Shoulder Instability

The shoulder is a complex joint that comprises the integration of four articulations: the glenohumeral, scapulothoracic, sternoclavicular, and acromioclavicular joints. These articulations need to work in tandem for proper arm elevation and function to occur without pain or excessive humeral head translation. Of these articulations, the glenohumeral joint permits a high degree of mobility, lacks inherent static stability, and exhibits the greatest amount of motion found in the body. This lack of inherent static stability places a greater demand on the dynamic stabilizers to help direct humeral motion in the glenoid and to protect against aberrant translation of the humeral head, which can possibly lead to shoulder instability.

Shoulder instability is a vague, nonspecific term that actually represents a wide spectrum of clinical pathologic conditions, ranging from gross and occult instability to symptomatic laxity or subluxation. Matsen et al described shoulder instability as a pathologic condition in which the laxity or the mobility of the joint increases abnormally. In other words, instability is the inability to maintain the humeral head centered in the glenoid cavity. In all patients with shoulder instability, some component of the stabilizing matrix has become dysfunctional.

According to Pagnani and Warren, typically no single “essential lesion” is responsible for all cases of shoulder instability. The pathophysiologic features of the shoulder produced may vary with the direction and the extent of the instability. The glenohumeral joint’s static restraints include a negative intra-articular pressure gradient, which induces cohesion and adhesion between the humeral head and the glenoid fossa. During cadaveric sectioning, muscle activity is not required to hold the shoulder together, as long as the capsule is not vented. Speer reported that the magnitude of this pressure is small and is capable of producing an approximate stabilizing force of only 20 to 30 lb. This anatomic negative intra-articular pressure is often disrupted during open capsular surgery, thus leaving a postoperative joint pressure of approximately 0 mm Hg.

The glenoid labrum and capsuloligamentous complex also play integral parts in the static glenohumeral restraints. The glenoid labrum is a fibrous rim that functions to slightly deepen the glenoid fossa and allows for attachment of the glenohumeral ligaments. The function of the glenoid labrum is similar to a “chock-block” or buttress in controlling humeral head translation. Biomechanical studies indicated that resection of the labrum can reduce the effectiveness of the concavity compression by 20%. Injury to the labrum is thought to disturb the negative intra-articular pressure gradient and thereby contribute to shoulder instability.

The glenohumeral capsule was reported by Gohlke et al to be thickest and strongest at the anterior-inferior region because of its dense organization of collagen and by the invagination of the inferior glenohumeral ligament complex. The anterior glenohumeral joint capsule exhibits three distinct ligaments consisting of the superior, middle, and inferior glenohumeral ligament complex. The inferior glenohumeral ligament complex is the primary restraint at elevated positions such as 90° of abduction, whereas the superior glenohumeral ligament is taut at 0° of abduction. The middle glenohumeral ligament tightens more so at the midrange of elevation when the arm is abducted and externally rotated.

Proper treatment and management of the shoulder require an understanding of the pathophysiology of shoulder instability to direct clinical decision making regarding conservative rehabilitation or surgery. The following section briefly describes the proposed mechanisms of injury and management guidelines for Bankart lesions, superior labrum anterior to posterior (SLAP) lesions, and rotator cuff interval injuries, and posterior instability, with the latest interventions suggested for these injuries and for those patients with recurrent instability. The postoperative
rehabilitation for each surgical procedure is demonstrated, including the most recent guidelines available and in a case study format.

On clinical examination, the patient with a Bankart lesion presents with a positive result on the apprehension test for anterior instability. The patient reports extreme feelings of vulnerability or pain as the shoulder is brought into end-range external rotation with the arm in 90° of abduction.

A Bankart lesion results in anterior instability of the gleno-humeral joint. The cadaveric model of Abboud and Soslowsky suggested that a Bankart lesion alone reproduced only small amounts of anterior and inferior translations at all positions of abduction. These investigators believed that the amount of humeral head translation needed to produce clinical anterior glenohumeral dislocation required inferior glenohumeral ligament plastic deformation in addition to the Bankart lesion. Thus, they recommended surgical repair for recurrent instability and capsular laxity produced by the initial traumatic event and stated that the detachment of the glenoid insertion of the inferior glenohumeral ligament must be addressed to permit full stability.

The operative indications for glenohumeral joint surgical stabilization are as follows: recurrent symptomatic instability, despite a minimum 3-month trial of a well-designed and supervised rehabilitation program; a requirement for stability for occupational reasons, such as in heavy manual laborers and military cadets; and connective tissue disorders in subgroups of patients, such as adolescents, who are at high risk for recurrence of instability. In the adolescent subgroup, it is important to rule out a psychological component through psychological testing before proceeding with the surgical intervention.

A Bankart lesion typically results from a traumatic anterior dislocation of the shoulder. The lesion itself is usually identified as a compromise or tear of the attachment site of the labrum to the gleno-humeral ligaments. Thus, the definition of a Bankart lesion is an injury that occurs when the capsular-labral complex is torn from the glenoid rim (Fig. 2A). Evidence suggests that patients between the ages of 21 and 30 years who sustained a primary shoulder dislocation and underwent physical therapy and immobilization did not reduce the risk of a recurrent dislocation of the shoulder. The suggestion is that patients in this age group who participate in high-risk sports should undergo primary surgical stabilization because of the risk of a dislocation recurrence. Another objective sign of recurrent anterior instability is the presence of an osseous defect or lesion seen on a radiograph, commonly noted on the posterior-lateral portion of the humeral head, known as a Hill-Sachs lesion (see Fig. 2B).

Occasionally, the dislocation may affect the axillary nerve, usually noticed as a change in sensation. At times, this lesion may have an effect on the motor branch of the deltoid, which has significant impact on functional lifting and reaching.

**Figure 1** Lateral aspect of the internal surface of the right glenohumeral joint. The humerus has been removed to expose the capsular ligaments and the glenoid fossa. Note the prominent coracoacromial arch and underlying subacromial bursa (blue). The four rotator cuff muscles are shown in red. (From Neumann DA: Kinesiology of the musculoskeletal system: foundations for rehabilitation, ed 2, St. Louis, 2010, Mosby Elsevier.)
indications for performing a Bankart surgical procedure also include decreasing the risk of future dislocations and avoiding the potential for more permanent injury to the axillary nerve.\textsuperscript{13}

The open Bankart surgical stabilization technique for post-traumatic recurrent anterior stabilization has been referred to as the procedure of choice for patients who do not respond to nonoperative treatment.\textsuperscript{14} This procedure is based on the premise that anterior instability is caused by detachment of the anterior-inferior labrum from the glenoid rim.\textsuperscript{10}

Gill et al\textsuperscript{15} reported on long-term results with patients after open stabilization for a Bankart repair for anterior instability of the shoulder. The study consisted of 60 shoulders in 56 patients, with a minimum follow-up of 8 years after a Bankart procedure. These patients had a mean follow-up period of 11.9 years and were examined for range of motion (ROM), stability, and strength according to the data form of the American Shoulder and Elbow Surgeons (ASES) for examination of the shoulder. The mean loss of external rotation was 12\textdegree{} (range, 0\textdegree{} to 30\textdegree{}). No significant differences were reported in elevation, abduction, or internal rotation between the involved shoulder and the contralateral, normal shoulder. Fifty-five of the 56 patients returned to their preoperative occupations without having to modify their activities. Fifty-two patients rated the result as good or excellent; 3 rated it as fair, and 1 rated it as poor.\textsuperscript{15} Although this study demonstrated great patient satisfaction, the average loss of 12\textdegree{} of external rotation could be disabling for athletes. More recently, Randelli et al\textsuperscript{16} also demonstrated an average loss of external rotation similar to the findings of Gill et al. Randelli et al quantified active ROM after arthroscopic Bankart repair with rotator interval closure and found a significant reduction in average active external rotation in the adducted position (12.14\textdegree{}) and a 7.21\textdegree{} reduction in 90\textdegree{} of abduction.\textsuperscript{16}

Pagnani and Dome\textsuperscript{17} reported their open stabilization procedure on 58 American football players over a 6-year period and noted the operation to be a predictable method to restore shoulder stability while maintaining an ROM approximating that found after arthroscopic repair. The average follow-up was 37 months after the surgical procedure; 55 patients reported good or excellent results, and 52 of the 58 returned to playing football for at least 1 year.\textsuperscript{17} According to these investigators, the open stabilization procedure offers postoperative stability superior to that reported after arthroscopic techniques in this patient population.\textsuperscript{17} The open Bankart repair, as described by Pagnani and Dome,\textsuperscript{17} involves vertical tenotomy of the subscapularis tendon, which is performed with electrocautery approximately 1 cm medial to the tendon’s insertion on the lesser tuberosity. The interval between the anterior aspect of the capsule and the subscapularis tendon is moved with blunt dissection to permit exposure to the anterior joint, and the capsular laxity and quality are assessed. Transverse capsulotomy is performed to permit exploration of the Bankart lesion. The glenoid neck is roughened with an osteotome to provide a bleeding surface. These investigators used two or three metallic suture anchors placed in the anterior-inferior aspect of the glenoid neck near, but not on, the glenoid articular margin. The capsule and labrum are reattached to the anterior aspect of the glenoid with slight medial and superior mobilization of the capsule. The goal of this surgical procedure is not to reduce external rotation, but to obliterate excess capsular volume to restore the competency of the inferior glenohumeral ligament at its glenoid insertion. These investigators also proposed performing anterior capsulorrhaphy to eliminate excess capsular laxity.\textsuperscript{17}

Figure 2: Plain radiographs demonstrate an anterior glenohumeral dislocation before (A) and after (B) reduction. Postreduction anterior-posterior view (B) demonstrates a Hill-Sachs lesion of the posterior-lateral humeral head (arrowhead) and a typical “bony Bankart” fracture of the anterior-inferior glenoid rim (arrow). (From Stechschulte D, Warren R: Anterior shoulder instability. In Garrett W, Speer K, Kirkendall D, editors: Principles and practice of orthopaedic sports medicine, Philadelphia, 2000, Lippincott Williams & Wilkins.)
CASE STUDY 1

This case presents a standardized postoperative rehabilitation protocol for the athlete after a Bankart repair, based on the latest literature and procedures. The enhancement and the dynamic stabilization or concavity-compression mechanism are not addressed in surgery. Instead, neuromuscular exercises and training of the rotator cuff by means of a dedicated and essential rehabilitation program ultimately optimize functional recovery of the shoulder following capsulorrhaphy.

