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What Went Wrong and What Was Done About It: Pitfalls in the Treatment of Common Shoulder Surgery

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Fortunately, the majority of shoulder surgical procedures yield consistently good results. However, when a surgical procedure fails, identifying the causative factors to eliminate helps to make a revision procedure successful. The purposes of this review were to highlight common problems that can occur during surgery to treat shoulder instability, rotator cuff tears, acromioclavicular joint dislocations, and proximal humeral fractures and to discuss techniques that can be used to address these problems during revision surgery.

Instability Surgery

There are multiple complications that can occur following surgery to treat glenohumeral instability, including recurrent instability, stiffness, arthritis, loose or prominent implants, nerve injury, and infection. The most common complication following an anterior soft-tissue repair is recurrent glenohumeral instability secondary to bone loss.

The remainder of this section focuses on the evaluation and treatment of these patients. Burkhart and De Beer reported a 4% incidence of recurrent instability following an arthroscopic Bankart repair in patients without substantial bone loss compared with a 67% rate of recurrence with anterior glenoid bone loss or an engaging Hill-Sachs lesion.

A thirty-three-year-old physician (Case 1) underwent an arthroscopic Bankart repair for traumatic anterior glenohumeral joint instability. He had a redislocation three months after the index procedure and continued to have frequent dislocations with daily activities. On physical examination, he had slightly reduced external rotation, a negative abdominal compression test, and substantial apprehension with apprehension testing. An axillary radiograph (Fig. 1-A) demonstrated a concentrically reduced glenohumeral joint with irregularity of the anterior aspect of the glenoid. A computed tomography (CT) scan with three-dimensional reconstructions and digital subtraction of the humeral head was obtained to further evaluate for potential osseous causes of instability. If the patient has had a prior open repair and there is concern on physical examination for the integrity of the subscapularis muscle, we add a magnetic resonance imaging (MRI) arthrogram or ultrasound. The CT scan of this patient demonstrated a large anteroinferior glenoid bone fragment (Fig. 1-B). If the length of the anterior glenoid bone fragment is greater than the maximum radius of the glenoid, then the force required to dislocate the joint is reduced by at least 30%.

A Latarjet transfer is our procedure of choice for the treatment of most patients with anterior glenoid bone loss. In addition to providing an anterior bone block, this procedure reestablishes stability of the shoulder via a sling created anterior to the humeral head by...
Case 1. A thirty-year-old physician had previously undergone an arthroscopic Bankart repair for traumatic anterior glenohumeral instability. He had a redislocation within three months after the original surgery and continued to have frequent dislocations with daily activities. Axillary radiographs (Fig. 1-A) and axial CT scan (Fig. 1-B) demonstrated substantial anterior glenoid bone loss, which was treated with a Laterjet transfer (Figs. 1-C and 1-D).
the conjoint tendon and reinforcement of the anterior capsule with the stump of the coracohumeral ligament. Several recently introduced commercial products make this procedure technically easier by aiding the surgeon in placing the coracoid fragment flush with the glenoid articular surface and correctly spacing the fixation screws so that they do not split the fragment. Walch and Boileau reported a recurrence rate of 1% in a study of 160 patients, with >98% of the patients rating their results as good or excellent. More recently, Shah et al. found a 25% complication rate, including a 10% rate of neurologic injury, with this surgery in the hands of an experienced, fellowship-trained shoulder surgeon. This patient had a Laterjet transfer performed through a subscapularis split (Figs. 1-C and 1-D) and had returned to all of his activities with no further instability at the time of the latest follow-up.

One area that has not been fully defined is the upper limit of size for which glenoid defects can be effectively treated with a coracoid transfer. For larger defects, Warner et al. reported good results with reconstruction of the anterior aspect of the glenoid using tricortical iliac crest autograft. Recently, reported excellent results in a prospective study combining an arthroscopic Bankart repair with imbrication of the infraspinatus tendon into the humeral head defect using two suture anchors placed trans-tendinously. The authors referred to this as an arthroscopic remplissage and stated that this procedure is not appropriate if there is any glenoid bone loss. For small to medium-sized Hill-Sachs defects combined with anterior glenoid bone loss, we typically do a Laterjet transfer. For defects that are greater than 25% to 30% of the humeral articular surface, Miniaci and Gish described filling the defect with a wedge of humeral head allograft secured with two countersunk screws. This can be combined with a procedure to restore anterior glenoid bone loss if needed.

