Open Operative Treatment for Anterior Shoulder Instability: When and Why?

Peter J. Millett, Philippe Clavert and Jon J.P. Warner
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Current Concepts Review

Open Operative Treatment for Anterior Shoulder Instability: When and Why?

By Peter J. Millett, MD, MSc, Philippe Clavert, MD, and Jon J.P. Warner, MD

- The treatment of anterior glenohumeral instability continues to evolve.
- Open capsulolabral repairs are time-tested and reliable.
- In an era in which arthroscopic techniques continue to improve, open surgery remains an acceptable option, and there are still certain injury patterns that cannot be adequately addressed arthroscopically.
- Decision-making regarding surgery for instability is influenced by the surgeon's experience and the relevant pathological findings.
- Open operative treatment is the preferred approach in many instances of recurrent anterior instability, particularly when there is bone and soft-tissue loss and in revision settings.

Open surgical treatment for primary anterior glenohumeral instability is reliable and time-tested and can yield excellent clinical results[1-4]. With advancements in arthroscopic technique, there has been a growing trend toward arthroscopic treatment of anterior shoulder instability. In many instances, arthroscopic treatment is preferred by patients and surgeons because it is minimally invasive, obviating the need for releasing and repairing the subscapularis; because it allows better identification and treatment of associated pathological conditions; and because it decreases morbidity and facilitates an outpatient approach. Furthermore, recent studies have demonstrated that the results of arthroscopic treatment of recurrent traumatic anterior instability are comparable with those achieved historically with open procedures[5-8].

Despite these exciting advances, open surgery remains an acceptable method of treatment, particularly when a surgeon lacks the equipment, experience, or technical expertise needed to perform an arthroscopic repair. Furthermore, open surgery remains the preferred method of treatment in situations where even the most modern arthroscopic techniques cannot adequately address the pathoanatomy, such as anterior instability in the setting of large bone defects or soft-tissue deficiencies. We will review the indications, techniques, and complications of open surgical treatment of anterior shoulder instability, summarizing the various types of open stabilization procedures and their clinical results and highlighting the specific situations in which open surgery remains the preferred method of treatment.

Open Surgical Techniques

There are two basic types of surgical approaches for shoulders with anterior instability: "anatomic" and "non-anatomic" repairs. With anatomic repairs, the goals are to restore the labrum to its normal position and to reestablish the appropriate tension in the shoulder capsule and ligaments. Depending on the pathoanatomy encountered, anatomic repairs were historically accomplished either with the classic Bankart procedure that was popularized by Rowe or with the capsular shift procedure that was popularized by Neer[1-3,9-15]. Currently, most open procedures involve a combination of these approaches, with a Bankart repair performed in conjunction with a capsular shift, and the tension of the capsule is determined selectively. The importance of this combined approach to the capsule and labrum was highlighted by the biomechanical study of a cadaver model by Speer et al., who found that complete dislocation could not occur after the creation of a Bankart lesion unless there was associated injury to the capsule[16].

The goal of non-anatomic surgical procedures is to stabilize the shoulder by compensating for the capsulolabral and osseous injury with an osseous or soft-tissue checkrein that blocks excessive translation and restores stability. Examples of non-anatomic types of stabilizations include the Bristow and Latarjet procedures, which are transfers of the coracoid to the glenoid[17,18]; the Magnuson-Stack procedure[19], which is an advancement of the subscapularis that was popularized by DePalma; and the Putti-Platt procedure, which is an imbrication and shortening of the subscapularis[20]. Many studies[21-25] have

demonstrated excellent outcomes with non-anatomic stabilizations, but the reported complications, such as loss of motion, recurrent instability, and premature arthritis[2,19,26-30], have led many North American surgeons to avoid them as a first-line approach[1,2,31,32]. Furthermore, because the anatomy is distorted by these types of repairs, revision surgery can be very challenging; however, when these procedures are performed properly in appropriate situations by skilled surgeons, good results can be obtained.

Patient Selection

Careful preoperative evaluation that includes determination of the pathoanatomy is critical so that the best method of treatment can be selected[33-36]. The clinician must collect detailed information about the cause of the instability, the number and frequency of episodes, the degree of trauma necessary for recurrence, the arm position at the time of the initial injury, and the arm position that provokes symptoms. Mechanical symptoms, such as catching or locking, may suggest a displaced labral tear or a large osseous defect that is engaging. Instability that occurs in the midrange of motion or that occurs during sleep suggests an osseous defect.

Several important findings of the physical examination should be highlighted. Passive and active motion should be assessed and compared with those of the contralateral limb. A substantial side-to-side difference in abduction suggests injury to the inferior glenohumeral ligament complex. Strength-testing is used to evaluate the functions of the rotator cuff. Weakness in an older patient with a traumatic dislocation suggests a rotator cuff tear. In the revision setting, a marked increase in passive external rotation with positive lift-off and belly-press tests confirms failure of the subscapularis. A detailed neuromuscular assessment should be performed because axillary nerve injury is not uncommon with traumatic anterior instability. Although infrequent, suprascapular nerve injuries can also occur, especially in revision settings. Associated injuries to the superior part of the labrum (SLAP lesions) are common and can be detected by provocative examination maneuvers such as the active compression test. In the appropriate clinical setting, an apprehension sign that is relieved by a relocation maneuver can be virtually diagnostic of anterior shoulder instability and a Bankart lesion[37]. The anteroposterior laxity of the shoulder should be assessed with load and shift testing, and the inferior laxity should be assessed with inferior translation (sulcus testing). A large sulcus sign that recreates symptoms of instability is pathognomonic for multidirectional instability. Furthermore, a large sulcus sign in the adducted arm that does not decrease when the arm is placed in external rotation indicates an insufficiency of the rotator interval[10,38-44]. When marked muscle-guarding confounds the office evaluation, careful examination with the patient under anesthesia prior to surgery is essential[10,41-44].

Imaging

Orthogonal radiographs of the shoulder[45-47] help one to classify the direction of the instability and to demonstrate relevant osseous lesions. Anteroposterior and axillary radiographs aid in the detection of relevant glenoid fractures, Hill-Sachs lesions[45], or associated fractures of either the anatomic neck or the greater tuberosity. We prefer a true anteroposterior radiograph of the glenohumeral joint, a West Point axillary radiograph, and a Stryker notch radiograph for individuals in whom instability is suspected. The appearance of static anterior subluxation of the humeral head suggests either disruption of the glenoid or a subscapularis rupture. A rotator cuff tear should be suspected in patients with an inferior dislocation.

Advanced imaging can be very helpful for defining the pathoanatomy and for planning the surgical approach. A magnetic resonance imaging-arthrogram can confirm a capsulolabral injury, such as a Bankart lesion or a SLAP lesion, and can be particularly useful for diagnosing rare but important lesions, such as humeral avulsions of the glenohumeral ligaments or capsular ruptures (Fig. 1). Because of the technical difficulty involved in arthroscopic repair of these types of injuries, it is useful to obtain this information preoperatively so that adequate patient counseling and surgical planning can be carried out.

