Chapter 2

Stiffness After Rotator Cuff Repair

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Case Presentation

History

A 57-year-old man with type II diabetes mellitus presented with right shoulder pain and weakness. The onset of symptoms was insidious and progressive over a 2-year period. The patient thought he initially injured his shoulder while swimming but noted that his symptoms had become much worse since re-injuring it while throwing a tennis ball 6 months before presentation. The pain was localized to his right shoulder and often awakened him from sleep. He had taken nonsteroidal anti-inflammatory drugs (NSAIDs) for the 6 months after re-injuring the shoulder and completed an intermittent course of physical therapy that included a rotator cuff strengthening program. He was an active person who enjoyed hunting and fishing but had been unable to do either because of the shoulder problems.

On physical examination, there was no asymmetry or atrophy about his shoulders. The greater tuberosity on his right shoulder was tender to palpation, but the bicipital groove and acromioclavicular joint were not tender. His left shoulder had normal motion and full rotator cuff strength. His right shoulder had limited passive (forward flexion 110°, external rotation 20°, abduction 80°, internal rotation to L5) and active motion and weakness of abduction with a drop-arm sign. External rotation strength and the belly press and lift-off tests were normal; the Neer and Hawkins impingement signs were markedly positive. The patient had no pain with external or internal rotation with the arm in adduction.

Radiographs showed a type 2 acromion and no glenohumeral arthritis. MRI showed a 1- × 2.5-cm full-thickness supraspinatus tendon tear with 1 cm of retraction from the insertion on the greater tuberosity (Figure 1).

The patient started a rehabilitation program that focused on stretching the capsule and restoring passive glenohumeral joint mobility. After 6 weeks, his pain and weakness persisted but passive motion improved to 140° of forward flexion, 110° of abduction, and 45° of external rotation. At this time, he decided to undergo surgical treatment of the rotator cuff tear.

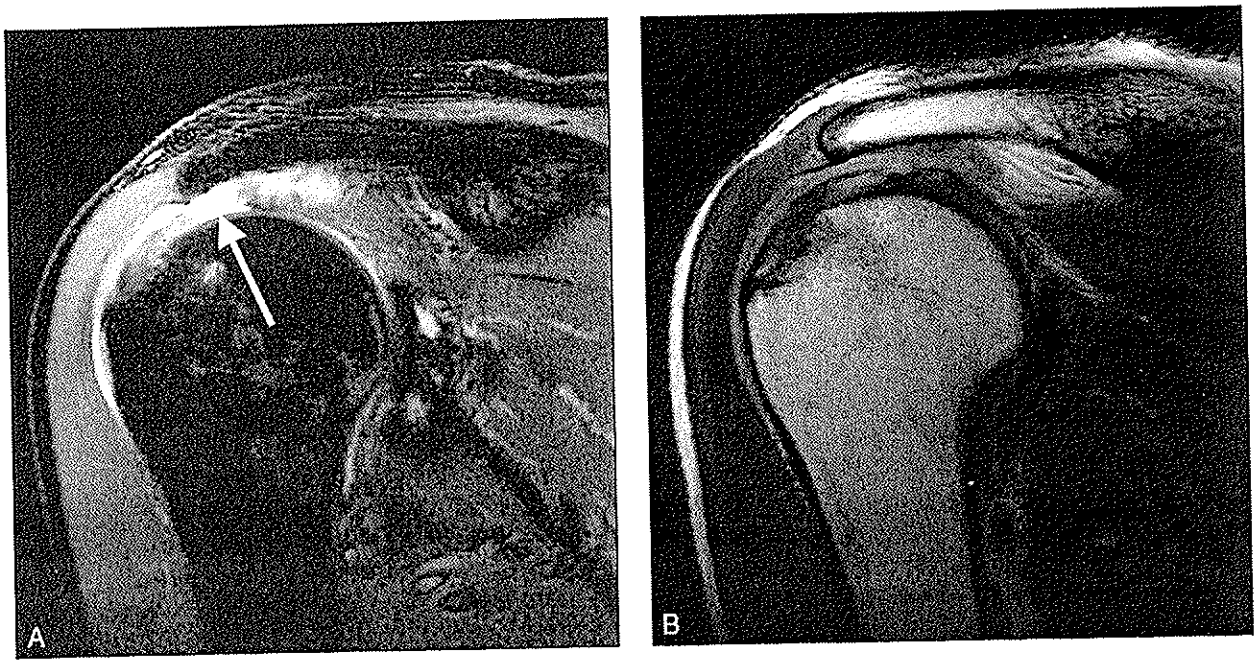

Figure 1 MRI scans showing a full-thickness supraspinatus tear (*arrow*). Coronal T2-weighted fat suppression **(A)** and STIR **(B)** images.

A full-thickness crescent-shaped supraspinatus tear extending into the infraspinatus with delamination was identified at arthroscopy in addition to moderate subacromial bursitis and evidence of subacromial impingement with scuffing and tearing of the coracoacromial ligament. The biceps and subscapularis tendons were intact. An arthroscopic subacromial bursectomy and acromioplasty were performed in addition to a double-row arthroscopic rotator cuff repair with suture anchors.[1] The quality of the tissues was excellent, and the repair was very secure. Postoperative rehabilitation consisted of protection in an arm sling with a small abduction pillow. Pendulum range-of-motion exercises were permitted for the first 6 weeks. Passive range of motion began at 14 days postoperatively. At 6 weeks postoperatively, he started active and active-assist motion with a physical therapist.

At 2 weeks after surgery, on his routine follow-up visit, he was noted to have significant pain and poor pain control. Shoulder motion was 90° forward elevation, 45° abduction, 10° external rotation with the arm at his side, and internal rotation to the sacral level. He was encouraged to continue the postoperative rehabilitation program and maintained on oral opioid pain medications. NSAIDs were discouraged given their adverse effects on tendon healing. He was instructed to begin weaning from his sling at 4 weeks. At 6 weeks after surgery, he still had moderate pain and did not have full passive motion. The therapist was contacted and daily stretching exercises were encouraged. Strengthening exercises were initiated at 10 weeks after surgery.

Current Problem and Treatment

At 3 months after surgery, he had persistent pain and shoulder stiffness. Forward elevation was 90°, abduction was 45°, and external rotation 20°. No warmth or erythema was noted. A physical therapy regimen with manual capsular stretching and dynamic bracing was prescribed, and he was given both intra-articular and subacromial injections with corticosteroids (triamcinolone 40 mg/mL) to reduce the inflammation in his shoulder. The pain decreased after the injection, which included 1% lidocaine, but the passive range of motion remained limited. He was evaluated again in 6 weeks. Laboratory studies including

a CBC count, erythrocyte sedimentation rate, and C-reactive protein were negative. He remained afebrile, the shoulder was not warm, and there was no drainage. He had experienced some mild improvements in motion and elected to continue with the nonsurgical aggressive rehabilitation program.

Unfortunately, despite the aggressive physical therapy program, there was persistent marked limitation of motion noted at the 6-month follow-up. His range of motion had not improved for 2 months, although the pain in his shoulder had markedly decreased. After discussing his options for treatment, the patient elected to proceed with arthroscopic capsular release of his shoulder.

DISCUSSION

Stiffness is an unfortunate complication that can occur following rotator cuff surgery. Its incidence ranges from 4% to as high as 10%.[2] When the loss of motion is minimal and painless, it is usually well tolerated. When the stiffness is more advanced and when it is painful, it is not well tolerated. Furthermore, substantial loss of motion without associated pain also can be extremely debilitating. Many studies evaluate range of motion as part of the overall outcome assessment, but it rarely is addressed specifically as a problem.