General Demographics
Mr. C.M. is a 26-year-old professional football player, who is an offensive lineman. The patient injured his right (dominant side) shoulder during a blocking technique while his arm was in a position of abduction and external rotation. The resultant force stressed his shoulder quickly into horizontal abduction during the play, and he began feeling numbness and pain immediately thereafter in the arm. The team physician determined that Mr. C.M. had anteriorly dislocated his shoulder, which was manually relocated on the field and then placed in a sling. A magnetic resonance imaging (MRI) scan was taken in the locker room and displayed a Bankart lesion and tear of the anterior capsule. The patient underwent an open Bankart repair 1 week later.

Social History
Mr. C.M. is single, with no children. He does not smoke or drink alcohol.

Employment
He is a professional offensive lineman in the National Football League.

Living Environment
Mr. C.M. lives with his girlfriend in a bilevel home.

Growth and Development
He is an extremely muscular young man, with no external deformities noted.

Patient Medical History
He had right knee arthroscopy 2 years ago for a torn medial meniscus, with no complaints over the last year with respect to his knee.

History of Chief Complaint
Mr. C.M. is unable to resume football at the present time because of weakness, pain, and stiffness in his right shoulder. He comes to the physical therapy clinic 4 weeks after a right Bankart repair. He reports pain at the right upper trapezius and anterior-lateral shoulder that wakes him up at night, but he no longer feels numbness or “dead arm” symptoms. The patient has been immobilized for 4 weeks since surgery and has been taught only pendulum and elbow ROM exercises up to this time.

Prior Treatment for This Condition
The patient has not received prior treatment with respect to shoulder stability. Before his injury, the patient was active with a general weight training program with the team.

Structural Examination
The patient comes to physical therapy with his shoulder in a sling. Visual inspection reveals a well-healed anterior incision, and the patient is fully intact to light touch sensation surrounding the surgical incision. Mild ecchymosis and swelling are noted in the anterior shoulder region, as is tenderness along the lesser tuberosity at the insertion of the subscapularis. Mild atrophy is noted of the right deltoid, pectoralis major, and infraspinatus when compared with the contralateral side.

Range of Motion

Active Range of Motion
Active motion of the right shoulder is contraindicated at this time because of the tissue vulnerability from the surgery and the pull-out rate of suture anchors for stabilization. However, care must also be taken to protect the repair site with passive ROM (PROM), especially in the abducted and externally rotated position. Penna et al. examined the actual forces with PROM encountered at the glenoid-labrum interface after an isolated Bankart repair and a Bankart repair with a capsular shift. These investigators found that the forces at the repair site were significantly less than those determined by previous authors to be necessary to result in failure of the Bankart repair. Thus, their data suggest that during the early postoperative period, rehabilitation must be modified to protect the repair site further than currently accepted guidelines indicate.

Active motion testing is postponed at this time for the right shoulder. The left shoulder has full active ROM (AROM) with proper scapulohumeral rhythm with elevation. Right elbow flexion and extension, along with wrist flexion and extension, are full and pain free.

Passive Range of Motion
Initial PROM of the right shoulder is 80° of flexion, 120° of abduction, 0° of external rotation in the adducted position, and 45° of internal rotation. No hypermobility is noted at the contralateral upper extremity at the elbows or metacarpophalangeal joints. Again, care is taken to avoid stretching into external rotation in the abducted position until 6 weeks postoperatively, to protect the repair site.

Accessory Motion Testing of the Glenohumeral Joint
Mr. C.M. has a moderately tight posterior capsule.

Muscle Testing
No further testing of the right shoulder is performed because of the acuteness of the patient’s symptoms and the postoperative time frame.

Special Tests
The left shoulder does not demonstrate shoulder laxity in any direction with load and shift testing. No further special testing is performed at this time because of the acuteness of
the patient’s symptoms and nature of his postoperative time frame.

**Palpation**

Palpation elicits tenderness in the anterior shoulder along the subscapularis tendon insertion and along the anterior glenohumeral joint.

**Physical Therapist’s Clinical Impression**

Based on the patient’s signs and symptoms, and time frame from surgery (4 weeks), the main goal at this stage of rehabilitation is to begin restoration of PROM and active-assisted shoulder ROM while still protecting the surgical site. The main factor to consider at this stage is using a methodical yet progressive approach to restore shoulder external rotation while protecting against overstressing the anterior capsule, inferior glenohumeral ligament complex, and subscapularis musculotendinous junction. Therefore, anterior capsule joint mobilizations are contraindicated, along with aggressive pectoral stretching or stretching into external rotation in 90° of abduction.

**Treatment Plan**

**Initial Treatment: 4 to 6 Weeks Postoperatively**

Initial treatment goals are to reduce and eliminate inflammation of the anterior shoulder tissues with modalities as needed and graded manual scar tissue mobilization. The patient’s external rotation should be limited to 30°, and forward flexion limited to 90° provided he has no signs or symptoms of impingement or rotator cuff symptoms. Proximal stabilization for the scapular rotators may begin at this time for retraction, posterior depression, and neuromuscular control exercises. Submaximal isometrics for the internal and external rotators are performed as tolerated. No strengthening isotonic exercises or repetitive exercises are started until after full ROM has been established. By the sixth week, the patient demonstrates 160° of active forward flexion in the sitting position, with compensatory superior humeral migration and upper trapezius dominance. He demonstrates 55° of external rotation. At this time, a progression into graded resisted internal and external isometrics up in the plane of the scapula and prone shoulder extensions, serratus supine punches, rowing, and horizontal abduction with the weight of the arm may begin in modified arcs of motion while protecting the anterior restraints.

**Treatment: 6 to 12 Weeks Postoperatively**

At 8 weeks postoperatively, the patient demonstrates 175° of flexion, 160° of abduction, 65° of external rotation, and 65° of internal rotation. At this phase, he is tolerating rhythmic stabilization with the shoulder in varying degrees of flexion to enhance kinesthetic awareness and dynamic stability. He is now emphasizing his infraspinatus and teres minor strength, with side-lying external rotation, using progression to a 3-lb weight. His rotator cuff strengthening is advanced by week 10 to Thera-Band (Hygenic Corp., Akron, Ohio) exercises, and his abduction angles are slowly increased during rotator cuff and deltoid strengthening exercises. The scapular rotators are strengthened with the following: press-ups (seated dips), shrugs, horizontal abduction with modified arc to protect the anterior capsule, and open can exercises with continued prone rowing and shoulder extensions now at 5 lb.

**Treatment: 12 to 18 Weeks Postoperatively**

At this stage of the rehabilitation, the patient demonstrates 180° of flexion, 180° of abduction, 80° of external rotation, and 70° of internal rotation. On manual muscle testing, he demonstrates the following: abduction, 4+/5; flexion, 5/5; external rotation, 4/5 (fatigues with repetition); and internal rotation, 5/5. His scapulohumeral rhythm is comparable to his contralateral side. He has a positive Neer test result and mild posterior capsular tightness relative to the uninvolved side. During this phase of his rehabilitation, the focus is on restoration of terminal external rotation and further enhancement of neuromuscular control of the humeral head. The use of proprioceptive neuromuscular facilitation in dynamic patterns and in sport-specific patterns is initiated, along with plyometric exercises, such as medicine ball catches and chest passes. Use of Thera-Band exercises and isokinetics is elevated to the plane of the scapula and then to 90° of abduction. These exercises are performed at slow and fast speeds to prepare the anterior-posterior stabilizers properly for quick and prolonged stress and strain forces to the shoulder.

Assessment of anterior laxity and instability with load and shift testing is negative, as are apprehension test results. The end-range external rotation in the apprehension position is 95° by week 18 and pain free. An isokinetic evaluation to compare strength with the contralateral shoulder is performed at 17 weeks and demonstrates 5% and 15% deficits at the external and internal rotators, respectively.

**Treatment: Past 18 Weeks Postoperatively**

At this time, the patient has a negative Neer test result and 180° of flexion, 180° of abduction, 95° of external rotation, and 75° of internal rotation. The patient’s program focuses on closed kinetic chain exercises, which are more sport specific for his profession as a lineman. He also progresses to a conventional weight-training program, with education placed on not overstressing the anterior capsule with end-range dips or chest presses. The patient is retested at 23 weeks postoperatively, with a second isokinetic evaluation demonstrating equal strength at his external rotators and 10% greater strength of his internal rotators relative to the contralateral side. At this time, the patient is cleared to progress from field to contact drills with the team. However, his surgeon suggests that he obtain an abduction harness initially as protection during blocking drills. The patient is cleared to return to full contact football by his...
CASE STUDY 1—cont’d

physician and physical therapist by the 25th week postoperatively after he demonstrates good tolerance to contact drills with, and then without, the abduction brace and after he demonstrates symmetrical abduction and external rotation strength on isokinetic and manual muscle testing. Finally, the patient is instructed in posterior capsular (cross-body) stretching, as well as the “sleeper stretch,” to maintain tissue extensibility and help reduce the likelihood of recurring impingement. The patient is checked periodically by the team physician for any recurring signs or symptoms of instability.