**Rotator Cuff Surgery**

While the majority of patients who undergo rotator cuff repair obtain pain relief and return of strength, some have suboptimal outcomes. There are many reasons for persistent pain following rotator cuff repair that may occur singularly or in combination. These include biceps tendon entrapment, biceps tears and/or degeneration, labral tears, postoperative stiffness, unrecognized preexisting adhesive capsulitis, failure of rotator cuff healing, retearing of the rotator cuff, acromioclavicular arthrosis, supraspinatus nerve compression, cervical radiculopathy, and scapular dyskinesis. Failure to assess and recognize these issues during the preoperative and intraoperative evaluation increases the risk for persistent postoperative pain. We recommend a careful and thorough evaluation of these potential complicating factors before recommending rotator cuff surgery.

While each of these causes is a topic in itself, this discussion is limited to biceps pathology as it is our belief that this concomitant pathology is under- treated during rotator cuff surgery and that failure to address the biceps can lead to persistent pain. We think biceps lesions occur commonly, are difficult to diagnose, and have multiple treatment options. There is also no consensus about the optimal treatment. Management of the biceps tendon during rotator cuff repair continues to evolve, and controversy exists regarding the true function of the biceps. Some surgeons prefer to leave it intact during rotator cuff repair if an abnormality is not readily apparent. Some believe that with rotator cuff tears, the biceps acts as a secondary humeral head depressor, and should be preserved even with some biceps degeneration.

In an illustrative example, a sixty-two-year-old man (Case 2) underwent an uncomplicated rotator cuff repair but continued to complain of anterior shoulder pain. A normal intra-articular biceps tendon was seen during operation. Resisted forward flexion and the O'Brien test produced pain in the area of the biceps groove. An MRI scan demonstrated rotator cuff healing. An ultrasound-guided injection of the biceps sheath resulted in partial pain relief. At the time of arthroscopic examination, flexion of the arm demonstrated that the patient had the hourglass lesion described by Boileau et al. (Fig. 2-A). The arthroscope was inserted into the subacromial space, and the biceps sheath was opened distal to the transverse humeral ligament. Tendon degeneration was identified (Fig. 2-B). The biceps was tenodesed in its groove with an interference screw midway between the transverse humeral ligament and the pectoralis major tendon insertion (Fig. 2-C). The patient recovered uneventfully, gaining complete movement and pain relief.

After rotator cuff repair, an abnormal or normal biceps tendon may become a source of postoperative pain. Rotator cuff tears that involve the anterior portion of the supraspinatus, when repaired, are in direct contact with the biceps tendon. The repeated motion of even a healthy biceps tendon past an area characterized by inflammation and then fibrosis may be a pain generator. Additionally, the biceps tendon may become involved in the healing rotator cuff repair, lose its gliding ability, and become entrapped.
Case 2. A sixty-two-year-old man who underwent an uncomplicated rotator cuff repair but continued to complain of anterior shoulder pain. Fig. 2-A An arthroscopic view showing the hourglass lesion (arrow), as described by Boileau et al.\textsuperscript{10}. Fig. 2-B Opening of the biceps tendon sheath distal to the transverse humeral ligament revealed fraying of the tendon. Fig. 2-C Screw tenodesis within the biceps groove successfully resolved the symptoms.
On the basis of this line of thought and enhanced by our clinical experience, we routinely perform biceps tenodesis with rotator cuff repairs. We stress that a normal-appearing intra-articular biceps, even one that we displace into the joint with traction, may not reveal a source of biceps disease distal to the transverse humeral ligament. We have seen advanced disease in the biceps tendon distal to the transverse humeral ligament coexisting with a completely normal intra-articular biceps tendon. For this reason, we inform our patients that concomitant pathology unrelated specifically to the rotator cuff tear (and appearing normal on MRI) may be present in the shoulder and may require operative treatment. We prefer tenodesis over tenotomy because our patients have reported biceps deformity and cramping pain after tenotomy.

Our experience that a normal-appearing biceps tendon may be, in fact, pathologic, has basic-science and clinical support. Basic-science studies have demonstrated neoangiogenesis and increased vascular endothelial growth factor expression (a marker for tendon degeneration) in biceps tendons associated with rotator cuff tears. A study by Walsh et al. showed that 70% of patients with impingement-type symptoms presented with biceps tendon abnormalities. Murthi et al. showed almost half of all patients with rotator cuff pathology had disease in the biceps tendon. Walsh et al. demonstrated no acceleration of degenerative glenohumeral changes and minimal superior humeral head migration after biceps tenotomy with irreparable rotator cuff tears but noted improved pain scores.

We emphasize that we do not perform or advocate tenodesis in every rotator cuff repair. However, since we tendone the biceps in all anterior supraspinatus tears, and since most of our practice is composed of these tears, biceps tenodesis is performed frequently.

**Acromioclavicular Joint Reconstruction**

The preferred treatment of acute type-I and II acromioclavicular joint injuries is nonoperative treatment, while surgical stabilization is recommended for more severe injuries—i.e., types IV, V, and VI. Treatment of type-III dislocations of the acromioclavicular joint is less clear, and reports are varied for operative or nonoperative treatment.