This case presents some of the diagnostic and therapeutic dilemmas inherent in treating patients with stiffness after rotator cuff repair (Table 1). Factors contributing to the development of postoperative stiffness included diabetes mellitus, a stiff shoulder before surgery, low pain tolerance, inadequate postoperative pain management, and inappropriate rehabilitation. In the postoperative setting, it is always important to exclude infection as a cause of the stiffness or persistent pain. Most patients with symptomatic rotator cuff tears do not have significant shoulder stiffness or loss of passive motion. In patients with chronic rotator cuff tears, the stiffness should be resolved before the rotator cuff is repaired. Treating the adhesive capsulitis eliminates some patients' pain and dysfunction, which in certain settings may obviate the need for rotator cuff repair. This patient had persistent pain despite resolution of the preoperative stiffness. Unfortunately a postoperative contracture developed that did not respond to aggressive physical therapy. Subsequent arthroscopic capsular release resulted in improved motion and function.

TABLE 1 Four Types of Patients With Stiffness Following Rotator Cuff Repair

1. Stiffness without a tear of the repaired rotator cuff
2. Stiffness with a tear of the repaired rotator cuff
3. Stiffness with untreated osteoarthritis
4. Stiffness with nerve or deltoid injury

When stiffness occurs after a rotator cuff repair, it is rare that subsequent surgery will be needed. Most resolve with appropriate rehabilitation and judicious use of corticosteroid injections. The rehabilitation program should focus on stretching exercises, and this frequently resolves the issue completely. Slow and steady progress is the typical pattern, and surgical release of the contracture rarely is required. However, if a patient does not recover satisfactory functional motion, a capsular release may be needed. It would be rare to recommend surgical intervention earlier than 4 months from the original surgery. In the postoperative setting, particularly after open rotator cuff repair, subacromial and subdeltoid scarring often occurs. The scarring is typically less after prior arthroscopic rotator cuff repair. Stiffness after mini-open and open rotator cuff repairs is associated with more extensive subdeltoid and subacromial scarring. Arthroscopic capsular release and subacromial débridement allows for a minimally invasive approach to the treatment of persistent stiffness after rotator cuff repair. The capsule of the glenohumeral joint can be effectively released, and scarring in the subacromial space also can be débrided without traumatizing the deltoid muscle.

Recognizing the Problem and Situations at Risk

Etiology of Stiffness After Rotator Cuff Repair

Several patient-specific factors are considered risk factors for shoulder stiffness after rotator cuff repair (Table 2), including diabetes mellitus, infection, history of keloid formation, low pain tolerance, history of complex regional pain syndrome, and an associ-

TABLE 2 Associated Patient Risk Factors for Stiffness

1. Diabetes mellitus
2. Low pain threshold
3. Chronic pain and dependent personality
4. Prior keloid formation

ated dependent personality.[3] Trenerry and associates[4] reported that restriction of preoperative range of motion of the hand behind the back best predicted shoulder stiffness at 6 weeks after rotator cuff repair. Chen and associates,[5] evaluating the effect of diabetes mellitus on the outcome of rotator cuff repair, reported significant differences in range of motion at all follow-up points.

Some loss of motion after rotator cuff repair may be inevitable because of scar tissue formation and loss of tissue compliance during the immediate postoperative period. Dissection and mobilization of the torn rotator cuff tendons and shortening of the muscle tendon units during repair may result in scarring and limitations in overall excursion. In addition, subacromial decompression and bursectomy, which typically are performed in association with rotator cuff repair, can contribute to scarring, secondary to bleeding and disrupted soft-tissue surfaces. The term "captured shoulder" was coined to describe the subdeltoid adhesions that form after subacromial space surgery.[6] This problem, which occurs more commonly after mini-open and open rotator cuff repair, can lead to compensatory mechanics, asynchronous shoulder-girdle motion, transfer of symptoms to the scapulothoracic articulation, and pain. As mentioned previously, it is always essential to exclude the possibility of postoperative infection as a cause.

The principal causes of stiffness after rotator cuff repair can be classified as either intra-articular or extra-articular (Table 3). Capsular contracture (intra-articular origin) is a common cause of stiffness (Figure 2, *A*) that can occur globally, as in the case of idiopathic adhesive capsulitis, or locally in a specific region of the capsule (Figure 2, *B*). Contractures limited to specific regions of the capsule may be iatrogenic, secondary to surgical shortening of the capsule (eg, closure of the rotator interval) or to a stabilization procedure. However, capsular contracture more commonly results from an inflamed fibrotic process within the capsule.

TABLE 3 Causes of Symptomatic Motion Loss

1. Motor-unit failure
   - Tear of the rotator cuff tendon
   - Muscle failure – deltoid avulsion or disuse atrophy
   - Nerve injury – axillary, suprascapular, brachial plexus
2. Capsular contracture (global)
   - Adhesive capsulitis
3. Capsular contracture (limited)
   - Surgical shortening
4. Extracapsular constraint
   - Shortened tendon/capsule
5. Interfascial scarring between tissue planes
   - Subdeltoid adhesions between the deltoid and the rotator cuff tendon or proximal humerus
   - Joint surface incongruity

Extracapsular constraint of the glenohumeral joint, another common mechanism for postoperative stiffness (Figure 2, *C*), can result from repairing the rotator cuff under excessive tension, inadequate rehabilitation, or prolonged immobilization. Another major extra-articular factor in postoperative stiffness appears to be interfascial scarring between tissue planes. Scarring and adhesions can form between the deltoid and the rotator cuff, and the deltoid and the proximal humerus. Complex regional pain syndrome also can result in significant stiffness that usually is caused by capsular and extracapsular scarring. Other causes for stiffness after rotator cuff repair may not be directly related to the surgery. For example, abnormalities in the glenohumeral joint, such as preexisting osteoarthritis or posttraumatic arthritis, can contribute to stiffness.

Evaluation of Stiffness After Rotator Cuff Repair

Awareness and early recognition of stiffness after rotator cuff repair are keys to its successful treatment. The best preventative measures are to (1) be aware of the potential problem, (2) design and follow a postoperative rehabilitation protocol to prevent it, (3) follow patients postoperatively and modify rehabilitation as needed, and (4) act accordingly if stiffness presents early after surgery.