Summary of Case

The crucial phase of rehabilitation after the Bankart repair is the initial period of immobilization, followed by the beginning of ROM restoration. The biologic healing response of the repaired and imbricated tissue must be respected. The first goal is to maintain anterior-inferior stability. The second goal is to restore adequate motion, specifically external rotation, because it is well established that a significant lack of external rotation from capsular plication can hasten early degenerative arthritic changes at the glenohumeral joint. The third goal is a successful return to sports or physical activity in a reasonable amount of time. Patients must be compliant and must understand the need to permit these anterior structures to heal, for adequate stabilization. This patient was not seen in physical therapy until the fourth week, so it was up to his physician to instill this point. The physical therapist must also respect the healing nature of the anterior stabilizers by not being too aggressive early on with restoring external rotation. This protocol is based on tendon-to-bone healing in a dog model and emphasizes avoidance of early resistance exercises, with aggressive early postoperative rehabilitation to help prevent compromise to the repair. The approach to this case is typical for a patient after Bankart repair and emphasizes a safe progression through rehabilitation. The latter part of the rehabilitation is more sport specific and individualized, depending on the goals of the patient. However, as in this case when the patient demonstrated impingement signs, it is important to think critically and reassess, as the patient progresses, to be able to deter secondary complications. In this case, it appears the patient’s impingement was related to residual posterior capsular tightness and limited external rotation in the abducted position, and possibly a concurrent increase in elevation with his graded strengthening exercises.

Originally, shoulder instability was corrected primarily through open procedures, whereas current technique allows correction of the entire spectrum of instability patterns by arthroscopic techniques. Speer et al retrospectively investigated the outcomes of an arthroscopic technique for anterior stabilization of the shoulder that used a bioabsorbable tack in 52 patients with shoulder instability. The cause of the instability was a traumatic injury in 49 of the patients; 26 of these injuries were sustained during participation in a contact sport. Fifty of the shoulders had a Bankart lesion. The patients were evaluated at an average follow-up of 42 months postoperatively. Forty-one (79%) patients were asymptomatic and were able to return to their respective sport without restriction. The repair had failed in 11 (21%) of the patients. In 4 of these patients, the failure resulted from a single traumatic re-injury during participation in contact sports, and 3 of the 4 patients were treated nonoperatively. The remaining 7 treatment failures occurred atraumatically.

The investigators reported that the rate of recurrent instability Speer et al following this arthroscopic procedure (21%) greatly exceeded the rates of recurrence of open capsulorrhaphy (up to 5.5%). The investigators believed that the wide discrepancy in results reflected this arthroscopic technique and did not address the coexistent capsular injury or plastic deformation reported to occur with Bankart lesions. Therefore, they suggested that anterior stabilization with a bioabsorbable tack may be indicated for patients with anterior instability who do not need capsulorrhaphy to reduce joint volume.

A prospective study by O’Neill evaluated the results of an arthroscopic transglenoid suture stabilization procedure in athletically active patients who had recurrent unilateral, unidirectional anterior dislocations of the shoulder and an isolated Bankart lesion. The mean duration of follow-up was 52 months, within a range of 25 months to 7 years. The patients were evaluated annually with a physical examination, radiographs, isokinetic strength testing, the modified shoulder rating scale of Rowe and Zarins, and the scoring system of the ASES.

The results of O’Neill’s study determined that 40 (98%) of the 41 athletes returned to their preoperative sports after surgery. Thirty-nine patients (95%) had no additional dislocations or subluxations, and 2 (5%) had a single episode of subluxation. These last 2 patients were football players. These investigators concluded that arthroscopic transglenoid repair of an isolated anterior labral detachment or Bankart lesion restored stability of the shoulder and led to a favorable outcome in 39 (95%) of the 41 athletes. The only 2 patients who suffered a postoperative subluxation were the 2 football players, who also were the only patients to score less than 80 points on the ASES scale.

The arthroscopic Bankart reconstruction, as described by Rook et al, uses an anterior portal to ensure access to the inferior glenoid and to evaluate the lesion and anterior capsule. The anterior portal is also used for débriding and releasing the capsulolabral complex from the glenoid. The capsulolabral complex is released inferiorly to the 6 o'clock position of the glenoid. Rook et al then abrade the anterior and inferior glenoid to promote a bleeding surface on which...
the suture anchors will be placed at the 5 o’clock, 3 o’clock, and 1 o’clock positions (Fig. 3).

Figure 3 Drawing of the glenoid with numbers identifying anchor placement. (From Rook R, Savoie F, Field L, et al: Arthroscopic treatment of instability attributable to capsular injury or laxity, Clin Orthop Relat Res 390:52–58, 2001.)

Evidence indicates that arthroscopic treatment for shoulder instability may parallel the gold standard of open surgical techniques.24 However, some studies may refute this claim and continue to suggest that arthroscopic treatment of shoulder instability has a greater failure rate than open procedures, especially in athletes who desire to return to contact sports postoperatively.21,25-27 Ultimately, the need may exist for longer outcome studies of both approaches to determine which procedure (open versus arthroscopic) provides the highest success rate. Magnusson et al14 suggested follow-up studies of up to 7 years and recommended that researchers consider incidences of subluxation and recurrent dislocations in their success rates. According to Magnusson et al,14 a gold standard for reconstruction in patients with unidirectional, post-traumatic anterior instability does not appear to exist. Therefore, the choice of method for post-traumatic anterior instability must still be based on the experience of the surgeon and the patient’s choice, rather than on scientific evidence from long-term prospective, randomized studies at the present time.14

MUSCLE MECHANICS: CONTRIBUTION TO SHOULDER DISLOCATION AND STABILITY

Increased understanding of the sequelae of and predispositions to shoulder dislocation may improve functional results during nonoperative treatment, surgical repair, and postoperative rehabilitation. McMahon and Lee27 developed an in vitro, cadaveric model that investigated relevant shoulder musculature, its relationship with glenoid concavity compression for dynamic stability, and its role in contributing to dislocation. This research integrated work by Matsen et al,28 who defined a muscle’s function as a dynamic restraint related to a “stability ratio” between the displacing component (contributes to instability) of the joint force and the compressive component (contributes to stability). The Matsen model suggested that shoulder muscle dysfunction on one side of the joint not only may decrease the compression component, but also may increase the displacing component if forces on the other side are unbalanced.28

The term concavity compression refers to the stability afforded a convex object that is pressed into a concave surface.29 This mechanism is particularly active in all glenohumeral positions, but most important in the functional midrange, in which the capsule and ligaments are slack.30 The specialized anatomic features of the rotator cuff muscles and the intra-articular long head of the biceps are located ideally to compress the humeral head dynamically into the glenoid concavity.31

McMahon and Lee27 assessed the alteration in glenohumeral joint forces with simulated shoulder muscle dysfunction. The joint was positioned in apprehension while the rotator cuff and deltoid were simulated and loaded. While the arm was in the apprehension position, the investigators altered the load in the infraspinatus and the pectoralis major tendons. The conditions were altered by first removing the load from the infraspinatus (infraspinatus muscle palsy) and then adding it to the pectoralis major; then these changes were repeated simultaneously, by removing the load from the infraspinatus as the load was added to the pectoralis major.

Compared with the intact condition, the magnitude of the compression force when the infraspinatus was unloaded decreased substantially by approximately 31%. The results also demonstrated a significant increase in the anteriorly directed force when the pectoralis major was loaded with and without infraspinatus muscle palsy of 143% and 142%, respectively. These simulated muscle dysfunctions resulted in a significant decrease in concavity compression of the humeral head into the glenoid cavity and a concomitant increase in the anteriorly directed force, a situation that could result in joint instability.27 The investigators concluded that the large force developed in the pectoralis major muscle may be related to its ideal orientation to lever the humeral head effectively anteriorly and inferiorly out of the glenoid.27

An anatomic study by Ackland and Pandy32 measured lines of action of 18 major muscles and “muscle subregions” crossing the glenohumeral joint of the shoulder and computed the potential contributions of these muscles to joint shear (instability) and compression (stability) during scapular plane abduction and sagittal plane flexion. The results demonstrated that, during flexion and abduction, the rotator cuff subregions were more favorably aligned to stabilize the glenohumeral joint in the transverse plane than in the scapular plane.

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Overall, these investigators found that the anterior supraspinatus was most favorably oriented to apply glenohumeral joint compression. The pectoralis major and latissimus dorsi were the chief potential destabilizers of the scapular plane and demonstrated the most significant capacity to impart superior and inferior shear to the glenohumeral joint, respectively. These investigators also found the middle and anterior deltoid to be significant potential contributors to superior shear, and they believed that these muscles would act as a force couple to challenge the combined opposing “destabilizing” inferior shear potential of the latissimus dorsi and inferior subscapularis. Ackland and Pandy32 believed that the posterior deltoid and subscapularis had posteriorly directed muscle lines of action, whereas the teres minor and infraspinatus had anteriorly directed lines of action, and that both acted as potential stabilizers, depending on the directed instability. They suggested that knowledge of these lines of muscle actions and of the stabilizing potential of individual subregions of the shoulder musculature could assist clinicians in identifying muscle-related joint instabilities and aid in the development of rehabilitation designed to improve joint stability and the concavity-compression effect.32

Contrary to the study by Ackland and Pandy, Gibb et al33 demonstrated, with simulated supraspinatus muscle paralysis, that the glenohumeral kinematics were unaffected. This study suggested that joint compression was maintained through the remaining rotator cuff and was adequate to provide a stable fulcrum for concentric compression of the glenohumeral joint during abduction. This is typically what is seen clinically in that a patient with a massive supraspinatus tear with the remaining rotator cuff intact maintains abduction. However, a tear extending into the infraspinatus tendon disrupts the transverse force couple, and the stable platform for the glenohumeral abduction is lost.33 It becomes even more important to strengthen the infraspinatus and teres minor in the patient with anterior-inferior instability because these muscles have been shown to reduce the strain on the anterior-inferior capsuloligamentous complex.9,34 The subscapularis has been shown to be a primary dynamic restraint for stabilizing the glenohumeral joint anteriorly with the arm in abduction and neutral rotation, but it becomes less important in external rotation, in which the posterior cuff muscles reduce strain.9