There is no consensus on which technique to use for acromioclavicular joint fixation or reconstruction, and more than sixty techniques have been described. Limited evidence is available to dictate the best strategy for operative treatment, and even less evidence is available regarding complications and recommended treatment strategies for revision following failed fixation. Reported complications following operative treatment of acromioclavicular joint dislocation include loss of reduction, implant failure, clavicular and coracoid fractures, graft tunnel widening and/or osteolysis, secondary acromioclavicular joint arthritis, infection, and acromial erosion.

The most common postoperative complication following operative fixation of acromioclavicular joint dislocation is loss of reduction, with failure rates reported to range between 15% and 44%. Patients with minimal symptoms following loss of reduction may be successfully treated nonoperatively. Revision of a symptomatic failed reconstruction depends on the mode of failure. An intact coracoid and clavicle allow one to use the coracoid as a mooring to secure alternate fixation and grafts. Likewise, an intact clavicle provides a stable structure by which fixation and a graft can be secured. As an example, a failed modified Weaver-Dunn coracoacromial ligament transfer can be revised with semitendinosus autograft or allograft looped around the coracoid base and secured to the clavicle through bone tunnels and suture or screw augmentation.

Implant failure and migration can be a devastating complication. Primary fixation of the acromioclavicular joint with smooth pin fixation has largely been abandoned because of potentially catastrophic complications of pin migration. Primary coracoclavicular screw fixation provides high tensile strength and stiffness, but requires eventual screw removal and has a high complication rate. Mechanical coracoid button pullout has also been reported as a common method of failure. Primary fixation of the acromioclavicular joint with hook-plate fixation has also been associated with complications, including implant failure, plate dislocation, acromial erosion, and infection. There are many complications that can occur, and most are specific to the method of fixation except for loss of reduction, which is common to all. We attempt to minimize the complication rate by choosing an operation that uses autologous tissue to reconstruct the joint with minimal effect on the local tissue, that is, with smaller holes in the coracoid and clavicle.

If the implant failure has resulted in a coracoid fracture, the decision has to be made as to how to address the fracture or insufficiency. If the distal fragment is large enough to accept a screw, we have performed open reduction and internal fixation with single-screw fixation from the tip of the coracoid into the scapula. If the coracoid fixation is strong enough, then a graft can be passed under the coracoid and secured to the clavicle. We usually augment this revision construct with a hook plate to decrease the load on the clavicle (Figs. 3-A and 3-B). A hook plate can also be used to stabilize the acromioclavicular joint if the coracoid fragment is too small for open reduction and internal fixation. The authors strongly believe this construct requires biologic fixation between the coracoid and the clavicle by securing graft to the remaining coracoid or using the coraco-acromial ligament that is attached to the coracoid as local graft. Hook plates need to be removed by three months to prevent erosion of the hook through the acromion.

Clavicular fractures following acromioclavicular joint reconstruction have been reported. Minimization of the clavicular tunnel diameter to allow at least 20 to 25 mm between clavicular tunnels and to allow at least 10 to 15 mm between the lateral tunnel and the distal edge of the clavicle reduces the number of clavicular fractures.
noted after anatomic coracoclavicular reconstruction have been successfully treated nonoperatively. Clavicular tunnel widening has been noted with synthetic materials and with allograft and may lead to fractures. We have treated displaced clavicular fractures via open reduction and internal fixation with a hook plate. These fractures often require bone-grafting to prevent non-union. For larger segments of bone loss, structural grafts with 5 to 7 cm of iliac crest have been used successfully.

Techniques utilizing drill-holes through the coracoid for graft placement and fixation as part of anatomic reconstruction of coracoclavicular ligaments introduce potential for coracoid fracture and cutout. Up to a 20% prevalence of coracoid fracture has been reported with coracoclavicular ligament reconstruction using coracoid tunneling. Minimization of the tunnel diameter in the coracoid and appropriate visualization are recommended to help prevent coracoid fracture or cutout. Coracoid fractures are managed as described above with hook-plate stabilization with or without open reduction and internal fixation of the coracoid.

In conclusion, there are multiple modes of failure in acromioclavicular joint reconstructions. When choosing a method of initial stabilization, it is important that the surgeon consider the potential complications particular to the type of fixation. For primary surgery, the authors prefer an open modified Weaver-Dunn type of reconstruction with the osseous origin of the coracoacromial ligament transferred into the medullary canal of the distal end of the clavicle and concomitant suture fixation from the coracoid to the clavicle augmented with EndoButtons (Smith & Nephew Endoscopy, Andover, Massachusetts). The complication rate is low with this procedure. When complications occur, it is usually loss of reduction, which, if symptomatic, can be more easily treated as the clavicle and coracoid are still intact, leaving multiple options. We have markedly reduced the rate of reduction loss by slower postoperative progression of physical therapy.