When bone deficiency is suspected, a computed tomography-arthrogram with three-dimensional reconstructions can be helpful (Figs. 2-A and 2-B). This type of study best demonstrates acute or chronic bone loss[48] and shows the orientation of the articular surfaces, as the contrast medium outlines the cartilage of the glenoid and humeral head[49-51]. A magnetic resonance imaging-arthrogram is better suited for demonstrating soft tissues, although bone deficiencies can still be detected[50-53].

Gerber and Nyffeler[54] demonstrated a method for quantifying the degree of glenoid bone loss by measuring the glen-

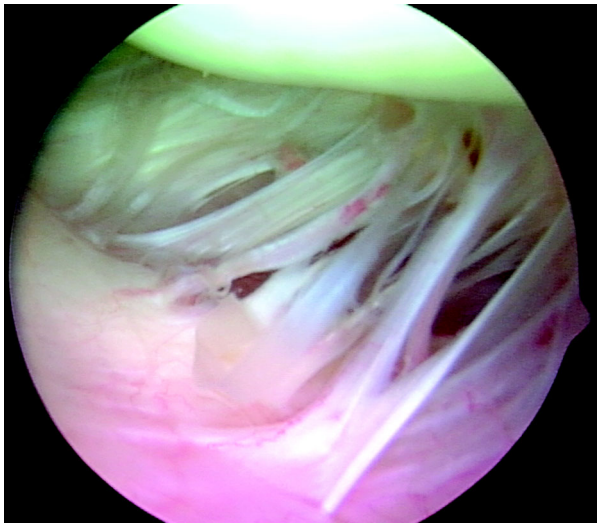

Fig. 1

Arthroscopic photograph of a humeral avulsion of the glenohumeral ligaments in a right shoulder, viewed from posterior. The humeral head is superior, and the tear is located at the anteroinferior aspect of the axillary pouch, as is typical. Because the capsule and ligaments insert beneath the humeral head, arthroscopic repair is usually not possible.

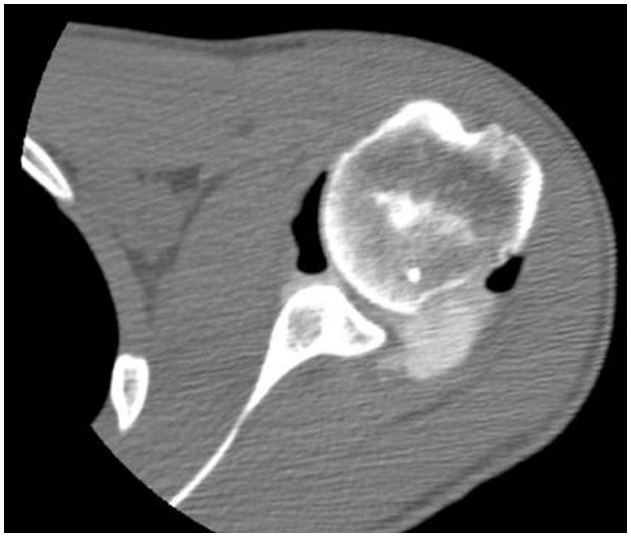

Fig. 2-A

Axial computed tomography scan demonstrating marked anterior glenoid loss.

oid surface on either an oblique sagittal image or a three-dimensional reconstruction. Through biomechanical testing, they determined that the force required for anterior dislocation is reduced by 70%, compared with that required when the glenoid is intact, if the length of the glenoid defect exceeds its maximum radius. In such cases, standard Bankart repairs (arthroscopic or open) are likely to fail, and osseous augmentation is recommended[48].

Indications for Surgery

In most cases, the essential lesion in a shoulder with traumatic anterior instability is a Bankart lesion[9], which usually occurs with some degree of capsular injury or stretch[16]. When this lesion is encountered, either an arthroscopic or an open anatomic capsulolabral repair should be successful.

Most cases of anterior glenohumeral instability can be treated with either open or arthroscopic approaches, depending on the experience and expertise of the surgeon, because there is substantial overlap in the indications for these procedures. Shoulder arthroscopy requires special technical expertise and equipment, and the arthroscopic surgery becomes even more demanding as the instability patterns become more complex. For example, repairing a Bankart lesion arthroscopically in a young patient with anterior instability is fairly straightforward, but a revision procedure may be much more difficult to tackle arthroscopically. Moreover, when a patient has multidirectional instability, which requires both anterior and posterior capsular imbrication, even a primary repair can be a challenge for even an experienced arthroscopic surgeon. If a surgeon has neither the expertise nor the equipment needed for arthroscopy, open surgery should be performed. A surgeon with experience in open surgery can achieve excellent results if the appropriate surgery is performed for the appropriate indication and with an acceptable level of skill. A good open procedure will always outperform a bad arthroscopic one.

Despite the advances in shoulder arthroscopy, there are still several relative contraindications to the procedure. These include humeral avulsions of the glenohumeral ligaments and capsular ruptures. These two injuries are extremely difficult to address arthroscopically by all but the most experienced arthroscopists. Other relative indications for open surgery include a previous failed arthroscopic or open repair because it is easier to address the causes of the instability (which may be multiple) with an open procedure. Another relative indication for an open approach is a prior failed thermal capsulorrhaphy. In this setting, the surgeon must be prepared to deal with poor-quality capsulolabral tissue or even the complete capsular deficiency that can occur with capsular necrosis.

The appropriate treatment of anterior instability in an athlete who engages in contact sports remains controversial. Some consider shoulder instability in such an athlete to be a clear indication for open surgery, and excellent results have been reported[55]. Pagnani and Dome recently reported excellent long-term results in a group of American football players who had been treated for recurrent traumatic anterior instability[56]. No patient had recurrent dislocation postoperatively, and only two of fifty-eight had recurrent subluxation. Others believe that, with careful patient selection, arthroscopic approaches can yield similar results. Burkhart and De Beer[33] reported on a group of 194 patients who had undergone an arthroscopic Bankart repair of the shoulder. One hundred and one of those patients were athletes who participated in contact sports. While the recurrence rate was 87% in patients with marked bone defects, it was only 6.5% in those who did not have bone defects.