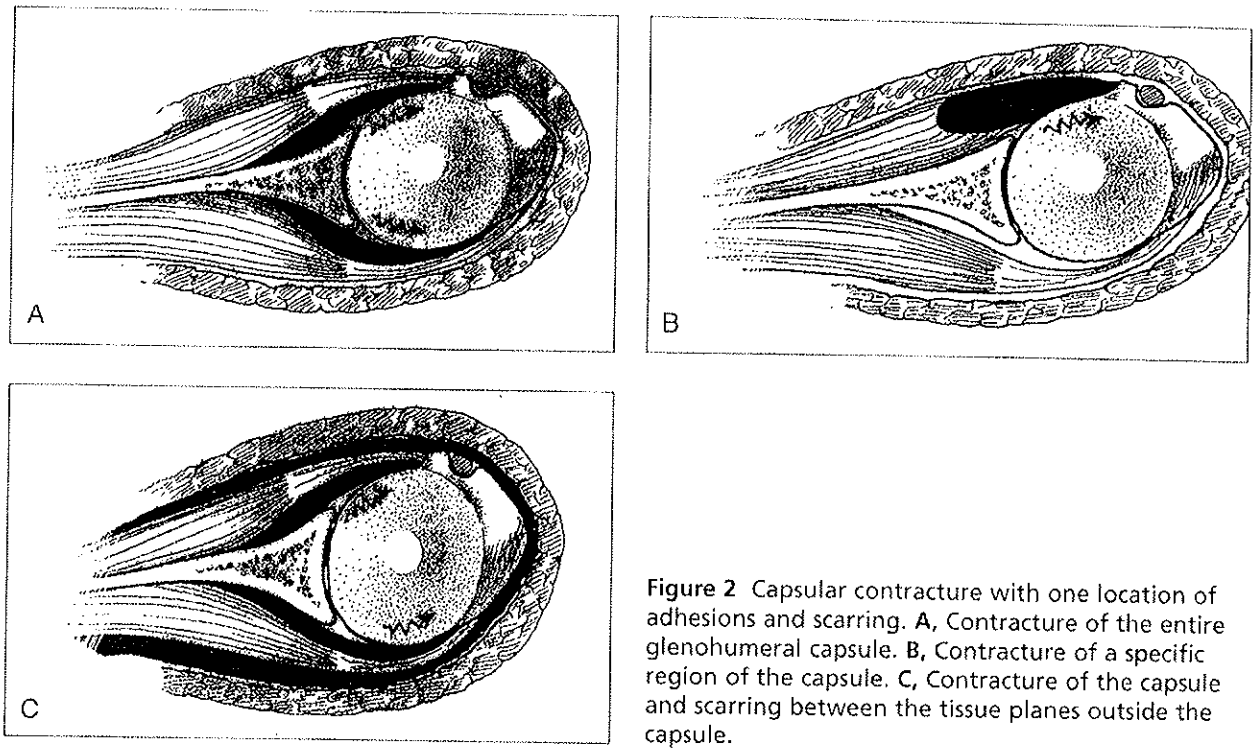

Figure 2 Capsular contracture with one location of adhesions and scarring. **A,** Contracture of the entire glenohumeral capsule. **B,** Contracture of a specific region of the capsule. **C,** Contracture of the capsule and scarring between the tissue planes outside the capsule.

When a patient presents with motion loss following rotator cuff repair, the clinician should look closely for additional associated pathology, including signs of a recurrent rotator cuff tear, residual impingement, acromioclavicular joint disease, or biceps tendon disease. Other possible findings include decreased skin sensation (secondary to axillary nerve injury) and defects in the deltoid muscle (either secondary to deltoid dehiscence or injury to the axillary nerve). Again, the possibility of occult infection should also be considered.

A detailed history often provides insight into the causes of motion loss. For example, prolonged immobilization without passive range-of-motion exercises can lead to early postoperative scarring and stiffness. Other causes include inadequate postoperative pain control or a low pain threshold, either of which can result in avoidance of range-of-motion exercises and limited mobility. Because motion loss can be secondary to disruption of the repair, the patient should be questioned regarding any inappropriate loads that might have been applied to the repair in the postoperative period, such as from a fall or early aggressive active motion.

A standard physical examination of the shoulder should be performed. Examination of the cervical spine might identify pathology that contributes to shoulder pain and contracture. Keloid formation of the previous surgical scars suggests a propensity to hypertrophic scarring. The deltoid, infraspinatus, and suprapsinatus muscles are examined for atrophy, which may be the result of nerve injury or compression. Infraspinatus atrophy is most commonly the result of chronic rotator cuff tearing. Specific anatomic structures, such as the bicipital groove, acromioclavicular joint, and greater tuberosity, should be palpated for tenderness. Temperature differentials, erythema, or wound drainage should alert the clinician to the possibility of infection.

The patient's specific type of motion loss should also be determined. Is it passive, active, or both? Is it caused by stiffness alone, weakness, or both? Testing should always include forward flexion, abduction, internal and external rotation in adduction and in 90° of abduction, and cross-arm adduction (horizontal flexion).[2,3] Motion always should be compared with that of the contralateral shoulder. Active range of motion can be assessed with the patient seated.

Simultaneous bilateral assessment can reduce the effect of compensatory motion. Passive motion is assessed with the patient supine to stabilize the scapula. To accurately discriminate between scapulothoracic and glenohumeral motion, the glenohumeral motion must be isolated by limiting compensatory movements of the scapula on the thorax (scapulothoracic substitution) and trunk tilting (from the hips and low back). Direct palpation of the proximal humerus and the scapula during the examination enables the examiner to detect the end range of glenohumeral motion.

Pain can make it difficult to discriminate between loss of active and passive motion. A subacromial injection of 10 mL of 1% lidocaine can help eliminate pain from rotator cuff and subacromial pathology, making it possible to determine whether the stiffness is secondary to contracture alone or guarding from pain inhibition.[7]

Once the type of motion loss is known, the clinician can determine the cause of the stiffness. Typically, patients with stiffness have loss of both active and passive motion. Patients retaining good strength with equivalent loss of both passive and active motion may have an intact rotator cuff repair. Preservation of passive motion with loss of active motion may indicate failure of the rotator cuff repair or a nerve injury involving the axillary or suprascapular nerve. The finding of equivalent loss of active and passive motion is consistent with postoperative adhesions with, or without, associated capsular contractures.

The specific location of the adhesions, or capsular contractures, can, at times, be accurately predicted by physical examination. When there is global loss of shoulder motion, the problem commonly is both intra- and extra-articular (Figure 2, C). Significant loss of external rotation with the arm in 0° of abduction is associated with contracture of the rotator interval, whereas decreased external rotation with the arm in 90° of abduction signifies contracture of the anteroinferior capsule.[2,3,8,9] Significant loss of internal rotation in 0° and/or 90° of abduction typically correlates with contracture of the posterior capsule.[2,3,8]

Imaging of the stiff shoulder following rotator cuff repair always should start with radiographs, including an AP shoulder view, a true AP glenohumeral joint view (Grashey view), a scapular outlet view, and an axillary view. The radiographs allow interpretation of the previous surgical resections (such as the subacromial decompression and/or the distal clavicle resection) and inspection of the glenohumeral and acromioclavicular joints for degenerative arthritis. An infection may present as mild joint space narrowing that is only apparent when the images are compared to those obtained preoperatively. The axillary view is the best view in which to visualize joint space narrowing in the glenohumeral joint. On occasion, one may also see displaced suture anchors or other hardware-related problems on radiographs.

Although MRI with intra-articular contrast is very helpful in identifying defects in the repair, artifact often makes it difficult to interpret; thus, determining the location and extent of capsular contracture and subdeltoid adhesions can be difficult.[10] However, postoperative MRI can be helpful in providing information about the coexistence of intra-articular pathology.

Contrast extravasation into the subacromial space on magnetic resonance arthrography indicates a rotator cuff tear that may be either a persistent defect from the original repair, a recurrent tear, or, most commonly, failure of healing of the original repair.[11] This information can be alarming but may not completely correlate with the clinical status because complete healing, although desired, is not always necessary for good function.[2,12] MRI also is used to determine the degree of rotator cuff muscle atrophy and fatty degeneration. If the muscle has extensive atrophy and fatty degeneration, a future repair may not be feasible even if the shoulder stiffness is treated.[13]

Management of Stiffness After Rotator Cuff Repair

Patients with shoulder stiffness following rotator cuff repair typically fall into one of four groups: (1) stiffness with an intact rotator cuff, (2) stiffness with a rotator cuff tear, (3) stiffness with associated joint arthrosis, and (4) stiffness with injury to the deltoid muscle and/or neurologic injury. Most patients have limitation of motion and an intact rotator cuff. Treatment depends on both the pathoanatomy pres-

ent and the patient's preferences. Many patients with loss of motion after rotator cuff repair remain asymptomatic and satisfied with the outcome. However, even without associated pain, further treatment may be necessary when stiffness affects activities of daily living or the ability to return to sports.

Nonsurgical Management

A supervised physical therapy program along with aggressive passive manual stretching and, sometimes, dynamic bracing, is often successful in treating shoulder stiffness resulting from primary adhesive capsulitis.[14] Good outcomes typically can be expected if stiffness is recognized early and appropriate measures are taken. However, unlike primary idiopathic adhesive capsulitis, postoperative stiffness is more frequently resistant to a nonsurgical approach.[2,3,15,16] We do not believe that manipulation under anesthesia is indicated in such settings because of the possibility of collateral injury or re-tear of the healed rotator cuff tendon. A patient who is noncompliant or unmotivated may be best treated nonsurgically.