Anterior dislocation of the glenohumeral joint occurs either by disruption of the glenohumeral ligaments and labrum or by rupture of the rotator cuff.9 The rotator cuff acts as a force couple around the joint, by controlling or directing force through the joint. Abboud and Soslowsky9 described two types of force couples that work around the glenohumeral joint. The first force couple is coactivation or simultaneous activation of the agonist and antagonist muscles around the joint. The second force couple is coordinated activation of the agonist with inhibition of the antagonist. According to Nichols,35 this force couple increases joint torque and motion, increases forces through the joint, and allows transfer of forces through the joint. The coordinated muscle activation is necessary to produce torques and accelerations required for using the glenohumeral joint in a controlled and stable manner.35

Lee et al29 hypothesized that dynamic factors can potentially stabilize the glenohumeral joint throughout the entire ROM. Investigators previously thought that the capsuloligamentous restraints were the only primary stabilizing factors at end range. Lee et al combined the force components with concavity-compression mechanics and a new entity, the dynamic stability index, was calculated. These investigators calculated a 20% lower stability index in the end range provided by the four rotator cuff muscles compared with the midrange. They believed that the difference reflected a decrease in dynamic stability for the subscapularis in the end range.29

Although the rotator cuff has been the mainstay of focus on the stability of the glenohumeral joint, another study, by Kido et al,36 determined the deltoid muscle also to function as a dynamic stabilizer in shoulders with anterior instability. Using a controlled laboratory study with nine fresh cadavers, Kido et al placed the arm in 90° of abduction and 90° of external rotation. They monitored the position of the humeral head by an electromagnetic tracking device with 0 and 1.5 kg of anterior translation force. This device was applied with 0, 1, 3, and 5 kg of force to each of the anterior, middle, and posterior portions of the deltoid muscle with the capsule intact, vented, and with a simulated Bankart lesion. The results demonstrated that with the capsule intact, anterior displacement was significantly reduced by application of load to the middle deltoid muscle. After the capsule was vented, load application to the anterior, middle, or posterior deltoid muscle significantly reduced anterior displacement. With a simulated Bankart lesion, the effects of loading were most apparent in that anterior displacement was significantly reduced with loading of each muscle portion. These investigators concluded by stating that their model showed that the deltoid muscle is an anterior stabilizer of the glenohumeral joint with the arm in abduction and external rotation and that the deltoid takes on more importance and dynamic stabilizer as the shoulder becomes more unstable.36

Additional improvements in outcome after glenohumeral joint dislocation warrant improved understanding of the interplay of the static and dynamic restraints.27 The therapist should attempt to focus the rehabilitation on those muscles found to contribute to concavity compression and enhance joint stability while appreciating those muscles that may contribute to dislocation and instability.

### SLAP Lesions

In 1990, Snyder et al37 reported on a lesion that occurred at the anterior-superior labral-biceps complex, which they described as a tear located at the superior labrum that begins posteriorly and extends anteriorly (SLAP). This lesion involves the anchor of the biceps tendon to the labrum. Several investigators reported on the strong correlation between SLAP lesions and glenohumeral instabilities.38-40 Pagnani et al40 found that a complete lesion of the superior labrum was large enough to destabilize the insertion of the biceps tendon and
was associated with significant increases in anterior-posterior and superior-inferior glenohumeral translation.

SLAP lesions are believed to be secondary to a traumatic event, and they can also be a sequela of repetitive stress, especially in the overhead athlete. One model that underwent two arthroscopic studies investigating clinical observations and biomechanical data questioned the role of microinstability as a cause of SLAP lesions in the throwing athlete. Burkhart and Morgan reported on 53 baseball players, 44 of whom were pitchers, who had type II SLAP lesions that were surgically repaired. Arthroscopic repair of these type II SLAP lesions returned 87% of these athletes to sport with a preinjury level of performance. This result was superior when compared with the 50% to 68% of athletes able to return to sport after open anterior capsulolabral repair. These investigators proposed that the mechanism of SLAP injuries is the Morgan-Burkhart peel-back model, which describes the pathologic lesion at the posterior-superior labrum.

Unlike the Walch-Jobe-Siddles model of internal impingement resulting from capsular laxity or microinstability, Burkhart and Morgan believed that the underlying cause of SLAP lesions is not anterior instability or internal impingement, but rather contracture of the posterior-inferior capsule secondary to the follow-through in the throwing motion. Burkhart and Morgan demonstrated that a glenohumeral internal rotation deficit (GIRD) caused by a contracted posterior capsule would induce a posterior-superior shift of the glenohumeral contact point and thus permit a greater amount of external rotation to occur before internal impingement. Moreover, a GIRD reduces the cam effect of the anterior-inferior capsule and induces pseudolaxity. These investigators believed that this condition was misdiagnosed in the past in overhead-throwing athletes as anterior instability. The investigators defined GIRD as a loss in degrees of glenohumeral internal rotation of the throwing shoulder compared with the nonthrowing shoulder. Burkhart and Morgan emphasized the importance of evaluating GIRDS and believed that it is a priority to restore these deficits at least to symmetry with the nonthrowing shoulder, to prevent the pathophysiologic cascade that can lead to SLAP lesions.

Investigators have also postulated that SLAP lesions can result from a compressive force applied directly to the shoulder from a fall on an outstretched arm, with the humerus in a position of abduction and slight forward flexion. This type of injury has the potential to drive the humeral head superiorly, thus avulsing the biceps or labral attachment from the glenoid. This appears to be the most common mechanism of SLAP lesions and accounts for 23% to 31% of injuries. Traction injuries have accounted for 16% to 25% of all SLAP lesions, and dislocation or subluxation has accounted for up to 19%. Bey et al made some generalizations about the possible causes of SLAP lesions and suggested that types I, III, and IV lesions may be the result of a shearing force between the humeral head and the glenoid.

The presence of a destabilizing SLAP lesion may have a profound impact on shoulder stability and function. Rodosky et al demonstrated that the presence of superior labrum and biceps anchor injury diminished the force necessary to translate the humeral head anteriorly. According to Higgins and Warner, the rotator cuff may be subject to internal impingement and may lead to tearing secondary to the instability sequelae of the SLAP lesion. Moreover, SLAP lesions have been found to occur more commonly in younger patients with acute rotator cuff tears. Snyder et al arthroscopically identified and classified SLAP lesions into four types (Fig. 4). In the type I lesion, the superior labrum is markedly frayed, but the attachments of the labrum and biceps tendon remain intact. The type I lesion is regarded by many orthopedic surgeons as benign, or not pathologic. The type II lesion resembles the type I lesion, except that the attachment of the superior labrum is compromised, resulting in instability of the labral-biceps complex. Type III lesions consist of a bucket-handle tear of the labrum, which can be displaced into the joint space. However, the labral-biceps attachment remains intact. Type IV lesions are similar to type III lesions, except that the labral tear extends into the biceps tendon and permits it to subluxate into the joint.

Maffet et al suggested expanding beyond the original four types of SLAP lesions, as suggested by Snyder et al, after noting in a retrospective review of 712 arthroscopies that 38% were not classifiable as types I to IV. Maffet et al suggested an expansion to seven categories and added descriptions for types V through VII. Type V SLAP lesions are characterized by the presence of a Bankart lesion of the anterior capsule that extends into the anterior superior

![Figure 4](image_url) Superior labral tear classification. A, Type I. B, Type II. C, Type III. D, Type IV. (From Snyder SJ, Karzel RP, Del Pizzo W, et al: SLAP lesions of the shoulder, Arthroscopy 6:274–279, 1990.)
labrum. A type VI lesion indicates disruption of the biceps tendon anchor with an anterior or posterior superior labral flap tear. Type VII SLAP lesions are described as extensions of a SLAP lesion anteriorly to involve the inferior to the middle glenohumeral ligament.

### Treatment of SLAP Lesions

#### Nonoperative Management

Conservative management of SLAP lesions is often unsuccessful, particularly when a component of glenohumeral instability is present. However, a few of patients with a type I SLAP lesion are amenable to conservative treatment. The initial phase is to reduce the inflammation with short course of nonsteroidal anti-inflammatory drugs and cessation of throwing. Once the pain has subsided, physical therapy is initiated with a focus on restoring normal shoulder motion and strengthening the scapulothoracic rotators. Restoring glenohumeral internal rotation is critical, and thus emphasis should be placed on stretching the posterior capsule and external rotators to reduce the GIRD. Work by Izumiy et al. suggested that the typical cross-body stretch and the sleeper stretch, as advocated by Burke and Morgan, may not be sufficient to stretch the entire posterior capsule. These investigators recommended that the arm be placed in 30° of elevation in the scapular plane with internal rotation for the middle and lower capsular tissues and stretching in 30° of extension with internal rotation for the upper and lower capsule. The patient should be advanced as tolerated to a strengthening phase that includes the trunk, core, rotator cuff, and scapular musculature. Once the patient demonstrates adequate strength ratios of external to internal rotation of 70%, he or she is started on a throwing program for 3 months and continues with sport-specific strengthening.

Higgins and Warner described an arthroscopic technique for repair of type II SLAP lesions. Historically, debridement alone did not provide adequate long-term results because the underlying instability was not addressed. Currently, suture anchors are recommended, with an arthroscopic knot-tying technique instead of bioabsorbable tacks because of the risk of fragmentation of the tack and further complications. Addressing any associated disorders at the time of arthroscopy, such as Bankart lesions or instability, is also important.

The technique advocated by Higgins and Warner involves three portals: posterior, anterior (under the biceps tendon), and at the anterior-lateral acromion to allow for suture anchors and arthroscopic knots to be tied through this portal. The superior glenoid is removed of all fibrous material to prepare for repairing the labrum. The glenoid is decorticated, and the anchors are inserted through the working cannula. At least one anchor must be placed at, or posterior to, the biceps insertion to ensure solid fixation in this region. The sutures are tied off to the anchors with a sliding knot and are reinforced with several half stitches.