There are some absolute indications for an open approach. These include substantial glenoid or humeral bone loss, capsular deficiency, or irreparable rotator cuff deficien-

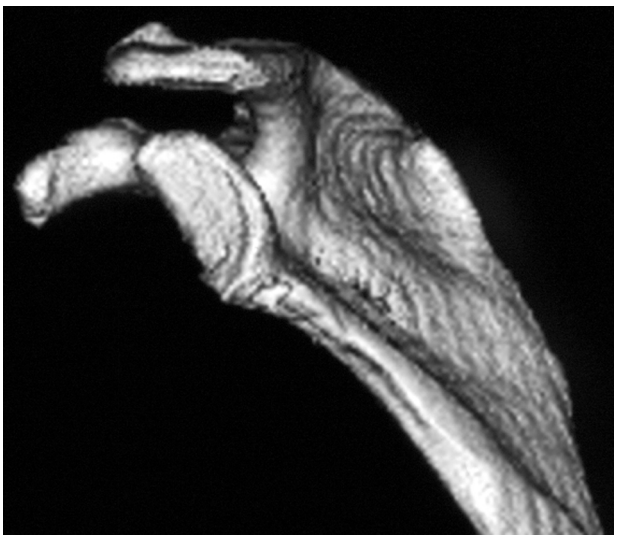

Fig. 2-B

Three-dimensional computed tomography reconstruction highlighting the amount of anterior bone deficiency. In these settings, arthroscopic repair is contraindicated and an open bone-grafting procedure is indicated to restore the glenoid arc and concavity.

cies, particularly those of the subscapularis. An osseous reconstruction should be performed in individuals with major anterior glenoid erosion. In the rare case in which a large humeral head defect (a Hill-Sachs lesion) plays a role in the recurrence of instability, open surgery should be performed. More commonly, however, anterior glenoid bone deficiency plays a role when there is a large Hill-Sachs defect and instability. When there is a chronic disruption of the subscapularis, usually in the setting of prior surgery, an open repair is indicated.

Open repair may not be effective for the treatment of instability in patients with concomitant severe arthritis. Depending on the status of the glenoid and surrounding rotator cuff, arthroplasty or arthrodesis may be better options. Paralysis may also be associated with chronic instability, and in such cases arthrodesis may be more successful in eliminating pain[57-60]. Absolute contraindications to open repair for the treatment of anterior instability include voluntary or psychogenic instability[61-63] and active infection.

Anatomic Repairs

Open Bankart repairs and capsular shift procedures have been used for many years, with various modifications, and excellent results have been reported[1,3,11,64]. With appropriate patient selection and careful surgical technique, they yield excellent success rates. In their classic article, Rowe et al. reported five recurrences in a series of 145 shoulders (a 3.5% recurrence rate)[3]. Gill et al.[1] reported a 95% success rate, with three recurrences in a series of sixty shoulders, at a mean of 11.9 years postoperatively. Studies such as these support the assertion that this technique is the "gold standard." The Bankart procedure restores normal anatomy by reattaching the labrum to its anatomic position at the anterior articular margin of the joint[9,65]. The concept of a selective capsular shift was introduced as a refinement of this technique (Fig. 3). The selective shift is based on the observation that the capsuloligamentous static stabilizers function at predictable positions of rotation and act as checkreins against excessive rotation and translation[11,66] and that the pathoanatomy involves injury to both the labrum and the capsule[16]. The Bankart lesion is anatomically repaired, and then the capsule is shifted to tighten the joint with avoidance of overconstraint.

Glenoid Bone Deficiency

Osteoarticular pathology is rarely a cause of recurrent anterior instability, but when it is present it is easily missed. Bone deficiency is also more likely to be a relevant factor in patients who present for revision surgery. In a small percentage of individuals, developmental glenoid dysplasia, in which the glenoid is flat or less concave than normal, may predispose to instability. This is more commonly associated with recurrent posterior instability, with which a dysplastic, retroverted glenoid may be present. Morrey and Janes[67] believed that loss of glenoid bone accounted for <2% of all cases of anterior instability requiring surgical repair. Marked loss of the glenoid articular surface as a result of a fracture or erosion occurs more commonly after

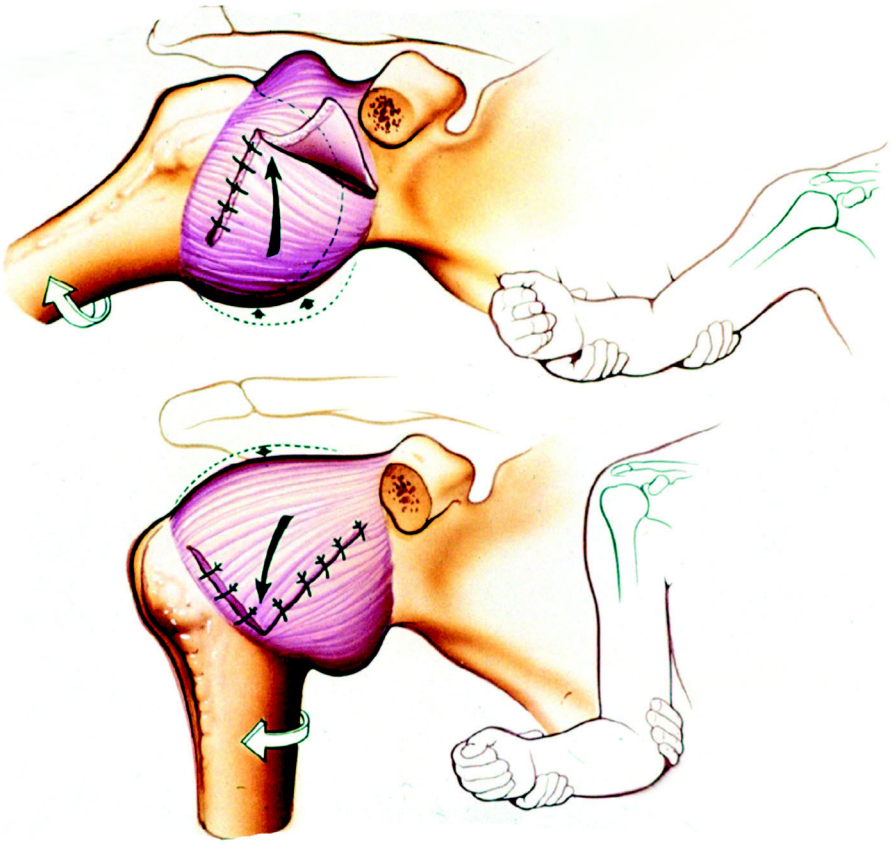

Fig. 3

Illustrations demonstrating the concept of a selective capsular shift. The Bankart lesion is repaired anatomically, the arm is then placed in the desired position (approximately 30° of glenohumeral abduction and 30° of external rotation), and the capsule is shifted laterally to the humerus to remove redundancy. (Reprinted, with permission, from: Warner JJ, Johnson D, Miller M, Caborn DN. Technique for selecting capsular tightness in repair of anterior-inferior shoulder instability. J Shoulder Elbow Surg. 1995;4:352-64.)

traumatic dislocations or recurrent episodes of instability (Figs. 2-A and 2-B). The anterior glenoid rim can actually become rounded and flattened from recurrent dislocations[68]. Experience has shown that, when such defects are present, there is an increased risk of failure when only soft-tissue repairs are performed[54,69-71]. Indeed, Burkhart et al.[33,72] observed that, when substantial glenoid erosion (which they described as an "inverted pear"-shaped glenoid) was identified at arthroscopy in athletes who participated in contact and collision sports, the failure rate of arthroscopic capsulolabral repair was >80%. Burkhart et al. evaluated 194 patients who had undergone arthroscopic Bankart repair of the shoulder and found the recurrence rate to be 4% in 173 patients without bone defects and 67% in those with substantial bone defects[33].