For nonsurgical management to be effective, the stiffness must be recognized early, and pain must be controlled. Pain can be controlled by reducing inflammation through the use of both subacromial and intra-articular corticosteroid injections, oral steroids, and NSAIDs. We prefer to delay the use of steroids or NSAIDs until after 12 to 14 weeks because of their potential adverse effects on tendon healing. Icing and judicious use of oral narcotic medications usually are needed. Symptomatic relief also can be provided by ultrasound and electrical stimulation.

In general, patients with significant stiffness following rotator cuff repair initially should be managed nonsurgically with a structured therapy regimen for at least 3 to 6 months after the repair. During this period, the pain typically subsides and the patient's tolerance for stretching will improve. Because the clinical course is usually one of improvement, it is generally appropriate to wait 4 to 6 months after the primary rotator cuff repair before surgical intervention for stiffness. Patients usually improve significantly during this time frame, and it is rare that patients need surgical treatment. That being said, there may be instances where early intervention for stiffness might be necessary, such as in the case of a suspected infection.

Surgical Management

Treatment options include manipulation under anesthesia (MUA), selective arthroscopic release (with or without MUA), and open release (with or without MUA). Although closed manipulation may play a role in the treatment of idiopathic adhesive capsulitis, it usually is not helpful for patients who have stiffness after a rotator cuff repair.[3,15-17] These patients usually have extra-articular adhesions in addition to capsular contractures and can be resistant to manipulation. Furthermore, forceful MUA may jeopardize the integrity of the rotator cuff repair. Forceful MUA also puts the patient at risk for tendon disruption, proximal humerus fracture, glenohumeral dislocation, and nerve injury. Closed management alone often results in residual motion loss.

We do not advocate MUA in these settings. If MUA is selected, it must be performed carefully. Complete paralysis of the shoulder, either with systemic neuromuscular blockade under general anesthesia or with interscalene nerve block, is required. Shoulder manipulation begins with manipulation of the arm in forward elevation in the scapular plane. The shoulder is stabilized with one hand and the other hand is placed proximally on the arm to reduce the torque applied to the humerus. If capsular disruption is palpated with this maneuver, then the manipulation can continue. Next, the inferior capsular release is completed by manipulating the shoulder in abduction. The posterior capsule is then released by manipulating the shoulder in adduction and very careful manipulation in internal and external rotation. Rotational manipulation is performed last, when less force is required, to prevent a humerus fracture that might occur with torsional stress.

Anesthesia

Appropriate anesthesia and immediate postoperative pain management are critical to the success of arthroscopic and open capsular releases. Indwelling interscalene catheters and intra-articular analgesic catheters are effective modalities for controlling postoperative pain.

Indwelling interscalene catheters are maintained for up to 48 hours and provide a continuous slow infusion of local anesthetic. Placement of the interscalene block and admission to the hospital for 48 hours allows for aggressive physical therapy with almost complete pain control in the immediate postoperative period. Indwelling analgesic catheters placed at the time of arthroscopic release can deliver local anesthetics continuously or on patient demand for 48 to 72 hours postoperatively.[18] These catheters provide pain control without neuromuscular blockade. Because of some recent concerns about the chondrotoxity of bupivacaine in some animal studies, we place such catheters extra-articularly or use repeated interscalene nerve blocks.

Arthroscopic Capsular Release

Arthroscopic release of the contracted capsule and adhesions is the preferred surgical treatment of the stiff shoulder after rotator cuff repair because it allows for precise, selective release of adhesions between tissue planes, division of shortened, thickened capsular tissue, and partial capsulectomy.[2,3,19-22] Arthroscopic evaluation can identify concomitant intra-articular and subacromial pathology. For example, persistent pain in the stiff postoperative shoulder may be a result of inadequate acromioplasty, untreated acromioclavicular joint arthritis, or biceps tendon pathology; all of these common causes of pain associated with failed rotator cuff surgery may be treated appropriately during arthroscopic capsular release. In these revision cases, we have frequently observed that the biceps becomes entrapped in scar such that it does not slide freely in the bicipital groove of the humerus. We believe that this can be a frequent source of persistent pain or loss of motion, and it is our opinion that this should be addressed either with tenotomy or tenodesis.

Patients with an intact repaired rotator cuff and persistent stiffness despite adequate nonsurgical treatment are good candidates for arthroscopic capsular release. Arthroscopic capsular release is also the preferred treatment for patients with stiffness and a recurrent tear of the repaired rotator cuff. A recurrent tear with stiffness does present a clinical dilemma with regards to treatment, and experts disagree about the best approach. One approach is to restore mobility by releasing the contracture, without simultaneously revising the rotator cuff, because combining the release with a revision cuff repair may increase the likelihood of subsequent shoulder stiffness. Postoperative physical therapy can then be used to maintain gains in motion. Several months later, when the shoulder is supple, a revision rotator cuff repair can be performed if needed. Another alternative would be to address both the stiffness and the recurrent rotator cuff tear at the same time. If the shoulder should become stiff again, a subsequent arthroscopic release can be performed. Either approach can be used, depending on the degree of stiffness present, the size of the recurrent rotator cuff tear, and the degree of fatty infiltration. Shared decision making with the patient is essential in such settings. Our preference is to address both the recurrent tear and the stiffness at the same surgical setting; however, in those patients who have very severe stiffness, less than a 30° arc of motion, and a recurrent rotator cuff tear, the treatment typically is staged, with the stiffness addressed first.

Appropriate treatment of stiffness after a rotator cuff tear also depends on the status of the glenohumeral joint. When the joint destruction is severe or when there is significant incongruity, it may be difficult to restore mobility, and joint resurfacing with a prosthetic arthroplasty may be needed. If the glenohumeral arthritis is mild or the patient is young, arthroscopic débridement with a chondroplasty and removal of mechanically unstable cartilage can be performed in conjunction with a capsular release and rotator cuff repair.

Compared with MUA, arthroscopic capsular release has the advantage of precise capsular release with less risk to the repaired cuff tendons and furthermore, it allows for concurrent treatment of intra-articular and subacromial disease. After an adequate release, it is safe to gently manipulate the shoulder to obtain maximum motion. We have found that the force of manual manipulation required to regain motion in patients with postsurgical motion loss is greatly reduced if the capsule has been surgically released first. Furthermore, arthroscopic release prior to manipulation has the added benefit of a relatively bloodless surgical environment in the glenohumeral joint, as opposed to arthroscopy following a manipulation, which can

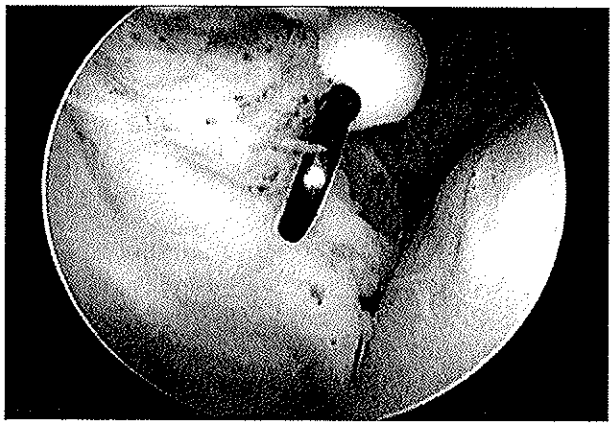

Figure 3 Arthroscopic view showing an anterior capsular release with electrocautery in the rotator cuff interval region.