Type III SLAP lesions are treated similarly to type II lesions, except that the bucket-handle component of this lesion is excised, and no attempt is made to repair this lesion. While the patient is under anesthesia, the surgeon should attempt to discern whether any underlying instability predisposed the patient to the SLAP tear. Type IV SLAP lesions that compromise less than one third of the biceps tendon are debrided. If more than one third of the biceps tendon is involved, then the torn tendon is repaired back to the major fragment of the biceps.

#### Postoperative Treatment for SLAP lesions

The rehabilitation following surgical intervention for a SLAP lesion should be specific to the type of lesion and the type of procedure performed (debridement versus repair), and it should also take into account other possible concomitant procedures, because of the underlying glenohumeral instability that is often present. The overall goal is to restore dynamic stability to the glenohumeral joint while simultaneously protecting the healing tissue from adverse stress, especially early postoperatively.

The surgical treatment and rehabilitation vary based on the concomitant disorders, but typically one should avoid the abducted and externally rotated position while the labrum is healing in those individuals with a SLAP lesion consistent with a peel-back lesion, as is often seen in the overhead athlete. In patients who sustained a compressive injury, such as a fall on an outstretched hand, weight-bearing exercises should be avoided, to minimize compression and shear on the superior labrum. Patients with traction injuries should avoid heavy resisted or excessive eccentric biceps contractions. These guidelines are crucial, especially in the early phase of recovery, because evidence has demonstrated failure rates as high as 32% in postoperative outcomes of SLAP repairs.

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**CASE STUDY 2**

This case represents the postoperative progression in a young patient who underwent repair for a type II SLAP lesion and supraglenoid cyst excision. Goals and treatment are based on soft tissue healing and on indications and contraindications postoperatively.

**General Demographics**

The patient, A.B., is a 10-year-old, English-speaking boy who comes to the clinic 4 weeks after right SLAP repair and supraglenoid cyst excision. He is right-hand dominant.
CASE STUDY 2—cont’d

Social History
A.B. lives with his mother and father. He does not smoke or drink.

Employment
He is a full time student in the fifth grade.

Living Environment
A.B. lives with his mother and father in a home in New Jersey.

Growth and Development
He is a lean boy, with hypermobile extremities.

Patient Medical History
He has a history of right shoulder pain, which occurred after too many innings and games as the starting pitcher for his traveling team that played all year round. He was treated for his SLAP tear and shoulder pain for 8 months of physical therapy before surgery and was doing reasonably well because his pain and dynamic stability improved. However, his glenoid cyst had grown in size and necessitates surgery.

Prior Treatment for This Condition
A.B. reports that toward the last month of his summer baseball season, he began feeling right shoulder pain and paresthesias down into his right hand when he would try to pitch. He had been playing baseball all year because of his participation on a traveling team. He tried to stop pitching for a 2-week period, but still had pain trying to play second base to minimize the stress on his arm. He eventually sought a doctor’s consultation and was diagnosed at the age of 9 years with supraspinatus tendinosis, a type II SLAP lesion, and a small paralabral ganglion cyst.

Physical Therapist’s Clinical Impression
The patient underwent a type II SLAP repair (two suture anchors) and supraglenoid cyst excision because of repetitive tensile loading to his capsuloligamentous restraints. His throwing mechanics were very poor on observation of video before his injury, which placed even greater shear forces at the glenohumeral joint and dynamic stability demand of his rotator cuff. A paralabral cyst invaginating into the glenoid and increasing in size is one of the possible sequelae of glenohumeral instability. His surgical procedure was necessary to help repair the detached labrum that was the underlying reason for his cyst formation. The main goals to consider in the early postoperative period are to permit proper soft tissue healing, to protect the biceps–superior labral complex from tensile stress, and to reduce pain, inflammation, and swelling. The early restrictions from 0 to 3 weeks are elevation to only 90° of the scapula, and external rotation to neutral to minimize strain on the labrum through the peel-back mechanism. This approach involves early avoidance of elbow flexion exercises, which are typically permitted after most shoulder procedures. Patients recovering from SLAP lesion repairs also require a longer period before they stress shoulder motion with external rotation in the abducted position. The reason is that as the biceps acts as a secondary anterior stabilizer in this position, it is also important to avoid the peel-back mechanism.38,42

Treatment Plan
The following is an overview of this patient’s postoperative rehabilitation program. The patient is instructed on continued use of the sling for an additional 2 weeks at all
times, except when he is doing his ROM exercises, to protect his biceps-labral complex. He is instructed to ice his shoulder three times a day for 10 to 15 minutes, to alleviate local inflammation and swelling, and to work on maintaining AROM of the elbow, wrist, and hand. He is instructed in middle and lower trapezius isometrics in the supine position to facilitate neuromuscular control at his scapular region. This protocol is reinforced during verbal and tactile cues instructing him to squeeze his shoulder blades down and inward, gently and slowly, while holding for 5 seconds. The patient’s shoulder ROM is strictly passive at this time. He avoids pain and limits external rotation to 0° to 15° initially in the adducted position.

At 4 weeks postoperatively, the sling is removed, and PROM is progressed to 45° of external rotation and scaption (plane of the scapula) to 120°. The patient’s initial PROM at this time is as follows: shoulder flexion, 105°; abduction, 100°; external rotation, 25°; and internal rotation, 50°. The initial phase of rehabilitation is to restore ROM, with particular attention paid to regaining proper length to the posterior capsule. When the posterior capsule is taut, the tendency is for the humeral head to shift anteriorly and superiorly, thus increasing the potential for augmenting compressive loading and shear at the biceps-labral complex. Modalities are used as needed to quell local postoperative inflammation and to prevent biceps or rotator cuff tendinitis. However, ultrasound is contraindicated, given the age of this patient and his open growth plates.

At 6 weeks postoperatively, strengthening of the rotator cuff and periscapular musculature is initiated, beginning first with isometrics and progressing to isotonic resisted training as tolerated in a pain-free arc of motion and in the adducted position. PROM is progressed as tolerated within the permissible range to protect the repair site. At this time, A.B.’s manual muscle testing demonstrates the following: shoulder flexion, 3+/5; abduction, 4−/5; external rotation, 3+/5; and internal rotation, 4/5; Biceps curls and resisted shoulder flexion are held for an additional 2 weeks.

At 8 to 12 weeks postoperatively, the patient progresses to light biceps curls. He is also instructed to begin shoulder scaption (0° to 90°) with 1-lb weights and to progress in 1-lb increments after he can perform 3 sets of 12 repetitions without altering the mechanics of the lift. Once he can perform external rotation with a 3-lb weight while side lying, he progresses to Thera-Band tubing beginning in the adducted position. Once he can tolerate Thera-Band scapular strengthening with rows and shoulder extensions, he progresses to prone scapular rotator exercises. The patient is instructed to avoid lifting his arm beyond his torso in the prone position, to avoid overstressing his anterior shoulder. At 12 weeks after surgery, the patient demonstrates full restoration of AROM, with the exception of external rotation in abduction, which is 88°. This motion is not stressed actively or with resisted exercises until 6 months postoperatively, to avoid possibly overstressing the superior labral-biceps attachment. Manual muscle testing results are as follows: forward flexion, 5/5; abduction, 5/5; external rotation, 4+/5; internal rotation, 5/5; middle/lower trapezius, 5/5; and serratus anterior, 5/5. At this time, he is discharged and given a home exercise program. He is instructed to avoid overstressing his shoulder with throwing activities until he comes back in 4 weeks for a follow-up assessment. He is progressed with his home exercise program to include proprioceptive neuromuscular facilitation (D1, D2) diagonal patterns in standing with red and progressing to blue resistance. He is also progressed with Thera-Band strengthening for his external rotators in up in the plane of the scapula and demonstrates good form with sleeper stretch and ancillary stretches for posterior capsular extensibility.

**Summary of Case**

The patient continued his home program for a month and returns for a follow-up assessment that demonstrates 5/5 strength throughout his rotator cuff and scapular rotator musculature and full AROM. Although this patient does not demonstrate significant posterior capsule tightness before or after the procedure, it is still important to assess this region, based on work by Morgan et al., Crockett et al. and Reagan et al. also suggested that as younger throwing athletes mature, their loss of internal rotation with concomitant increased external rotation is a function of skeletal changes at the humerus that induces greater humeral retroversion. Work by Liu et al. demonstrated the validity and accuracy of using a cluster of special tests, which have proven to be more accurate in predicting glenoid labral tears than MRI. The tests recommended by Liu et al. include the apprehension, relocation, load and shift, inferior sulcus sign, and crank tests. The use of the active compression test, as proposed by O’Brien et al. to diagnose the possibility of a SLAP lesion on examination more precisely, is also recommended. Several investigators believed that patients are predisposed to SLAP lesions when shoulder instability is present. This condition is typically checked on physical examination and is confirmed when the patient is under anesthesia. This patient did not demonstrate any signs of instability; therefore, his surgical procedure did not warrant capsulorrhaphy, and he did not require further soft tissue healing time.

After SLAP repair surgery, the athlete typically is permitted to participate in sports 3 to 4 months postoperatively unless the sport involves throwing. According to Higgins and Warner, throwing short distances and at low
velocity commences at approximately 4 months, with an emphasis on proper mechanics. Pitchers are permitted to practice low-velocity pitches from the mound at 6 months, and unrestricted throwing is held until at least 7 months postoperatively. Given the age of this patient, it seems prudent to wait closer to the 7- to 8-month postoperative period, to permit even more strength and soft tissue healing and thus prevent reinjury. He is also scheduled to work with a pitching coach to enhance his mechanics, to help avoid reinjury.