Until recently, there was little recognition of this potentially important risk factor for failure. Assessment of bone loss was usually anecdotal and carried out at the time of open or arthroscopic surgery, with descriptions of mild, moderate, or severe. There are scant quantitative data on what constitutes important glenoid bone loss and even less on what constitutes important humeral bone loss. Rowe and Sakellarides[73] believed that up to 30% of the glenoid can be absent without concern about an increased risk of failure of an open Bankart repair. However, in practice, it may be very difficult to quantify the exact degree of glenoid loss, even with direct inspection. This is particularly evident in chronic cases of glenoid erosion since there is no reference point, as a portion of the glenoid is already absent. More recent experimental observations have provided quantitative methods for assessing glenoid bone loss prior to surgery[54,68,69]. When a soft-tissue Bankart repair was performed experimentally in the setting of glenoid bone loss, the force required for dislocation remained low[54]. It seems likely, therefore, that a similar soft-tissue repair in a patient with such a lesion will fail unless the bone loss is addressed. A matched ball-in-socket congruity is essential for the stabilizing concavity-compression effect to occur[70].

Most surgeons now recognize the need to reconstruct or compensate for anterior glenoid bone loss[54,69,72,74]. The surgical options include either an intra-articular reconstruction with bone graft or a coracoid process transfer such as the Bristow or Latarjet procedure. Modern arthroscopic techniques cannot currently address marked glenoid bone loss. We have formed a framework with which to consider glenoid bone-grafting on the basis of the patient's symptoms and the biomechanical findings of Gerber and Nyffeler[54]. If the patient has recurrent instability, particularly with midrange symptoms or symptoms of instability in their sleep or with decreasing degrees of trauma; if a bone defect is seen on radiographs; or if a prior arthroscopic procedure has failed, then a computed tomography scan is made. If the scan demonstrates an osseous defect that is longer in the sagittal plane than the maximum radius of the glenoid, an anatomic glenoid reconstruction is performed[48].

Glenoid Reconstruction with Iliac Crest Bone Graft

Bodey and Denham were, to our knowledge, the first to report on the use of this technique, in 1983, in sixteen shoulders with recurrent anterior dislocation[75]. The results were generally good, with all patients returning to their preoperative level of work and sports activities. Glenoid grafting restores bone to recreate the arc of the glenoid (Figs. 4-A and 4-B). Haaker et al. reported that, of twenty-four soldiers treated with this technique, none had a recurrence of the instability[76]. Hutchinson et al. reported excellent results, with no recurrences, in fourteen individuals with epilepsy who were treated for recurrent anterior shoulder dislocation[77]. In most studies[76,77], the patients have been satisfied, there has been a low recurrence rate, and motion loss has been <10°.

Coracoid Process Transfers

Latarjet first described a technique of coracoid abutment in 1958[18]. This technique of coracoid transfer was later popularized and modified by Helfet[17], who named it for his mentor Rowley Bristow. The aim of these procedures is to stabilize the shoulder with the static action of the transferred bone block and the attached coracobrachialis tendon. In the Latarjet procedure, the coracoid process is osteotomized posteriorly at the junction of its horizontal and vertical parts, and then it is transferred. Only the tip of the coracoid process is transferred in the Bristow procedure, whereas, in the Latarjet procedure, the transfer includes a portion of the coracoacromial ligament, which is sutured to the capsular tissue through a short horizontal incision made in the subscapularis (Fig. 5). The Latarjet procedure reconstructs the glenoid depth and width with the bone block and creates a dynamic reinforcement of the inferior part of the capsule through the coracobrachialis muscle, particularly when the arm is abducted and externally rotated. These techniques are non-anatomic reconstructions and distort the normal anatomy. Although they are often successful, they may fail to address the essential lesion (i.e., the Bankart lesion), to address any associated pathology (SLAP lesion), and to restore the capsule.

Nevertheless, transferring the coracoid process does provide reliable and durable stabilization of the shoulder[21-25]. Recurrence rates have ranged from 0% (of fifty-eight procedures in the study by Allain et al.[22]) to 6% (seven recurrences in 111 patients in the study by Hovelius et al.[78] and three in fifty-two patients in the study by Levigne[79]). The average loss of external rotation has ranged from 6° in the study by Levigne to 23° in that by Torg et al.[80]. The motion loss is generally greater than that after an open Bankart procedure, which is usually around 10°[1,9,64]. More recently, some surgeons have advocated the addition of a coracoid bone block transfer to a standard Bankart repair for athletes who engage in collision sports[81].

Humeral Bone Deficiency

Humeral head defects are commonly present in patients with anterior shoulder instability. The defects are usually small and are called *Hill-Sachs lesions*[82]. The management of large lesions remains controversial. Furthermore, the quantification of these defects is difficult given the geometry of the humeral head. Humeral head defects are much more important when

there is an associated glenoid defect.

When the glenohumeral joint dislocates, the Hill-Sachs lesion can occur at any of a variety of joint angles as determined by the position of the humerus at the time of the dislocation. Some Hill-Sachs lesions engage the anterior glenoid rim when the glenohumeral joint is in a position of abduction and external rotation. Burkhart and De Beer described these as "engaging Hill-Sachs lesions."[33] They can be defined as defects in which the long axis of the humeral head defect aligns parallel to the anterior glenoid rim, when the shoulder is in a position of abduction and external rotation. Such fracture configurations have been found to be particularly prone to recurrent dislocation and subluxation after arthroscopic repair. If combined with a glenoid defect, they can be particularly problematic. Hovelius et al. found substantial Hill-Sachs defects in 54% of their study population of 247 individuals with primary anterior instability, and furthermore they found a higher risk of recurrence if a Hill-Sachs defect was present[83]. Rowe et al. also suggested that a Hill-Sachs lesion could be a reason for failure after open surgical repair[2]. Other authors, however, have found that the presence and magnitude of a Hill-Sachs lesion did not influence the result of an open Bankart repair[84].

With a "non-engaging" Hill-Sachs lesion, the long axis of the defect crosses diagonally across the glenoid rim with the arm in abduction and external rotation so that it never "engages" the glenoid rim. There is continuous smooth articular contact throughout the range of motion. According to Burkhart and De Beer, shoulders with a non-engaging Hill-Sachs lesion are not at substantial risk for recurrence after repair and therefore patients with this type of humeral lesion are good candidates for that type of repair[33].