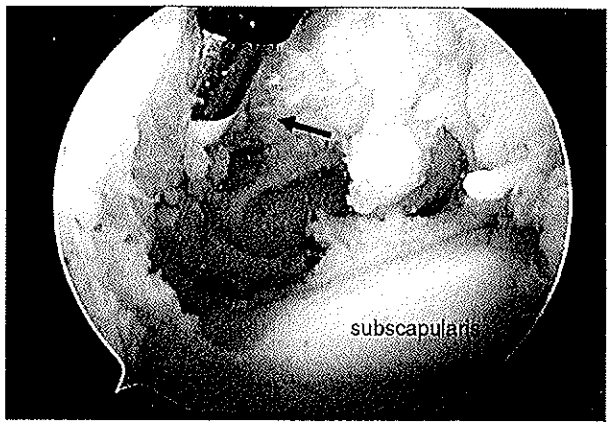

Figure 4 Anterior (rotator cuff interval) arthroscopic view showing capsular release with the top of the subscapularis identified and fibers of the coracoacromial ligament visible.

be quite bloody. It is helpful to work with the anesthesiologist to maintain the mean arterial pressure between 50 and 60 mm Hg to improve visualization.

Arthroscopic release can be performed with the patient in either the lateral decubitus or the beach chair position. A standard posterior viewing portal is used to enter the glenohumeral joint. It usually is difficult to insert the arthroscope into a stiff shoulder because of capsular contracture and decreased joint volume. Careful technique is required to avoid articular injury from forceful insertion of the arthroscope. The posterior joint line can be localized with a spinal needle. The joint is then injected with sterile saline to confirm the location and increase the intracapsular volume for the arthroscope during insertion. The arthroscopic cannula and blunt tapered trocar are directed into the joint carefully while palpating the interval between the glenoid and humeral head with the tip of the trocar.

Anterior Capsular Release

The biceps tendon is the first landmark inside the glenohumeral joint to be identified. It marks the rotator interval region, which is formed by the anterior edge of the supraspinatus tendon and the cranial border of the subscapularis tendon. This region usually is composed of a thick band of scar tissue that can obscure the normally visible upper edge of the subscapularis tendon. A varying amount of synovitis also is typically present.

An arthroscopic cannula is inserted just beneath the biceps tendon, and the capsular tissue is divided with the use of electrocautery, punches, and a motorized shaver (**Figure 3**). The capsular division begins superiorly from just anterior and inferior to the biceps tendon and continues inferiorly until the discrete upper edge of the subscapularis tendon is visible. At the completion of the release, the fibers of the coracoacromial ligament should be visible as they insert onto the coracoid, located in the center of the interval region (**Figure 4**). The anterior capsule is released and partially resected to visualize the subscapularis muscle. Electrocautery facilitates hemostasis during the capsular release. Careful control of the patient's systemic blood pressure and an arthroscopic pump help with visualization. If radiofrequency is used, excessive heat should be avoided by increasing the flow and using short bursts of energy. This will prevent thermal injury to the articular cartilage, which occurs around 50°C. When using electrocautery near the axillary pouch, the outflow can also be kept open to create a heat sink with the arthroscopy fluid to reduce the risk of thermal injury to the axillary nerve. As an alternative, the capsule can be released with capsular punches.

After release of the rotator interval region of the capsule, the humeral head moves inferiorly and later-

ally, allowing more space in the joint for the arthroscope to be moved both anteriorly and inferiorly. Continuing inferiorly, the capsule is released approximately 1 cm off the anterior edge of the glenoid (always staying just lateral to the labrum); the capsular release continues from the midcapsular region down to the 6 o'clock position inferiorly (Figure 5) and stops when the fibers of the underlying subscapularis muscle are visible.

Axillary Pouch Release

The axillary pouch is the region from approximately 5 o'clock to 7 o'clock and consists of the inferior glenohumeral ligament complex (Figure 6). The axillary nerve can be as close as 2 mm from the inferior glenoid rim at 6 o'clock and sometimes can be visualized through the capsulotomy. Unlike the anterior capsule, we do not always release this area. The decision to release the axillary pouch depends on the extent of the patient's persistent motion loss following complete release of the anterior capsule. Release of the axillary pouch will restore external rotation and internal rotation in abduction, as well as pure abduction with the arm in neutral from the posterior portal.

Posterior Capsular Release

After completing the anterior capsular release, with or without release of the axillary pouch, the posterior capsule is addressed. Here, a switching stick is used to reverse the working (anterior) and viewing (posterior) portals. The posterior capsule is released with instruments placed through the posterior cannula. The posterior capsular release is extended superiorly to posterior to the biceps tendon origin at the superior labrum. The posterior capsular release should be initiated at the labral capsular junction to avoid damaging the infraspinatus and supraspinatus tendons, which are located more laterally (Figure 7). During the posterior capsular release, the arm is placed in internal rotation to place the external rotators and posterior capsule under tension and, in turn,

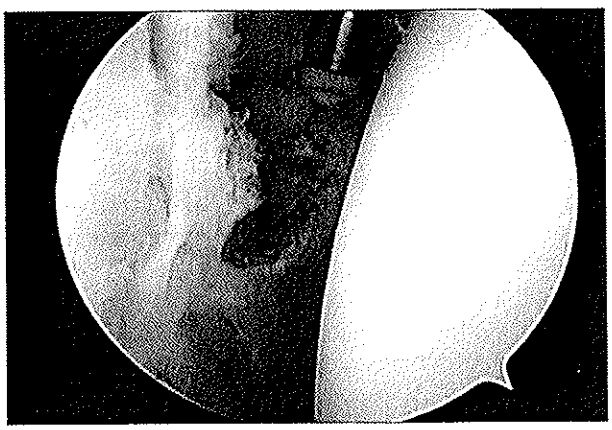

Figure 5 Arthroscopic view showing an anterior capsular release approximately 1 cm off the anterior rim of the glenoid.

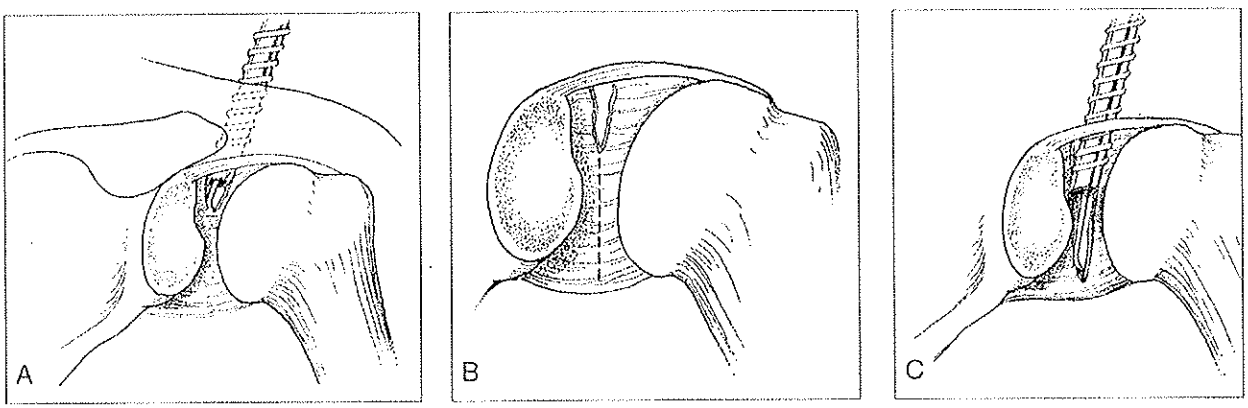

Figure 6 The axillary pouch consists of the inferior glenohumeral ligament complex. Illustrations (A through C) show an anterior capsular release down to the axillary pouch at the 6 o'clock position. There is risk of injury to the axillary nerve when performing capsular release in this region.