**CASE STUDY 2—cont’d**

**ROTATOR INTERVAL CAPSULE**

Neer\(^5^8\) was the first to use the term *rotator interval*, back in 1970. In 1981, Rowe and Zarins\(^3^3\) documented the different sizes and variations in the rotator interval among patients with anterior instability. Fitzpatrick et al\(^5^9\) suggested a wide patient spectrum involving potential laxity to instability of the rotator interval. Evidence suggests that the rotator interval region of the glenohumeral joint plays an integral role in the pathomechanics and intervention of patients with shoulder instability.\(^6^0^\)\(^6^2\) The term *rotator interval* has two distinct meanings when referring to the anterior-superior aspect of the shoulder. According to Gartsman and associates,\(^6^2\) when the term is used in conjunction with repair of the rotator cuff, it is referring to the tendinous connection between the supraspinatus and subscapularis. When the term is used in reference to shoulder instability, it is defined as a triangular space bordered superiorly by the anterior margin of the supraspinatus tendon and inferiorly by the superior border of the subscapularis tendon (Fig. 10-5).\(^6^1^\)\(^6^2\) This triangular interval is bridged by capsular tissue and is reinforced superficially by the coracohumeral ligament and in its deepest segment by the superior glenohumeral ligament.\(^6^2^\)\(^6^4\)

Harryman et al\(^6^3\) were among the first to investigate the role of the rotator interval in glenohumeral stability with a cadaveric model. These investigators determined that, through operative sectioning of the rotator interval, a resultant increase in anterior, posterior, and inferior humeral head translation occurred. Conversely, imbricating the rotator interval decreased inferior and posterior translation compared with the intact state of the shoulder.\(^6^5\) The studies by Harryman et al\(^6^5\) and of Rowe and Zarins\(^3^3\) suggested that the presence of defects in the rotator interval may be an important anatomic factor in shoulder instability.

**Anatomy of the Rotator Interval**

The triangular space also contains the biceps tendon. The quality of the capsular tissue varies in the rotator interval. Cole et al\(^6^0\) did anatomic dissections of the rotator interval in 37 fetuses and found that 75% the capsular layer was not continuous, and a thin synovial membrane covered the rotator interval. The histologic examination of the covering of the rotator interval in both fetuses and adult populations revealed a loose and thin collagenous tissue that was poorly organized with a sparse population of fibroblasts. Because of Cole et al,\(^6^0\) findings demonstrating that the tissue was relatively weak called into question the role of the rotator interval capsule in glenohumeral stability. Warner et al\(^6^6\) confirmed the stabilizing and structural role of the rotator interval. These investigators showed that the inferior translation of the adducted arm was restricted by the superior glenohumeral ligament, the coracohumeral ligament, and the negative intra-articular pressure. A sealed glenohumeral capsule is necessary to maintain the negative intra-articular pressure, and the thin rotator interval capsule provides that seal.\(^6^6\)

Field et al\(^6^1\) retrospectively reported on an operative approach for patients with recurrent instability symptoms involving isolated closure of the rotator interval. These investigators determined a clinical relationship between a 2+ or more positive sulcus sign for inferior instability and rotator interval defects that influenced shoulder instability. These investigators also examined the shoulders for direction of instability while the patient was under anesthesia. They determined that, in all patients, the humeral head could be subluxated anteriorly to either grade 2+ (11 cases) or 1+ (4 cases), posterior translation had an average grade of 1+, and a positive sulcus sign was present in all patients. Zazzali and Vad observed that rotator interval defects are associated with a large sulcus sign combined with anterior instability. Both issues need to be addressed if they are found during surgical repair.
Typically, before arthroscopic closure of the rotator interval, a supervised physical therapy regimen is implemented to attempt dynamic stabilization with a specific program to strengthen the rotator cuff and the scapular rotator. These exercises should be designed to enhance the concavity-compression effect of the rotator cuff at the glenohumeral joint without further compromising the static restraints of the shoulder. The physical therapy trial typically lasts 5 to 6 months before surgical intervention is considered.

According to Provencher and Saldua, indications for surgical repair of the rotator interval remain poorly defined; however, evidence suggests that closure should be considered in the following: (1) patients with anterior instability and rotator interval lesion (incomplete sulcus), (2) patients with symptomatic shoulder instability and laxity in the inferior direction (positive sulcus) that does not obliterate with external rotation with the arm at the side (Fig. 6), (3) patients who have significant laxity and a large sulcus finding with concomitant multidirectional instability, and (4) possibly some patients with posterior instability in whom prior surgical attempts at stabilization have failed.

The surgical technique for isolated closure of the rotator interval defect, as described by Field et al., involves an anterior arthroscopic technique, which necessitates release of the lateral 30% of the conjoined tendon insertion to permit access to the anterior capsule. The subscapularis tendon is released approximately 1 cm medial to its insertion on the lesser tuberosity; this approach also enhances visualization of the rotator interval. After delineation of the rotator interval, the defect edges are then approximated, typically with the patient’s arm placed in 45° abduction and external rotation. Imbrication is performed in a “pants-over-vest” fashion. The closure of the rotator interval defects reduces the anterior and inferior capsular redundancy. If necessary to reduce inferior translation further, imbrication of a lax superior glenohumeral ligament is performed by overlapping and suturing the ends with nonabsorbable sutures. Finally, the subscapularis tendon is reapproximated to its insertion with nonabsorbable sutures.

CASE STUDY 3

This case represents the progression postoperatively for a patient who underwent isolated closure of a rotator interval defect that induced shoulder instability. In general, the postoperative regimen follows the primary repair guidelines (i.e., for anterior, posterior or multidirectional instability). Patients are first placed in a sling for 4 weeks, and the primary procedure is allowed to dictate the postoperative regimen. Typically, patients are advised to limit forward flexion to 90° and external rotation to 0° for the first 4 weeks postoperatively. After the sling is removed, AROM and active-assisted ROM exercises are begun, with a gradual progression to end-range stretches. By 8 weeks, most patients have regained full forward flexion and external rotation. The emphasis is then placed on restoring

Figure 6 A, Test for inferior shoulder instability (sulcus test). B, Positive sulcus sign (arrows). (From Magee DJ: Orthopedic physical assessment, ed 5, St. Louis, 2008, Saunders Elsevier.)
rotator cuff and scapular rotator strength, to enhance their
dynamic stability and concavity-compression mechanism;
full recovery and return to function are usually expected
by 6 months.65

General Demographics
The patient, Mr. S.Y., is a 32-year-old, English-speaking,
Asian man who comes to physical therapy 4 weeks after
rotator interval closure. He is right-hand dominant.

Social History
Mr. S.Y. is single and lives alone. He does not smoke, and
he drinks approximately twice per week.

Employment and Environment
He is a director of a nonprofit company, and he plays squash
and tennis.

Living Environment
Mr. S.Y. lives alone on the fifth floor.

Patient Medical History
He has a history of right shoulder pain and “dead arm”
symptoms, which occurred typically while playing
recreational squash.

History of Chief Complaint
Mr. S.Y. reports that his chief complaint is a recurrent
feeling of instability and clicking at the right shoulder,
which occurs during tennis and squash, and pain that began
approximately 4 months ago. He has ceased these sports
activities secondary to exacerbation of his symptoms.

Prior Treatment for This Condition
The patient was seen by his orthopedic surgeon, who
determined his symptoms to be associated with anterior
instability based on his history and a positive apprehension
test result, a positive sulcus test result that did not change
with placing the shoulder in external rotation, and a
2+ load and shift test result for anterior instability
grading. Standard radiographs of the affected shoulder
showed no Bankart lesions or Hill-Sachs deformities. An
MRI scan did not demonstrate the presence of capsular
irregularities. The patient underwent arthroscopic exploratory
surgery and was found to have a defect at the rotator
interval capsule that was 2.75 cm in medial-to-lateral
width and 2.1 cm in superior-to-inferior height. The
patient underwent arthroscopy to close this defect and to
reduce anterior and inferior capsular redundancy.

Structural Examination
The patient is seen 7 days postoperatively, and he is wearing
a sling. Visual inspection reveals modest swelling along the
anterior suture lines and ecchymosis, but the sutures are
intact, clean, and dry. His right scapula is elevated relative
to the right side and demonstrates some inferior angle
winging at rest.

Range of Motion
Shoulder Active Range of Motion
AROM is not assessed because of the acuteness of his symp-
toms and contraindications relative to the postoperative
time period. His PROM is assessed as follows: shoulder
flexion, 80°; abduction, 60°; external rotation, −5°; and
internal rotation, 50°. Elbow and wrist ROM are within
normal limits.

Accessory Motion Testing of the Glenohumeral Joint
This motion is not assessed because of the acuteness of the
patient’s symptoms and the time frame from surgery.

Muscle Testing
No resisted testing is permitted at this time, except for
elbow, wrist, and hand and finger motions, which are
within normal limits.

Special Tests
No testing is done at this time.

Tenderness
The patient has focal tenderness along the anterior-superior
glenohumeral joint and along the coracoid process.

Palpation
Tenderness is noted along the subscapularis tendon
insertion and at the coracoid process.

Physical Therapist’s Clinical Impression
The patient arrives for physical therapy for rehabilitation
1 week after right arthroscopy for isolated closure of the
rotator interval. This surgical procedure was suggested to
help reduce anterior-inferior instability.61 The patient’s
ROM will need to be restored, with a priority to achieve
a minimum of 35° of external rotation before advancing
elevation beyond 90°, to prevent impingement.68 However,
external rotation will initially be limited to 0° for the first
4 weeks, to permit adequate fixation of the rotator interval
region. Care will also need to be taken to avoid joint
mobilization to the anterior or inferior capsules, to prevent
overstressing the rotator interval repair site.

Treatment Plan
The following is an overview of this patient’s postoperative
rehabilitation program.

Pendulum exercises are started immediately postoperatively.
The patient is instructed on continued use of the sling
for an additional 3 weeks to protect the rotator interval
when he is not in physical therapy or performing ROM
exercises independently. Active-assisted external rotation
exercises are initially limited to 0° for the first 4 weeks. He
is instructed to ice his shoulder two to three times a day
for 10 to 15 minutes to alleviate local inflammation and
swelling and to work on maintaining AROM of the elbow,
wrist, and hand.