Clinically relevant, large humeral head defects are rare. They are usually diagnosed on the basis of recurrent symptoms of instability and locking or on the basis of three-dimensional imaging studies. It has been suggested by some that the morphology of the Hill-Sachs defect is a prognostic factor for the degree of instability[85]. Burkhart and Danaceau suggested that the mismatch in the articular arc that occurs with a Hill-Sachs lesion is the important pathoanatomic feature[86].

Most Hill-Sachs lesions are simply ignored at the time of surgery, and the anterior aspect of the capsule and labrum are addressed with an anatomic repair, as discussed previously. When the bone defect is large, however, it may need to be addressed. Unfortunately, there are no guidelines in the literature about the size of defect that requires surgical treatment. We become concerned when the defect exceeds 20% to 30% of the humeral head as measured on a computed tomography scan or when a humeral head defect is combined with a glenoid defect.

Surgical options for the management of humeral head defects include reconstruction of the humerus with an allograft to restore the humeral articular arc, reconstruction of the glenoid with an anterior bone graft to lengthen the glenoid articular arc and prevent the humeral defect from engaging the glenoid rim, or rotation of the humeral head with an osteotomy to move the defect so that it does not come into contact with the anterior aspect of the glenoid. If there is an associated glenoid defect, we recommend that the glenoid be reconstructed first; if the humeral defect is still marked, it can be reconstructed with an allograft. However, the evidence for each of these approaches is largely anecdotal and based on small series or case reports[86-88].

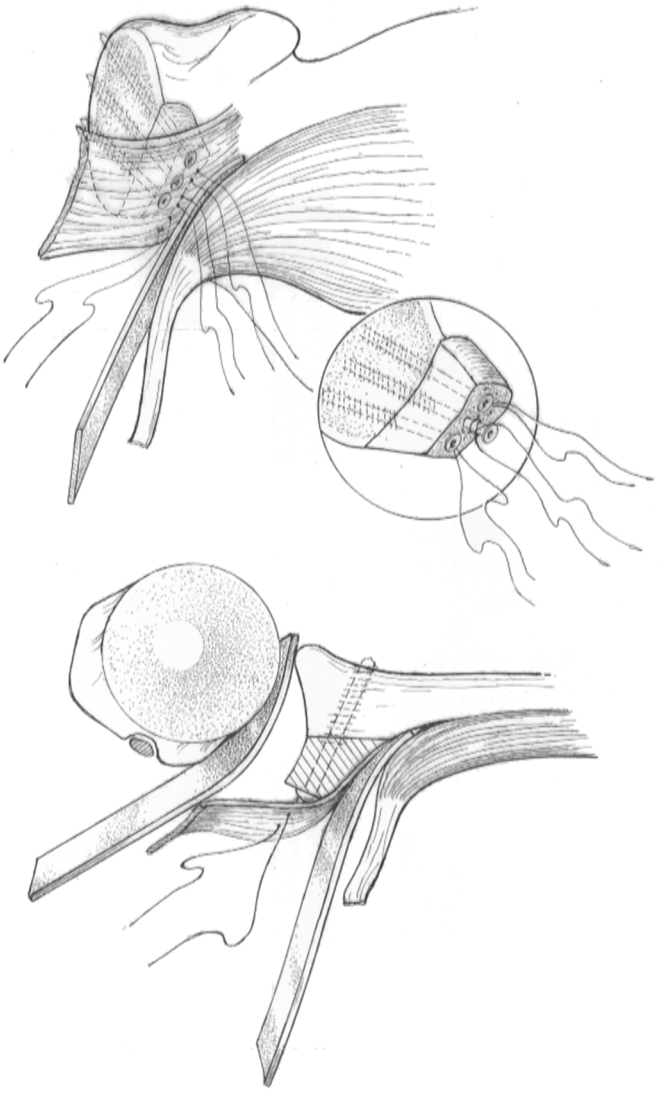

Fig. 4-A

Illustrations demonstrating an anatomic glenoid reconstruction with autogenous iliac bone graft. The graft restores the articular arc and glenohumeral stability.

End-Stage Instability

In rare cases, individuals will continue to complain of instability despite attempted surgical reconstructions. In certain salvage settings, glenohumeral arthrodesis may be the only option available[58,59]; however, Richards et al.[89] made the sobering observation that many of these patients had sensations of instability despite radiographic evidence of a solid fusion.

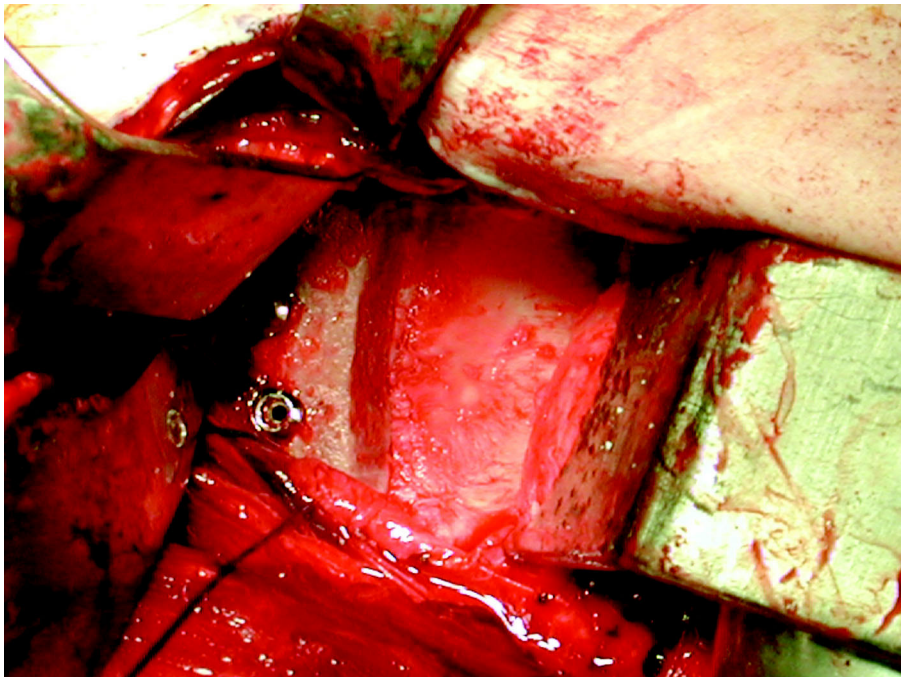

Fig. 4-B
Intraoperative photograph demonstrating the graft in position.

Moreover, in some of these patients, problems with the scapulothoracic joint developed as a result of severe posturing, secondary scapular winging, pseudo-winging, and a snapping scapula. These symptoms may occur as a result of, or be aggravated by, the arthrodesis[89]. Despite the concerns about arthrodeses, there may be no other reasonable surgical option for this subcategory of patients.