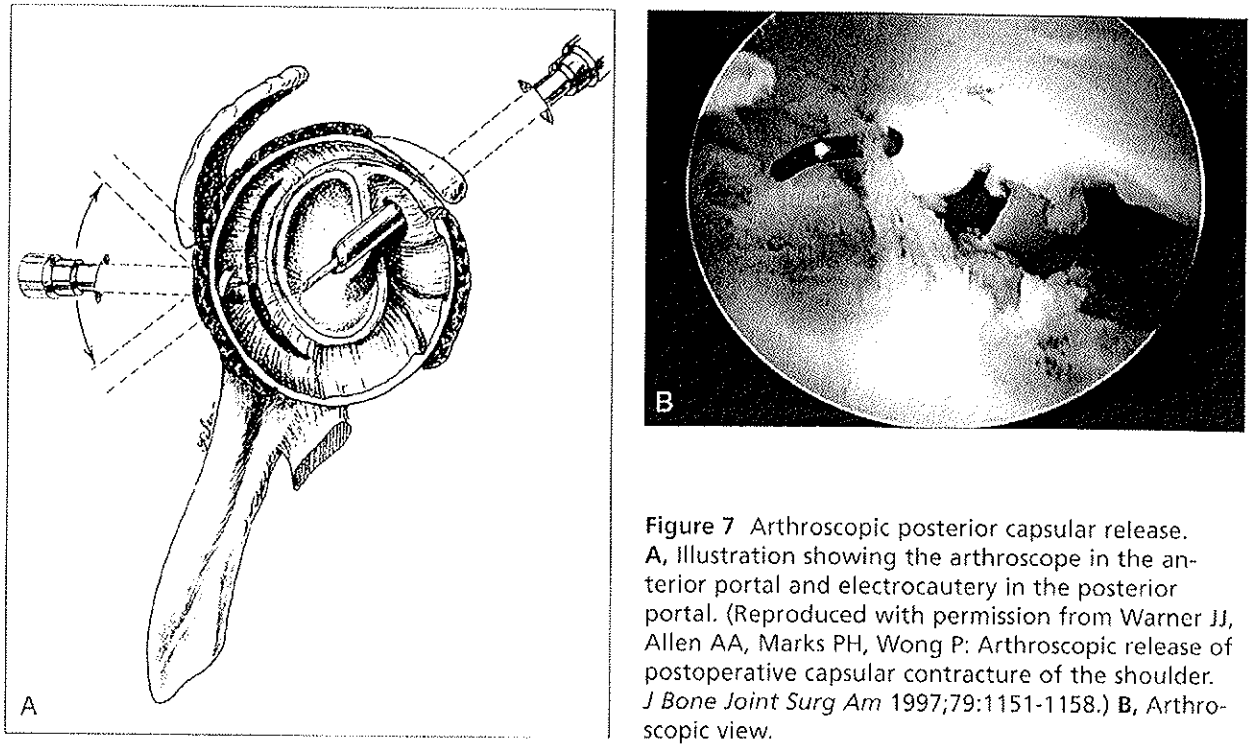

Figure 7 Arthroscopic posterior capsular release. **A,** Illustration showing the arthroscope in the anterior portal and electrocautery in the posterior portal. (Reproduced with permission from Warner JJ, Allen AA, Marks PH, Wong P: Arthroscopic release of postoperative capsular contracture of the shoulder. *J Bone Joint Surg Am* 1997;79:1151-1158.) **B,** Arthroscopic view.

to move the infraspinatus and teres minor tendons away from the glenoid to prevent inadvertent injury to the tendons deep to the capsule. Visualization of the infraspinatus muscle heralds successful release of the posterior capsule. The posterior capsule typically is thickened and lacks the redundancy seen in a normal shoulder.

Subacromial Space

Evaluation and débridement of the subacromial space is a fundamental part of the arthroscopic release of a stiff shoulder following rotator cuff repair. Subacromial and subdeltoid adhesions can restrict motion even after a complete capsular release. An arthroscopic shaver and electrocautery or radiofrequency instruments are used for bursal débridement and lysis of adhesions (Figure 8). It is important to address regions of the subacromial and subdeltoid spaces: anterior, posterior, the lateral gutters, and the bursal side of the rotator cuff extending medially to the acromioclavicular joint and scapular spine. Hypotensive anesthesia and electro- or radiofrequency cautery are used to avoid excess bleeding. Arthroscopic acromioplasty is not performed routinely because it creates bleeding bony surfaces that potentially can scar again. Residual acromial spurring and impingement rarely require acromioplasty.

Open Capsular Release

In patients in whom arthroscopic release is contraindicated or fails to restore motion, an open release can be performed.[17,23] A standard deltopectoral approach or an anterosuperior deltoid-splitting approach typically is used for open release. The former is the preferred technique because it provides better access to the anterior soft tissues and to intra-articular structures. The main advantages of an open release are that the subscapularis tendon can be lengthened if needed and bony deformity or retained hardware can be addressed. Whereas open release may be a better choice for a surgeon unskilled in advanced arthroscopy, arthroscopic release is clearly preferable in most patients. In some revision settings, open release may be the only way to achieve a 360° release and completely mobilize the subscapularis

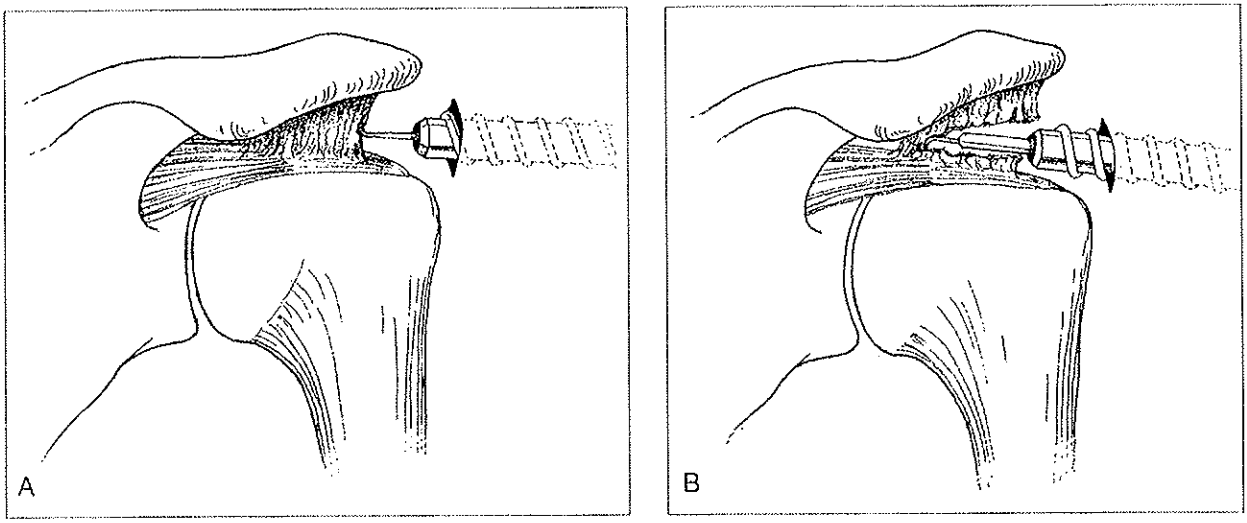

Figure 8 Illustrations showing arthroscopic débridement **(A)** and release **(B)** of subacromial adhesions.

tendon (Figure 9). Shortening of the subscapularis tendon after subscapularis repair might be a good indication for an open release. If necessary, an arthroscopic release easily can be converted to an open release without the need for again preparing or draping the patient.

As with a closed manipulation and arthroscopic release, anesthesia via an interscalene block is preferred. A deltopectoral incision is recommended. Extensive scarring through all layers often is identified. The deltopectoral interval is carefully dissected, and the adhesions between the deltoid and the humerus are released sharply and carefully (Figure 10, *A*). Because the axillary nerve may be at risk as it comes around to innervate the anterior deltoid, it should be palpated, identified, and tagged if necessary. The axillary nerve often can be palpated on the deep surface of the deltoid muscle approximately 3 to 5 cm below the lateral border of the acromion. The dissection is easier if the shoulder is abducted (Figure 10, *B*), relaxing the deltoid. Internal rotation of the arm while gently retracting the deltoid muscle will allow anterior-to-posterior release of the subdeltoid adhesions until the deltoid can move freely over the proximal humerus when the arm is rotated. The dissection then proceeds medially into the subacromial space. Release in the subacromial space must protect the rotator cuff.