Figs. 3-A and 3-B A coracoid fracture following treatment of an acromioclavicular separation. **Fig. 3-A** Preoperative axillary radiograph. **Fig. 3-B** The coracoid fracture was reduced with a screw, and the acromioclavicular separation was treated with a modified Weaver-Dunn procedure. A clavicle hook plate was used as supplemental fixation.
An anteroposterior radiograph demonstrating malunion of the tuberosities following hemiarthroplasty for a proximal humeral fracture.

We learned from the literature regarding rotator cuff repairs that slower rehabilitation leads to higher healing rates. This information, coupled with the fact that acromioclavicular reconstructions are extra-articular, led us to adopt a slower course of rehabilitation. The patient is managed with immobilization in a sling for six weeks. No therapy is initiated for the first two weeks. At two weeks postoperatively, supine passive external rotation with a stick is initiated to prevent adhesions under the acromioclavicular reconstruction. At four weeks postoperatively, supine passive forward elevation is added. Active-assisted exercises are initiated at six weeks postoperatively, with active exercises starting at eight weeks postoperatively. Our patients have experienced less loss of reduction with this protocol and no noticeable stiffness.

Hemiarthroplasty for Proximal Humeral Fractures

Although hemiarthroplasty has been a mainstay in the treatment of displaced proximal humeral fractures, its use has decreased because of the improvement in techniques of open reduction and internal fixation and the development of the reverse shoulder arthroplasty as treatment options. In addition, the unpredictable results following hemiarthroplasty, particularly with respect to shoulder motion and function, are another reason alternate treatments have been sought. However, hemiarthroplasty continues to be an important treatment option and, when selected, it is essential to utilize techniques that will minimize the risk of complications.

The principles of hemiarthroplasty for proximal humeral fractures are as follows:

1. Utilization of a deltopectoral approach to preserve the deltid origin
2. Restoration of humeral length and retroversion
3. Secure tuberosity fixation to the shaft, the implant, and to each other

Successful achievement of these principles does not guarantee a successful outcome; however, if these goals are not achieved, a compromised outcome often results. Utilization of a deltopectoral approach and preservation of the deltoid is easily achieved. Restoring humeral length and retroversion is essential, and different methods have been described. These include determining humeral length from radiographs of the contralateral humerus and maintaining the implant at a fixed position above the pectoralis major insertion. We have found that restoration of exact humeral length is not as important as avoiding lengthening or shortening of >1 cm. Retroversion should be restored by one of two methods: (1) placement of the humeral component in the so-called average amount of retroversion, which is usually 20° to 30°, or (2) alignment of the lateral flange of the implant just posterior to the remains of the bicipital groove, which also reproduces a reasonable range of retroversion. It is important that the humeral length and retroversion be maintained during implantation of the prosthesis. Although some surgeons implant humeral components without cement, we prefer using cement to maintain proper length and rotation.

Achieving secure tuberosity fixation and healing and avoiding tuberosity displacement, malunion, and nonunion (Fig. 4) are a challenge with this procedure for several reasons. First, the bone of the tuberosity is generally osteopenic with compromised healing potential. Second, the displacing forces of the rotator cuff tendons tend to distract the tuberosities and interfere with healing. Third, many implant designs place the tuberosity under excessive tension during rotation, which increases the risk of displacement.

The probability of the tuberosity healing in a nearly anatomic position is enhanced by a variety of measures. First, utilization of fracture-specific implants, including different implants for the right and left shoulder, is beneficial. These design modifications include a fenestration in the proximal portion of the implant to allow bone-grafting between the tuberosities, specific suture attachment sites to enhance suture passage and fixation of the tuberosities, and adherence to the principles of tuberosity fixation using heavy nonabsorbable sutures. These principles include the following:
to the development of the reverse shoulder arthroplasty, patients with pain after hemiarthroplasty following fracture had few, if any, reasonable treatment options. This is no longer the case, although revision of a hemiarthroplasty to a reverse shoulder arthroplasty is a technically challenging procedure that is best performed by an experienced shoulder surgeon. Complications are an unavoidable consequence of surgery. The best treatment of complications is avoidance via meticulous preoperative planning and careful surgical technique. However, it is important to understand that, even with excellent planning and surgical technique, complications can only be minimized and not completely avoided in most cases. When contemplating revision surgery for the treatment of complications, it is important that the surgeon has a clear idea of what was done the first time and a clear plan about what to do differently the second time since simply repeating the same procedure the same way is unlikely to be successful.

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References