Continued
POSTERIOR INSTABILITY

Posterior instability of the shoulder is uncommon and accounts for 2% to 5% of all cases of shoulder instability, and for less than 2% of all shoulder dislocations. Posterior shoulder instability covers a continuum of disorders ranging from acute posterior dislocation at one end of the spectrum to chronic recurrent subluxation posterior subluxations at the other end. Its origin has been classified as traumatic or atraumatic and its type as voluntary (individual can subluxate the shoulder posteriorly) or involuntary. The mechanism of injury and its type as voluntary (individual can subluxate the shoulder posteriorly) or involuntary.

The true incidence of rotator interval defects is unknown at the present time, but evidence suggests that these biologic insufficiencies may be congenital in origin. The aforementioned patient was treated solely for surgical closure of a rotator interval defect. The surgeon determined by arthroscopic examination that the patient had no comorbidity to the labrum or anterior or posterior capsules. The therapist communicated with the referring surgeon to appreciate exactly which tissue was involved during the surgical procedure. Once the initial period of healing is permitted and a pragmatic approach is instituted, with the chief concern not to be aggressive with joint mobilization techniques (especially anteriorly and inferiorly before 6 weeks postoperatively), the patient progresses predictably with respect to strength and return to function.

CASE STUDY 3—cont’d

After the fourth postoperative week, the sling is removed, and forward flexion and external rotation exercises for ROM and motor control are progressing. The patient’s initial AROM at this time is as follows: shoulder flexion, 90°; abduction, 75°; external rotation, 10°; and internal rotation, 50°. The initial phase of rehabilitation is to restore ROM, with graded physiologic stretching coupled with soft tissue mobilization to address periarticular fibrosis secondary to immobilization. Aggressive joint mobilizations are contraindicated at this time because of the possible risk of interfering with capsular length tension and shear to the repair site. Modalities are used as needed to quell local postoperative inflammation and to prevent manifestation of secondary rotator cuff tendinitis.

At 8 weeks postoperatively, he demonstrates the following: full forward flexion, 170°; abduction, 165°; internal rotation, 70°; and external rotation, 85°. At this time, a graduated strengthening program for the rotator cuff and periscapular musculature is initiated, beginning first with isometrics and progressing to isotonic resisted training as tolerated in a pain-free arc of motion and in the adducted position. At this time, Mr. S.Y.’s manual muscle testing results are as follows: shoulder flexion, 4/5; abduction, 4−/5; external rotation, 3+/5; and internal rotation, 4−/5.

At 12 weeks postoperatively, the patient progresses to Thera-Band rotator cuff exercises and prone scapular rotator exercises to address the middle and lower trapezius musculature. The patient is instructed to avoid lifting his arm beyond his torso in the prone position and to avoid overstressing the anterior shoulder. The rotator cuff exercises are gradually progressing to more provocative positions of elevated abduction for more sport-specific and functional patterns of motion.

By 16 to 20 weeks postoperatively, the patient demonstrates 5/5 strength throughout his right shoulder musculature on manual testing. He does not show any signs of laxity or symptoms of instability and is progressing to sport-specific exercises to prepare his arm for tennis and squash. Plyometric training is also instituted for proprioception and kinesthetic awareness, with the use of a medicine ball and quick Thera-Band repetitions in elevated positions of abduction for the internal rotators. The patient is permitted to return playing squash and tennis slowly by the sixth month postoperatively.

Summary of Case

The true incidence of rotator interval defects is unknown at the present time, but evidence suggests that these biologic insufficiencies may be congenital in origin. The aforementioned patient was treated solely for surgical closure of a rotator interval defect. The surgeon determined by arthroscopic examination that the patient had no comorbidity to the labrum or anterior or posterior capsules. The therapist communicated with the referring surgeon to appreciate exactly which tissue was involved during the surgical procedure. Once the initial period of healing is permitted and a pragmatic approach is instituted, with the chief concern not to be aggressive with joint mobilization techniques (especially anteriorly and inferiorly before 6 weeks postoperatively), the patient progresses predictably with respect to strength and return to function.
The mechanism of injury is typically a high-energy posteriorly directed force on an outstretched arm in the athlete. Williams et al theorized that a single traumatic episode, either alone or in conjunction with cumulative strain, may lead to excessive posterior head translation that can lead to detachment of the posterior capsulolabral complex.

**Symptoms and Physical Examination**

Individuals with posterior instability are typically men between the ages of 20 and 30 years and who are often involved in overhead-throwing or contact sports. Patients typically have increased sensitivity and pain during weight-bearing activities and report pain, a feeling of weakness, and a sensation of abnormal mechanics including catching, clicking, and clunking. On examination, pain is typically reproduced with the provocative position of 90° forward flexion combined with horizontal adduction and internal rotation. Patients usually describe posterior joint line tenderness, and they have excessive posterior translation of the humeral head with pain on posterior load-and-shift test, as well as a positive posterior apprehension sign. Patients may also have a positive result on a jerk test, which is performed by applying an axial load to the patient’s arm while it is in 90° of abduction and internal rotation, and after which the patient’s arm is horizontally adducted while the axial load is maintained. The test result is positive if pain and a palpable or audible clunk are reproduced. The jerk test has been reported to have a sensitivity of 73%, a specificity of 98%, a positive predictive value of 0.88%, and a negative predictive value of 0.95% for the detection of posterior-inferior labral lesions.

**Rehabilitation**

Physical therapy is the primary recommended treatment intervention for individuals with symptomatic posterior instability. A minimum of 6 weeks to 3 months is suggested for conservative physical therapy, consisting of a strong focus on rotator cuff strengthening (especially the infraspinatus) and scapular and rotator strengthening exercises. To prevent increased symptoms, combined motions of shoulder internal rotation and flexion must be avoided, horizontal adduction motion must be limited, and posterior shear forces on the shoulder (applying weights in the hands with the shoulder flexed to 90°) must be minimized.

The postoperative rehabilitation following shoulder stabilization surgery allows the patient to regain proper balance of mobility and stability. ROM should be restricted to 90° of flexion for the first 4 weeks and then to 120° from weeks 4 to 6. Full shoulder ROM should be restored through progressive stretching by week 10. Stretching should be done with methodical care in the early postoperative period and tailored to the type of stabilization to prevent failure at the repair site. Posterior capsular stretching or mobilization is not begun until week 10 postoperatively. Neuromuscular and proprioception training are used to enhance strength and motor control, with an emphasis eventually on the end ROMs. Proper balance of the musculature is emphasized, with extra concern for the rotator cuff because of its effective role in providing dynamic stability.

**OPEN INFERIOR CAPSULAR SHIFT**

In 1980, Neer and Foster were among the first to emphasize the importance of distinguishing between unidirectional and multidirectional instability because the standard repairs designed to correct unidirectional instability failed when they were performed on multidirectional unstable shoulders. Neer and Foster described the inferior capsular shift procedure for treating patients with symptomatic multidirectional instability of the shoulder who had failed to respond to nonoperative management. The inferior capsular shift is still considered the gold standard for multidirectional instability.

**Operative Technique**

The operative approach is based on the predominant direction of instability in each case. This factor is determined by the preoperative symptoms and physical findings and is verified at the time of surgery while the patient is under anesthesia. The anterior approach is described here, as reported by Pollock et al.

Once the superficial fascia is removed, the subscapularis tendon is incised 1 cm medial to its insertion on the lesser tuberosity. The incision proceeds from the superior rotator interval to the inferior border of the subscapularis tendon. The muscular portion of the subscapularis is also separated from the capsule. The capsule is then incised, starting inferiorly in the region of the capsular cleft between the superior and middle glenohumeral ligaments and proceeding inferiorly around the anatomic neck of the humerus. The dissection of the capsule proceeds inferiorly until the redundant inferior pouch can be sufficiently reduced by pulling up on the traction sutures placed in the capsule and thus extruding the surgeon’s index finger from the redundant inferior pouch. The surgeon must anchor the capsule medially to the glenoid with either nonabsorbable sutures or suture anchors. The capsule is then split in a T-shaped fashion just above the superior border of the inferior glenohumeral ligament (Fig. 10-7A). The patient’s arm is now placed in 20° of abduction and external rotation. The inferior flap is pulled superiorly, thereby reducing the inferior capsular pouch, and is sutured to the lateral capsular remnant (see Fig. 10-7B). The capsular cleft between the superior and middle glenohumeral ligaments is closed, and this entire superior flap is then shifted inferiorly over the inferior flap in a cruciate fashion to reinforce the capsule anteriorly (see Fig. 10-7B). Finally, the subscapularis is repaired back to the lesser tuberosity, and the deltopectoral interval and skin are closed.
CASE STUDY 4

This case represents the progression postoperatively for a patient who underwent an inferior capsular shift procedure to address anterior-inferior instability of the shoulder.

**General Demographics**
The patient, Mr. E.P., is a 29-year-old, English-speaking, Greek man who comes to physical therapy 4 weeks after inferior capsular shift of his right shoulder. He is right-hand dominant.

**Social History**
Mr. E.P. is single and lives alone. He does not smoke and drinks approximately twice per week.

**Employment and Environment**
He is a professor at a local university.

**Living Environment**
Mr. E.P. lives alone in a second-floor apartment.

**Patient Medical History**
He has a history of right shoulder pain and “dead arm” symptoms, which occurred after his first shoulder dislocation while playing recreational basketball. Over the course of a 3-year period, the patient dislocated his shoulder 8 to 10 times, with an increase in the ease of dislocation and subsequently greater difficulty with reduction of the shoulder. The patient reports intermittent paresthesia after each dislocation, which typically abates readily after relocation.