After release of the subacromial space, the conjoined tendon is elevated from the underlying subscapularis and retracted medially using both blunt and sharp dissection and being mindful of the musculocutaneous and axillary nerves. Again, the axillary nerve is at risk in this area as well. In this area, it is our preference to clearly define the axillary nerve to prevent its inadvertent injury. The dissection must remain lateral to the base of the coracoid process to protect the neurovascular structures.

Next, the superior border of the subscapularis is identified, and the rotator interval and coracohumeral ligament are released.[17] As the dissection proceeds, the shoulder should be gently stressed to assess motion gains. If external rotation remains substantially limited, the subscapularis can be lengthened and the anterior capsule released. The interval between the subscapularis tendon and the underlying capsule should be developed with an elevator. Lengthening the subscapularis and capsule by medializing the insertion on the lesser tuberosity is preferred over lengthening with a coronal Z-plasty, which often results in a thin tendon and internal rotation weakness. When the anterior capsule and the subscapularis have been dissected, the subscapularis may be found to be encased in scar tissue. To achieve full mobility, it may be necessary to visualize and dissect the axillary nerve (Figure 9). After a

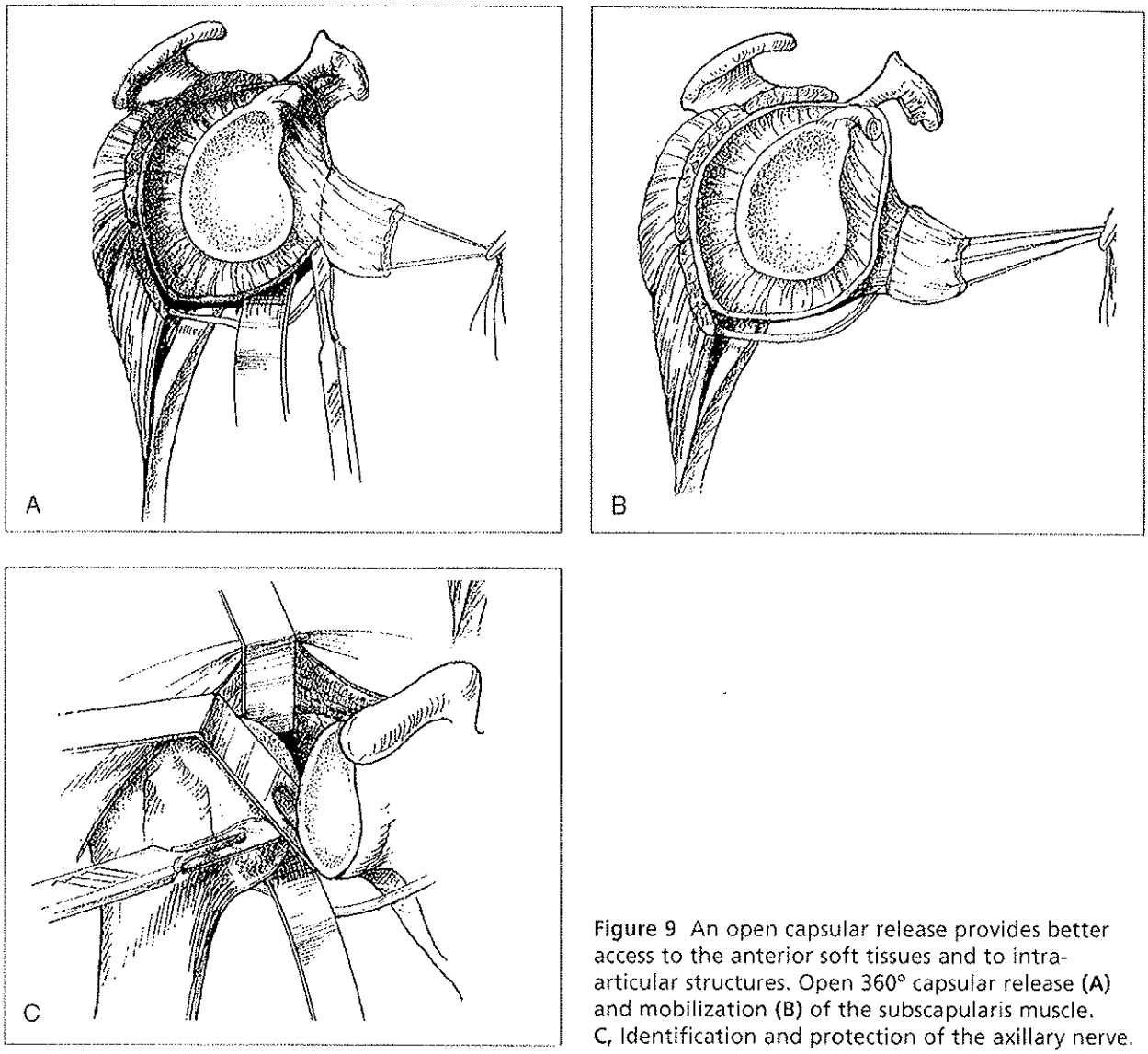

Figure 9 An open capsular release provides better access to the anterior soft tissues and to intra-articular structures. Open 360° capsular release **(A)** and mobilization **(B)** of the subscapularis muscle. **C,** Identification and protection of the axillary nerve.

vessel loop is placed around the axillary nerve, a 360° release and mobilization of the subscapularis is performed (**Figure 9,** *A* and *B*).

If abduction and internal rotation of the shoulder are still limited, the inferior and posterior capsule can be released through the joint. To do this, a Fukuda humeral head retractor is placed into the glenohumeral joint to displace the humeral head posteriorly, and a blunt retractor is placed beneath the inferior capsule to protect the axillary nerve (**Figure 9,** C). The capsule is then released from inferior to posterior and superior under direct visualization. After release, the retractors are removed, and the arm is again brought through a range of motion to evaluate motion gains.

Management of Associated Pathology

Some patients with stiffness following rotator cuff repair have associated and relevant shoulder pathology. In some cases, untreated acromioclavicular joint,

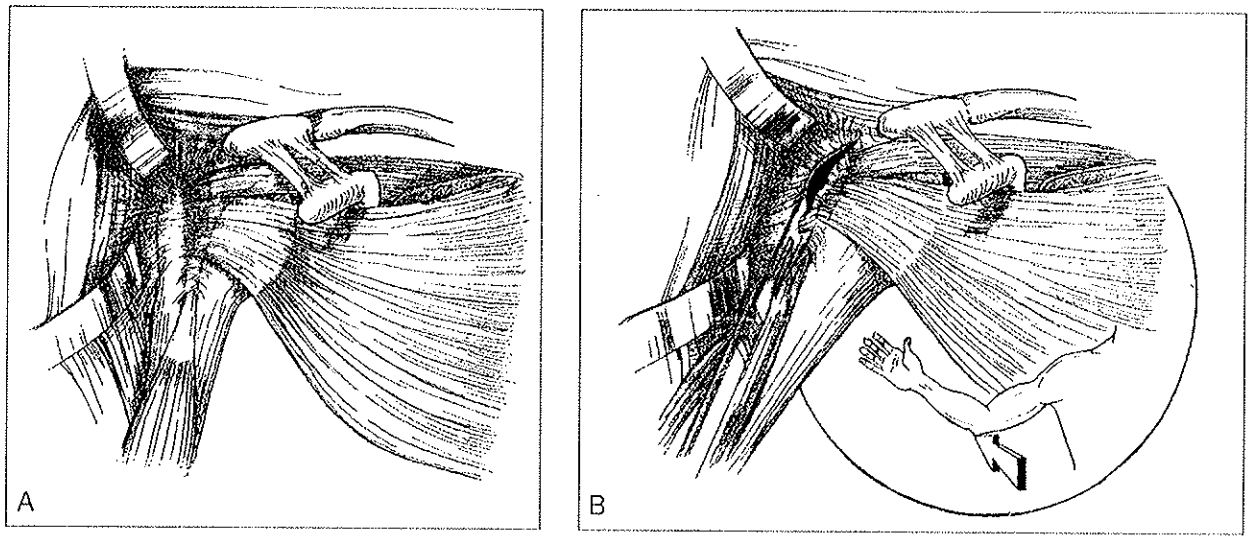

Figure 10 Open capsular release. **A,** Release of extra-articular adhesions between the deltoid muscle, rotator cuff tendons, and proximal humerus. **B,** Abduction relaxes the deltoid muscle and facilitates the repair.

biceps, or glenohumeral pathology may have contributed to the shoulder stiffness. If symptomatic, these problems should be addressed at the time of capsular release.