Revision and Complex Problems

Revision surgery for shoulder instability is among the most technically challenging of all. Nevertheless, it can also be among the most satisfying procedures if basic principles are observed. When non-anatomic repairs need to be revised, the normal tissue planes are often distorted. This adds technical complexity to the procedure and increases the risk of complications. When attempting to salvage failed repairs for anterior instability, surgeons should be prepared to face challenging scenarios such as distorted anatomic tissue planes, severe scarring, capsular deficiencies from multiple prior surgical procedures or thermal capsulorrhaphy[90,91], osseous deficiencies due to erosion or fracture, and subscapularis deficiencies.

Capsular Deficiency

Capsular deficiency is a rare condition, and there is a paucity of literature dealing with soft-tissue deficiency in relation to instability[92-95]. Capsular deficiency is more common in revision settings and after thermal capsulorrhaphy. The soft-tissue deficiency may include the subscapularis. There are several reasonable surgical options for an unstable shoulder with a deficient capsule. Lazarus and Harryman described a method of using

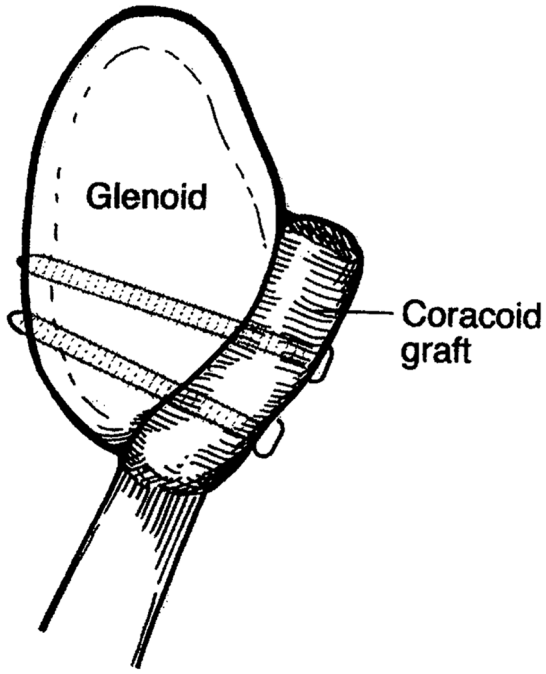

Fig. 5
Illustration demonstrating a coracoid bone graft (Latarjet procedure) being used to restore bone in a glenoid deficiency. The coracoid is osteotomized at its base and then transferred to the anteroinferior aspect of the glenoid with the conjoined tendon. (Reprinted, with permission, from: Burkhart SS, Debeer JF, Tehrany AM, Parten PM. Quantifying glenoid bone loss arthroscopically in shoulder instability. Arthroscopy. 2002;18:488-91.)

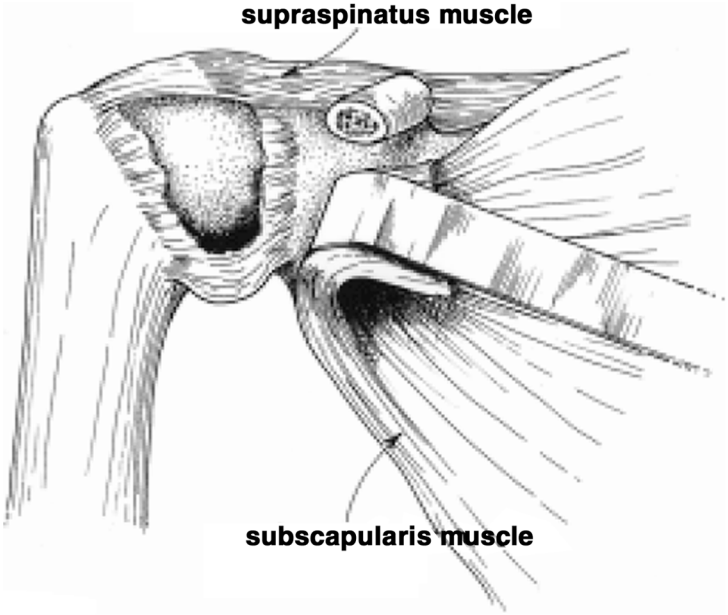

Fig. 6-A
Illustration demonstrating anterior capsular deficiency. (Reprinted from: Warner JPJ, Venegas AA, Lehtinen JT, Macy JJ. Management of capsular deficiency of the shoulder. A report of three cases. J Bone Joint Surg Am. 2002;84:1669.)

hamstring tendons for repair of such deficiencies[96], and Warner et al. reported good outcomes after using a modification of that technique[95]. The long head of the biceps can be combined with the autograft for additional support. Presently, this is our preferred method for treating anterior shoulder instability in the setting of capsular deficiency (Figs. 6-A and 6-B).

Gallie and Le Mesurier described the use of the iliotibial band for capsular reconstruction to treat glenohumeral instability associated with an irreparable capsule[97]. More recently, Iannotti et al. reported their experience with this technique in seven patients[92]. The results were generally good, with no recurrences or problems with persistent apprehension.

Moeckel et al. described the use of Achilles tendon allograft in ten patients who had persistent anterior instability following shoulder arthroplasty (in a series of 236 total shoulder arthroplasties)[93]. The results were generally fair to good with some loss of motion but restoration of stability.

Subscapularis Tendon Tears

Rupture of the subscapularis in association with primary anterior shoulder instability is a rare condition, and the diagnosis can be subtle. It is more common after a prior open repair for the treatment of instability, and it should be suspected in patients who have had a prior anterior stabilization procedure in which the subscapularis was released for exposure[98]. Subscapularis tears can also occur after shoulder arthroplasty with anterior instability of the prosthesis, although discussion of this topic is beyond the scope of this article. Failure to recognize and treat a subscapularis tear in a proper and timely fashion can result in a poor outcome. A careful physical examination to assess the subscapularis is necessary. Individuals with subscapularis deficiency have increased passive external rotation and positive belly-press and lift-off signs[99,100]. A computed tomography-arthrogram or magnetic resonance imaging-arthrogram can also be helpful for evaluation of the structural integrity of the subscapularis tendon. Three-dimensional imaging allows quantification of muscle atrophy, which is best observed on the axial and sagittal oblique views[101]. On rare occasions, individuals who have had prior surgery have subscapularis dysfunction due to denervation of the muscle, and in such settings an electromyogram may be helpful.

There are several published studies on rupture of the subscapularis tendon in association with instability[13,94,102-107]. Hauser[102] was, to our knowledge, the first to describe an isolated tear of the subscapularis tendon in association with anterior instability. Neviaser et al.[108] emphasized that a rupture of the subscapularis tendon should be suspected in all patients with recurrent instability and in older patients after an initial anterior dislocation of the shoulder. Results of surgical treatment of subscapularis tendon tears are less successful than those of supraspinatus tears. Gerber and Krushell[100] emphasized the importance of a timely diagnosis and early surgical management. Results are better if the duration between the traumatic event and the repair is short. A delay in diagnosis leads to retraction of the tendon and atrophy of the muscle so that tendon mobilization becomes difficult. Results of surgical repair are usually good with regard to pain relief and restoration of stability, but many patients continue to have mild-to-moderate internal rotation weakness[100,105].

