics. New York: Springer; 2006.
31. Neviaser RJ, Neviaser TJ. Recurrent instability of the shoulder after age 40. J Shoulder Elbow Surg. 1995;4 (6):416–8.
32. Neer II CS, Foster CR. Inferior capsular shift for involuntary inferior and multidirectional instability of the shoulder. A preliminary report. J Bone Joint Surg Am. 1980;62(6):897–908.
33. Hawkins RJ, Bokor DJ. Clinical evaluation of shoulder problems. In: Rockwood CA, Matsen FA, editors. The shoulder. 3rd ed. Philadelphia: WB Saunders; 1990. p. 149–77.

34. Speer KP, Hannafin JA, Altchek DW, Warren RF. An evaluation of the shoulder relocation test. Am J Sports Med. 1994;22(2):177–83.
35. Jobe FW, Tibone JE, Jobe CM. The shoulder in sports. In: Rockwood Jr CA, Matsen FA, editors. The shoulder. 3rd ed. Philadelphia: WB Saunders; 1990. p. 961–7.
36. Hawkins RJ, Koppert G, Johnston G. Recurrent posterior instability (subluxation) of the shoulder. J Bone Joint Surg Am. 1984;66(2):169–74.
37. Danzig LA, Greenway G, Resnick D. The Hill-Sachs lesion. An experimental study. Am J Sports Med. 1980;8(5):328–32.
38. Garth Jr WP, Slappey CE, Ochs CW. Roentgenographic demonstration of instability of the shoulder: the apical oblique projection. A technical note. J Bone Joint Surg Am. 1984;66(9):1450–3.
39. Itoi E, Lee SB, Amrami KK, Wenger DE, An KN. Quantitative assessment of classic anteroinferior bony Bankart lesions by radiography and computed tomography. Am J Sports Med. 2003;31(1):112–8.
40. Nyffeler RW, Jost B, Pfirrmann CW, Gerber C. Measurement of glenoid version: conventional radiographs versus computed tomography scans. J Shoulder Elbow Surg. 2003;12(5):493–6.
41. Beltran J, Rosenberg ZS, Chandnani VP, Cuomo F, Beltran S, Rokito A. Glenohumeral instability: evaluation with MR arthrography. Radiographics. 1997;17(3):657–73.
42. Parmar H, Jhankaria B, Maheshwari M, Singrakhia M, Shanbag S, Chawla A, Deshpande S. Magnetic resonance arthrography in recurrent anterior shoulder instability as compared to arthroscopy: a prospective comparative study. J Postgrad Med. 2002;48(4):270–3; discussion 273–4.
43. Shankman S, Bencardino J, Beltran J. Glenohumeral instability: evaluation using MR arthrography of the shoulder. Skeletal Radiol. 1999;28(7):365–82.
44. Cvitanic O, Tirman PF, Feller JF, Bost FW, Minter J, Carroll KW. Using abduction and external rotation of the shoulder to increase the sensitivity of MR arthrography in revealing tears of the anterior glenoid labrum. AJR Am J Roentgenol. 1997;169(3):837–44.
45. Wintzell G, Larsson H, Larsson S. Indirect MR arthrography of anterior shoulder instability in the ABER and the apprehension test positions: a prospective comparative study of two different shoulder positions during MRI using intravenous gadodiamide contrast for enhancement of the joint fluid. Skeletal Radiol. 1998;27(9):488–94.
46. Allmann KH, Uhl M, Gufler H, Biebow N, Hauer MP, Kotter E, Reichelt A, Langer M. Cine-MR imaging of the shoulder. Acta Radiol. 1997;38(6):1043–6.
47. Sahara W, Sugamoto K, Murai M, Tanaka H, Yoshikawa H. The three-dimensional motions of glenohumeral joint under semi-loaded condition during arm abduction using vertically open MRI. Clin Biomech (Bristol, Avon). 2007;22(3):304–12.
48. Hovelius L. Anterior dislocation of the shoulder in teenagers and young adults. Five-year prognosis. J Bone Joint Surg Am. 1987;69(3):393–9.