Postoperative Management

The key to postoperative treatment is adequate pain control. On the morning of the first postoperative day, either repeated interscalene block or the interscalene infusion catheter is continued. Alternatively, pain can be controlled with an intra-articular analgesic catheter. Many patients with intra-articular catheters can be discharged home after the surgery and begin their outpatient physical therapy the next day. Physical therapy optimally is started after the procedure in the postoperative care unit and continued twice a day, for the next 2 days. The patient is discharged after the second therapy session on postoperative day 2 if motion is sufficient and pain control is adequate. Narcotic analgesia is used as necessary to supplement the interscalene analgesia and continued in the days and sometimes weeks after hospital discharge. Formal physical therapy initially is carried out five times a week and is then reduced to 2 to 3 days a week, depending on postoperative progress. Aggressive passive self-assisted stretching in all planes of shoulder motion is emphasized. Patients should perform the exercises hourly during the first week and continue at least five times each day for at least 3 weeks after the procedure. It is vital to stress to the patient that the return of motion will likely take up to 1 year, and the importance of self-assisted exercises cannot be overemphasized.

Preventing the Problem

The main causes of stiffness after rotator cuff repair (Table 4) include (1) preexisting pathology in addition to the rotator cuff tear, (2) surgical technique, (3) postoperative rehabilitation technique, and (4) idiopathic stiffness. To some extent, the first three causes can be controlled by the surgeon. The last, idiopathic stiffness, probably accounts for a very small percentage of patients with postoperative stiffness for whom all of the appropriate selection criteria, surgical techniques, and rehabilitation protocols have been used.

In the first category, premorbid conditions, such as osteoarthritis and adhesive capsulitis, may be present in addition to a rotator cuff tear. If preoper-

TABLE 4 Three Main Causes of Persistent Postop-erative Motion Loss Following Rotator Cuff Repair

1. Premorbid condition (osteoarthritis or shoulder stiffness) and rotator cuff tear
   a. Incorrect management of a rotator cuff tear in the setting of stiffness
   b. Failure to recognize significant preoperative stiffness
      i. Analogous to osteoarthritis of the acute anterior cruciate ligament
      ii. Must treat stiffness before the rotator cuff tear
2. Surgical technique
   a. Tightening of the rotator interval
   b. Inadequate mobilization of the rotator cuff tear
   c. Over-advancement — with excessive tension
3. Postoperative rehabilitation technique
   a. Direct bearing on prevalence of postoperative stiffness following rotator cuff repair
      i. Initial phase (0 to 6 weeks) — protect repair but preserve motion
      ii. Move early (first week)
         1. Prevent intertissue plain adhesions
         2. Prevent capsular contracture

ative stiffness is not noted and addressed before surgical management of the rotator cuff tear, significant shoulder stiffness may follow the surgery.[2] This is a relatively common scenario that may lead to inappropriate rotator cuff surgery in patients who actually have adhesive capsulitis. Invariably, these patients have postoperative stiffness.

In patients with adhesive capsulitis and a concomitant rotator cuff tear, the adhesive capsulitis should be treated before repairing the rotator cuff tear. The first course of treatment should be nonsurgical, with aggressive physical therapy. If this fails to restore mobility, then staged surgery should be performed. First, the stiffness is treated with a capsular release. Then, if the patient is still symptomatic from the rotator cuff tear, it can be repaired. In the case of a patient with significant glenohumeral osteoarthritis and a concomitant rotator cuff tear, the severity of the arthritis must be considered. In severe cases of arthritis, shoulder arthroplasty with a rotator cuff repair may be preferred. If arthroplasty is not indicated and the stiffness is severe, the surgeon should consider performing an arthroscopic débridement and capsular release of the glenohumeral joint and then staging the rotator cuff repair for a later date, after motion has improved.

Incorrect or inappropriate surgical technique is another contributing factor to stiffness following rotator cuff repair. The most common surgical error is inadequate soft-tissue mobilization, which can lead to the rotator cuff being repaired under tension, not only jeopardizing the repair but also limiting the excursion of the glenohumeral joint. Less commonly, over-advancement of the rotator cuff repair can limit motion by capturing the shoulder, or an excessively tight closure of the rotator interval region can restrict the capsule, leading to motion loss.[2,3,17,24] A secure repair, under low tension, allows for earlier motion, thereby decreasing the chances of postoperative stiffness.

Another factor contributing to stiffness after rotator cuff surgery is inappropriate postoperative rehabilitation. In the early postoperative period, rehabilitation should focus on protecting the repair while attempting to preserve and regain motion. The initial phase of rehabilitation typically begins on the day after surgery and generally consists of assisted passive motion. This phase lasts at least 6 weeks postoperatively. This protocol can be modified based on the size and integrity of the repair. Formal supervised physical therapy is especially important for patients with a low pain threshold, who may avoid passive motion in the early postoperative period, as well as patients with cognitive difficulties. Patient compliance is critical to the success of rotator cuff repair. A severe form of postoperative shoulder stiffness that is highly refractory to nonsurgical management may develop in patients with low pain thresholds.[2,3]

CASE MANAGEMENT AND OUTCOME SUMMARY

An arthroscopic capsular release was performed. The rotator cuff repair was found to be intact, and there was extensive synovitis involving the rotator interval and capsule. Once the anterior and posterior capsules were released, there was 150° of forward flexion but only 100° of abduction and 40° of internal and external rotation with the arm in 90° of abduction. The capsule of the axillary pouch was carefully released inferiorly. There was some

improvement in abduction to 120° but forward flexion was still limited. Next, the arthroscope was placed into the subacromial space and subdeltoid and subacromial adhesions were released. The motion improved to 160° of forward flexion, 120° of abduction, and 70° of internal and external rotation with the arm in 90° of abduction. The patient remained hospitalized for 48 hours postoperatively for pain control, and aggressive supervised physical therapy that was supplemented with a continuous passive motion device.

Six months after the arthroscopic capsular release, the patient had 150° of forward elevation, 110° of abduction, 45° of external rotation, and internal rotation to L4. His rotator cuff strength had improved to near normal, and he returned to his previous activity level.

STRATEGIES TO MINIMIZE COMMON COMPLICATIONS

Fortunately, stiffness after rotator cuff repair is rare. The keys are prevention and early recognition. With the advent of arthroscopic rotator cuff repairs, the incidence has declined. When stiffness after rotator cuff repair does occur, however, the clinician should exclude the possibility of an infection and manage patients with a supervised nonsurgical approach that focuses on appropriate rehabilitation and pain management. Most patients will improve within 4 to 6 months of the original rotator cuff repair. If this strategy fails to restore adequate mobility, surgery may be indicated to effectively solve the problem. The procedure of choice, in such settings, is an arthroscopic capsular release combined with an appropriate postoperative pain management strategy and rehabilitation program.

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