**History of Chief Complaint**
Mr. E.P. reports that his chief complaint is a recurrent feeling of instability and clicking at the right shoulder, which occurs during basketball and overhead weight training. The patient reports that the pain and instability symptoms are more frequent and recently have begun to occur during sleep. His goal is to function with activities of daily living (ADLs) without shoulder pain and instability and to return to recreational basketball after surgery.

**Prior Treatment for This Condition**
The patient was seen for physical therapy at another clinic to attempt dynamic stabilization of his shoulder, with a regimented and progressive exercise program addressing the rotator cuff and scapular rotators. He was seen for 4 months, which helped to decrease his pain considerably with ADLs. However, he still had frequent episodes of subluxation and dislocation with his right shoulder during sleep. He also was not able to resume basketball because of residual signs and symptoms of instability with overhead quick movements.

**Structural Examination**
The patient is seen 14 days postoperatively, and he is wearing a sling. Visual inspection reveals a well-healed anterior incision, which is intact to light touch. Moderate
atrophy of the infraspinatus and supraspinatus is noted relative to the uninvolved side. His scapula is elevated on the right side when his arms rest at his side in the standing position.

**Range of Motion**
Shoulder AROM is not assessed at this time because of the acuteness of his symptoms related to the early postoperative time period. His PROM is assessed as follows: shoulder flexion, 90°; abduction, 60°; external rotation, −10°; and internal rotation, 50°. Elbow and wrist ROM were within normal limits.

**Accessory Motion Testing of the Glenohumeral Joint**
This motion was not assessed because of the acuteness of symptoms and the time frame from surgery.

**Muscle Testing**
No resisted testing is permitted at this time except for elbow, wrist, and hand and finger motions, which are of normal strength.

**Special Tests**
The load and shift test is performed for the left shoulder, and it demonstrates 1° of anterior and inferior translation. Hypermobility is also noted in the left and right elbows and the metacarpophalangeal joints.

**Tenderness**
The patient displays focal tenderness along the anterior glenohumeral joint and through the belly of the right upper trapezius muscle and subscapularis tendon insertion.

**Physical Therapist’s Clinical Impression**
Given the patient’s long history of instability, it is important to communicate with the referring surgeon regarding the patient’s chief directions of instability at the time of the surgery. The surgeon reports using an anterior approach after determining, while the patient was under anesthesia, that the chief direction of instability was anteriorly and inferiorly. Furthermore, the surgeon states the patient’s posterior capsule is tight, possibly augmenting the anterior capsular redundancy. Therefore, it is believed that posterior capsular mobilization techniques are indicated to reduce the stress at the anterior-inferior region of the shoulder and will not threaten posterior stability. The initial course of physical therapy is focused on addressing the impairments related to connective tissue dysfunction from immobilization and the surgical procedure.

**Treatment Plan**

**Initial Treatment: Weeks 2 to 4**
The patient is instructed on continued use of the sling for an additional 2 weeks to protect the anterior shoulder when he is not in physical therapy or performing ROM exercises independently. External rotation is limited to 30° for the first 6 weeks after repair. Submaximal isometrics for the rotator cuff are started at 3 weeks after surgery, along with manual resistance to the biceps, triceps, forearm, and wrist musculature. Manual resistance is also applied to the scapular retractors, with care to support and protect the glenohumeral joint.

**Weeks 4 to 6**
At the fourth postoperative week, the sling is removed, and forward flexion and external rotation exercises for ROM and motor control are begun, but external rotation is still progressing slowly, to prevent stretching the repair. Soft tissue mobilization and scapulothoracic mobilization are initiated along with glenohumeral posterior capsular mobilizations. The anterior and inferior joint glides are avoided to protect the healing anterior-inferior capsule. Rhythmic stabilization with the involved shoulder in varying planes of motion is initiated to promote proprioception, cocontraction, and kinesthetic awareness of the rotator cuff and scapular musculature.

**Weeks 6 to 12**
The patient’s initial AROM at this time is as follows: shoulder flexion, 140°; abduction, 125°; external rotation, 40°; and internal rotation, 60°. At this time, isotonic strengthening exercises are initiated for the rotator cuff, scapular rotators, and deltoid. A format of low resistance and high repetitions is used to promote the circulatory phase of healing and to build endurance of the surrounding dynamic stabilizers. The goal at this phase is to continue progressing ROM, to attain end-range motion gradually. Continued passive stretching and posterior capsule joint mobilization techniques, and now caudal glides to restore flexion and internal rotation, are coupled with progressive strength training while the patient’s signs and symptoms of tendinitis or instability are monitored.

**Weeks 12 to 20**
AROM by 12 weeks postoperatively is 170° of flexion, 165° of abduction, 75° of external rotation in 90° of abduction, and 70° of internal rotation. Results of manual muscle tests are as follows: forward flexion, 4+/5; abduction, 4+/5; external rotation, 4/5; internal rotation, 4+/5; and prone horizontal abduction with the thumb up (middle trapezius), = 4/5. At this time, the patient’s strengthening program is advanced to plyometric exercises initially using therapeutic balls, including a basketball for chest passes and then progressing to a 5-lb medicine ball for chest and overhead passes. The patient is using Thera-Band tubing, with progressive resistance in the plane of the scapula to work his external rotators and in 90° of abduction to work his internal rotators. Proprioceptive neuromuscular facilitation patterns are initiated to promote functional and synergistic patterning of his scapulothoracic rotators with the deltoid. The initiation of isokinetic
exercise for the internal and external rotator cuff in the “modified base position” is recommended at this time. The criterion for isokinetic progression is the tolerance of a 3-lb isotonic rotator cuff exercise in side-lying and standing external rotation, with at least blue Thera-Band resistance and full ROM within the training zones of motion. The isokinetic test on this patient is performed 16 weeks postoperatively and shows external rotation strength to be 10% weaker on the involved side and internal rotation strength to be 10% stronger on the involved side relative to the uninvolved, nondominant side. **Weeks 20 to 28**

At week 20 postoperatively, the patient demonstrates full forward flexion of 175°, abduction of 170°, external rotation of 90°, and internal rotation of 70°. He does not show any signs of laxity or symptoms of instability and is progressing to sport-specific exercises to prepare for return to basketball. At 24 weeks postoperatively, a second isokinetic test shows equal external rotation strength at 60°, 180°, and 240° per second and 20% greater internal rotation strength on the involved, dominant side. At this time, he progresses with closed chain exercises for his home program, including modified arc push-ups with a plus to protect the anterior capsule, seated press-ups, and Swiss ball wall circles.

**Summary of Case**

The inferior capsular shift procedure that this patient underwent was specific for anterior and, to a lesser degree, inferior instability. The surgical approach is most often related to the primary direction of instability, to permit adequate visualization and stabilization. Adequate communication between the surgeon and the therapist is essential to avoid overstressing the repaired capsular component with directed joint mobilization techniques. This procedure is also used for multidirectional instability, which precludes the use of posterior capsular mobilizations early in the rehabilitation process. This patient has a long history of dislocations and needs adequate surgical fixation and postoperative rehabilitation to permit a safe return to sports without jeopardizing his glenohumeral stability and to perform ADLs pain free.

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**CASE STUDY 4—cont’d**

**SCAPULAR KINEMATIC ALTERATIONS ASSOCIATED WITH GLENOHUMERAL JOINT INSTABILITY**

Interest and study have increased with respect to the scapular kinematic abnormalities associated with glenohumeral joint instabilities. A fairly consistent finding among investigations is that of significantly less scapular upward rotation or a significantly greater scapulohumeral rhythm ratio (defined as an indication of a lesser scapular upward rotation component) in subjects with instability. **Scapular winging** is also reported to be significant in subjects with glenohumeral instability and is defined as a greater prominence of the scapular medial border that is also consistent with increased internal rotation of the scapula. Paletta et al examined patients with anterior instability with two-plane x-ray evaluation and determined that, early in ROM (0° to 90°), subjects with instability had lesser scapular upward rotation contribution to arm elevation, whereas later in the range of elevation, the scapular contribution was significantly greater. This finding is the reverse of what is typically expected in the normal scapulohumeral mechanics of the glenohumeral joint.

According to work by Bagg and Forrest, who examined the electromyographic activity of the scapular rotators in the plane of the scapula during arm elevation, the scapula should set by the rhomboids in the first 30° of motion. During the ROM from 80° to 140° of elevation, the scapula should upwardly rotate and move in approximately a 1:1 ratio with the humerus. This is the critical phase of elevation, and the serratus anterior is very important throughout this phase, as are the middle and lower trapezius muscles, to provide proper glenohumeral contact to help facilitate inferior glenohumeral stability. Itoi et al suggested that the reduction in scapular upward rotation in individuals with multidirectional instability does not represent a positive compensation but likely contributes to inferior glenohumeral joint instability. During the last 40° of elevation, (140° to 180°), the scapular body needs to sit back or tilt posteriorly and remain to provide proper acromioclavicular interval distance and stability. This positioning is possible with the help of the lower trapezius and middle trapezius and with concomitant extensibility of the pectoralis minor, latissimus dorsi, and subscapularis, to allow the scapula to dissociate from the humerus.

Based on the foregoing premise that the lower and middle trapezius muscles are important stabilizers of the scapula and that deficiencies in either of these muscles can compromise normal shoulder function and play a role in glenohumeral instability, the therapist should tailor exercises specific to these muscles. Work by Cools et al investigated which exercises demonstrated high middle and lower trapezius activation with minimal upper trapezius output. These investigators established which exercises should be prescribed to restore scapular muscle balance and stability. The following four exercises met their criteria: (1) prone extension, (2) forward flexion in side lying, (3) external rotation in side lying, (4) and prone horizontal abduction with external rotation.
De Mey et al found that, of the four exercises, only the side-lying flexion exercise did not demonstrate significant timing differences in activation between portions of the trapezius. These two studies demonstrated the importance of proper specificity of training with particular exercises to promote better scapular muscle balance, to augment scapular stability, and to enhance proper scapular kinematics in patients with shoulder disorders related to glenohumeral instability.

REFERENCES