When the subscapularis tendon is deficient or irreparable, a pectoralis major muscle transfer may be used to augment or substitute for the subscapularis. Gerber and Krushell[100] originally described the technique for mobilization and repair of the subscapularis tendon and recommended that the inferior portion of the subscapularis tendon be repaired so that the pectoralis major transfer can be used simply to augment the function of the deficient upper part of the tendon (Fig. 7). There have been several reports on transfer of the pectora-

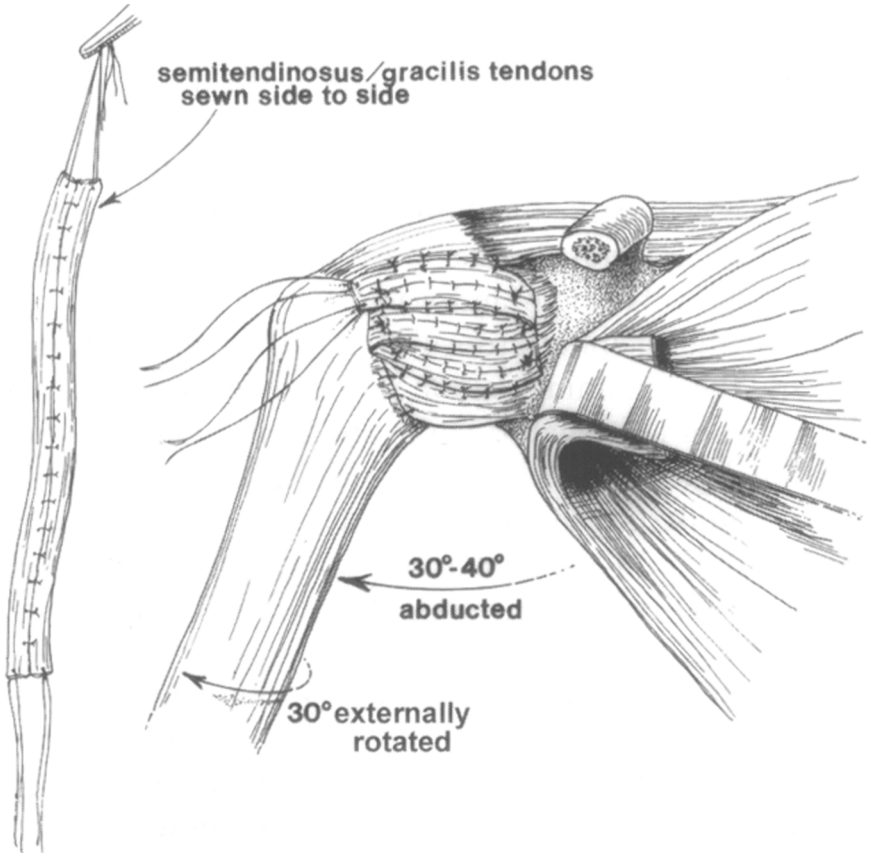

Fig. 6-B
Illustration demonstrating capsular reconstruction, with use of the hamstring tendons, performed to address a deficient anterior aspect of the capsule. (Reprinted from: Warner JPJ, Venegas AA, Lehtinen JT, Macy JJ. Management of capsular deficiency of the shoulder. A report of three cases. J Bone Joint Surg Am. 2002;84:1669.)

lis major tendon for treatment of anterior shoulder instability[66,94,100,109-111]. Decreased pain and restored stability are the main benefits of this surgery. Usually, functional gains in terms of mobility are variable and more limited. Even when flexion and abduction are improved, many individuals remain limited with regard to their ability to perform overhead activities. In the majority of instances, the lift-off test and the belly-press test remain positive postoperatively.

Complications and Pitfalls

Recurrence of Instability

Recurrence is the most frequently reported complication after open and arthroscopic surgery for the treatment of anterior instability[2,26,27,96,112-118]. Recurrence may be secondary to a new traumatic event or to atraumatic events[112,119,120]. Patients with a traumatic cause for the recurrence usually have better results after revision surgery than do patients with atraumatic recurrence[62]. The recurrence rate is related to the number of prior operations. For example, Levine et al.[62] found that the recurrence rate was 17% in patients who had had one prior operation, whereas it was 44% in individuals with multiple prior failed surgical procedures. The repetitive damage to the subscapularis and the capsule undoubtedly compromises the results of additional surgery.

A variety of factors can contribute to the failure of open surgical treatment of anterior instability. The most common are an incorrect diagnosis, an incorrect or technically inaccurate surgical procedure, a bone defect with loss of glenoid concavity, and anterior capsular deficiency. Examples of misdiagnoses are a failure to recognize posterior or multidirectional instability patterns[27,54,112,116,121], a failure to diagnose a substantial voluntary component to the instability[61,122], and a failure to recognize and treat associated injuries. Incorrect or technically imprecise surgical procedures can also lead to recurrence. Subscapularis rupture is a complication of faulty technique that can be devastating. Numerous studies have shown that residual Bankart lesions[123], undercorrected anterior capsular redundancy, and unrecognized laxity of the rotator interval[2,26,27,31,39,62,113,123] result in recurrent instability. As discussed previously, a defect in the glenoid concavity due to an osseous Bankart lesion or an erosion of the anterior glenoid rim increases the risk of recurrence[54,69-71].

Stiffness

Stiffness after surgery for the treatment of open anterior instability has been noted infrequently in the literature, and the prevalence is probably underreported[71,119,124]. Certain anatomic repairs were designed to limit external rotation and hence the risk of recurrence, so loss of motion was not considered a complication. In some settings (e.g., capsular reconstruction or revision surgery), limited external rotation remains an expected outcome, and this should be conveyed to patients preoperatively. While loss of 10° of external rotation may have little functional consequence for most individuals, it may be devastating

for an athlete who engages in overhead sports. This is an important point that should be considered when selectively shifting the capsule. Overconstraint should be avoided, as an overconstrained joint has abnormal kinematics, with shear across the articular cartilage and altered joint reactive forces[125]. Harryman et al.[126] showed that passive motion of the glenohumeral joint is coupled reproducibly with translation of the humeral head on the glenoid. When the anterior aspect of the capsule is overly tight, the humeral head has excessive posterior translation with external rotation. This posterior translation creates shearing forces on the posterior glenoid rim that may result in cartilage erosion and early osteoarthrosis[119,121,127]. This phenomenon has been called "capsulorrhaphy arthropathy" or "arthritis of dislocation" and results from loss of motion with subsequent cartilage deterioration and joint arthrosis. Unfortunately, there is no clear threshold beyond which these biomechanical consequences are realized; however, a loss of external rotation of >30%, as compared with the external rotation of the contralateral shoulder, increases the risk of capsulorrhaphy arthropathy[119,121,127].