49. Simonet WT, Cofield RH. Prognosis in anterior shoulder dislocation. Am J Sports Med. 1984;12(1):19–24.
50. Hovelius L, Olofsson A, Sandström B, et al. Nonoperative treatment of primary anterior shoulder dislocation in patients forty years of age and younger: a prospective twenty-five-year follow-up. J Bone Joint Surg Am. 2008;90(5):945–52.
51. Paterson WH, Throckmorton TW, Koester M, Azar FM, Kuhn JE. Position and duration of immobilization after primary anterior shoulder dislocation: a systematic review and meta-analysis of the literature. J Bone Joint Surg Am. 2010;92(18):2924–33.
52. Chalmers PN, Mascarenhas R, Leroux T, Sayegh ET, Verma NN, Cole BJ, Romeo AA. Do arthroscopic and open stabilization techniques restore equivalent stability to the shoulder in the setting of anterior glenohumeral instability? A systematic review of overlapping meta-analyses. Arthroscopy. 2015;31(2):355–63.
53. Rowe CR. Prognosis in dislocations of the shoulder. J Bone Joint Surg Am. 1956;38A:957–77.
54. Wheeler JH, Ryan JB, Arciero RA, Molinari RN. Arthroscopic versus nonoperative treatment of acute shoulder dislocations in young athletes. Arthroscopy. 1989;5(3):213–7.
55. Ozturk BY, Maak TG, Fabricant P, Altchek DW, Williams RJ, Warren RF, Cordasco FA, Allen AA. Return to sports after arthroscopic anterior stabilization in patients aged younger than 25 years. Arthroscopy. 2013;29(12):1922–31.
56. Perthes G. Uber operationen bei habitueller schulterluxation. Deut Z Chiropr. 1906;85:199–227.
57. Rubenstein DL, Jobe FW, Glousman RE, et al. Anterior capsulolabral reconstruction of the shoulder in athletes. J Shoulder Elbow Surg. 1993;1:229–37.
58. Post M, Bigliani L, Flatow E, et al. The shoulder: operative technique. Philadelphia: Lippincott Williams & Wilkins; 1998. p. 184.
59. Burkhart SS, De Beer JF. Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repairs: significance of the inverted-pear glenoid and the humeral engaging Hill-Sachs lesion. Arthroscopy. 2000;16(7):677–94.
60. Thomas SC, Matsen III FA. An approach to the repair of avulsion of the glenohumeral ligaments in the management of traumatic anterior glenohumeral instability. J Bone Joint Surg Am. 1989;71(4):506–13.
61. Langford J, Bishop J, Lee E, Flatow E. Outcomes following open repair of Bankart lesions for recurrent, traumatic anterior glenohumeral dislocations. Orthopedics. 2006;29(11):1008–13.
62. Carreira DS, Mazzocca AD, Oryhon J, Brown FM, Hayden JK, Romeo AA. A prospective outcome evaluation of arthroscopic Bankart repairs: minimum 2-year follow-up. Am J Sports Med. 2006;34(5):771–7.

63. Tjoumakaris FP, Abboud JA, Hasan SA, Ramsey ML, Williams GR. Arthroscopic and open Bankart repairs provide similar outcomes. Clin Orthop Relat Res. 2006;446:227–32.
64. Abrams JS, Savoie III FH, Tauro JC, Bradley JP. Recent advances in the evaluation and treatment of shoulder instability: anterior, posterior, and multidirectional. Arthroscopy. 2002;18(9 Suppl 2):1–13.
65. Sachs RA, Williams B, Stone ML, Paxton L, Kuney M. Open Bankart repair: correlation of results with postoperative subscapularis function. Am J Sports Med. 2005;33(10):1458–62.
66. Wang C, Ghalambor N, Zarins B, Warner JJ. Arthroscopic versus open Bankart repair: analysis of patient subjective outcome and cost. Arthroscopy. 2005;21(10):1219–22.