Motion loss is best prevented at the time of the surgical repair by physiologically tensioning the capsule while the arm is in abduction and external rotation. To avoid overconstraint, a rule of thumb has been to position the shoulder in 30° of external rotation and 30° of abduction. Furthermore, proper postoperative rehabilitation can prevent the development of excessive stiffness. When refractory motion loss persists, a formal capsular release may be considered[125].

Subscapularis Deficiency

Rupture of the subscapularis after an open repair for the treatment of anterior instability causes substantial functional disability, which may or may not be associated with recurrence of instability. Often, such tears are not recognized when patients present postoperatively with weakness and pain but no clear evidence of recurrent instability. A high index of suspicion and a careful physical examination are necessary in order to detect this problem.

When a subscapularis rupture occurs, repair poses a real surgical challenge and a risk of injury of the surrounding neurovascular structures[128-130]. Unless the rupture is detected and addressed quickly, the subscapularis muscle and tendon often retract and adhere to the surrounding structures. The axillary nerve, musculocutaneous nerve, and brachial plexus are all at risk. This problem is best avoided by meticulous repair of the tendon. If the subscapularis ruptures, a direct repair of the tendon is often successful. In chronic cases, tendon transfer of the pectoralis major is necessary, as previously described[100,109,110].

Arthrosis

Glenohumeral arthrosis is a well-described complication of various surgical procedures done to correct shoulder instability[21,22,67,131-135]. Overtightening of the anterior structures, with stiffness, can drive the humeral head posteriorly, creating shear on the cartilage and early arthrosis. Paradoxically, some patients may have instability and stiffness. The shoulder feels unstable because of excessive laxity in the axillary pouch and an untreated inferior glenohumeral ligament detachment, yet it feels stiff because the middle glenohumeral ligament, the rotator interval, and sometimes the subscapularis are excessively tight. Complex releases with revision capsular shift may be required. An example is a z-plasty subscapularis lengthening combined with an anterior-inferior selective capsular shift. Fortunately, such scenarios are rare.

Other causes of premature osteoarthrosis are iatrogenic,

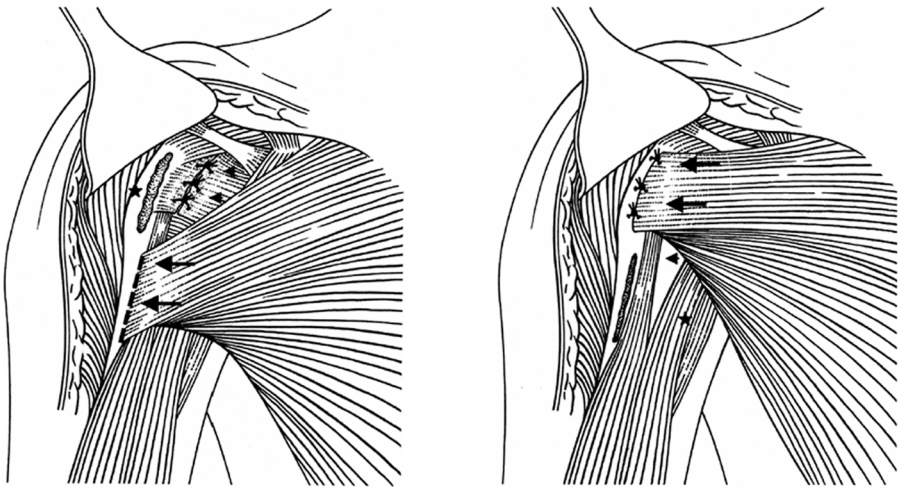

Fig. 7

Illustration demonstrating a pectoralis major transfer for the treatment of subscapularis deficiency with the technique of Gerber and Krushell[100]. The entire pectoralis major is transferred superiorly to the lesser tuberosity to substitute for the deficient subscapularis. (Reprinted from: Jost B, Puskas GJ, Lustenberger A, Gerber C. Outcome of pectoralis major transfer for the treatment of irreparable subscapularis tears. J Bone Joint Surg Am. 2003;85:1947.)

such as anterior impingement on a coracoid bone block that was placed too far laterally along the glenoid rim[21,22,78,80], impingement on local hardware such as a screw, and incorrect intra-articular placement of metal anchors[134].

Hardware Problems

Any surgical implant has the potential to break, loosen, and migrate. Zuckerman and Matsen[134] emphasized that loose hardware in the shoulder can migrate and threaten the vital structures of the thorax. They also reported that most of their patients with hardware problems required additional surgery and had marked iatrogenic chondral defects. Moreover, when hardware needs to be removed, there is always the potential for leaving bone defects that require grafting.

Neurovascular Injuries

The axillary nerve, musculocutaneous nerve, and brachial plexus are at risk during open surgery for the treatment of anterior instability. Injuries may occur as a result of excessive tissue retraction, especially retraction of the coracobrachialis; direct laceration; or suture entrapment. Fortunately, most are transient neurapraxias. Shoulder surgeons should be comfortable locating and isolating the axillary nerve, the musculocutaneous nerve, and the brachial plexus, especially in revision settings. Of all of the operations described in this review, the Bristow and Latarjet procedures are associated with the highest risk of injury to the axillary and musculocutaneous nerves[79,128,130,136]. Revision surgery after a failed Bristow or Latarjet procedure can be quite challenging, and exposing the axillary nerve in such instances can be difficult.

Overview

While arthroscopic capsulolabral repair is becoming the standard of care for the treatment of traumatic recurrent anterior shoulder instability, open approaches are still reliable, time-tested options that in many instances remain the gold standard. Despite tremendous advances in arthroscopic technique, major bone loss, soft-tissue deficiencies, and revision situations often require open approaches. As arthroscopic techniques continue to evolve, surgeons should carefully and continuously redefine their indications on the basis of their surgical skill and the spectrum of relevant pathological conditions that may be faced. As detailed in this review, there are many instances in both primary and revision surgery for the treatment of anterior shoulder instability in which an open approach remains the preferred method of treatment. A surgical approach that combines careful preoperative and intraoperative evaluation with a skillful technique ensures the highest possibility of good and excellent surgical outcomes.

Peter J. Millett, MD, MSc
Harvard Shoulder Service, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115. E-mail address: pmillett@partners.org

Philippe Clavert, MD
Department of Orthopaedic Surgery, Hautepierre University Hospital, Avenue Moliere, 67098 Strasbourg CEDEX, France

Jon J.P. Warner, MD
Massachusetts General Hospital, 55 Fruit Street, Boston, MA 02114

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