Principles for the Evaluation and Management of Shoulder Instability

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Publisher Information

The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
[www.jbjs.org](http://www.jbjs.org)
Selected Instructional Course Lectures

The American Academy of Orthopaedic Surgeons

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During use of the normal shoulder, the humeral head is centered within the glenoid and the coracoacromial arch. When the shoulder cannot maintain this centered position during use, it is unstable. An unstable shoulder prevents normal function of the upper extremity. Shoulder instability is not the same as joint laxity. Joint laxity is a property of normal joints and allows the shoulder to attain its full range of functional positions.

The concavity of the glenoid and the coracoacromial arch along with the passive and active forces that press the humeral head into the glenoid and the coracoacromial arch maintain the head in its centered position. This concavity-compression mechanism is dependent on the integrity of the glenoid and the coracoacromial arch, muscular compression, and restraining ligaments of the shoulder. Loss of any of these elements due to developmental, degenerative, traumatic, or iatrogenic factors may compromise the ability of the shoulder to center the humeral head in the glenoid.

The questions to answer during an evaluation of a patient with suspected instability are: (1) Is the problem in the glenohumeral joint? (2) Is the problem one of failure to maintain the humeral head in its centered position? (3) What mechanical factors are contributing to this instability? (4) Are the identified mechanical factors amenable to surgical repair or reconstruction?

This evaluation is based primarily on a carefully elicited history, a physical examination of the stability mechanics, and plain radiographs. If more complex imaging methods are needed to discover subtle or “occult” instability, the condition is often not responsive to surgical correction.

For surgical treatment of glenohumeral instability to be appropriate, the instability must be attributable to mechanical factors that can be modified by surgery. The causes may be deficiencies of the glenoid concavity, deficiencies in the muscles that compress the head into the socket, and/or deficiencies in the capsule and ligaments.

Instability is one of the most commonly diagnosed and treated conditions of the shoulder. Diverse and admittedly confusing approaches to this problem have been proposed, making it difficult to understand how best to evaluate and manage affected patients. This lecture offers a practical foundation to aid in the understanding of clinical shoulder stability and instability.

Glenohumeral stability requires that the humeral head remain centered in the glenoid fossa. When the humeral head does not remain centered, the patient has glenohumeral instability.

The glenohumeral joint is a balance between mobility and stability. Its mobility is limited by the joint capsule, which prevents the humeral head from rotating into excessive positions. The joint capsule and associated ligaments act as checkreins to rotation and function only at the extremes of motion, when they come under tension. While they also limit translation of the humeral head on the glenoid, restraint of translation alone cannot keep the head centered (just as a dog’s leash cannot keep the dog in the center of the yard unless it severely limits the dog’s motion). During the midrange of motion, the capsule and ligaments are lax and, therefore, allow the humeral head to be passively translated during physical assessments such as the sulcus and drawer tests. In spite of the capsuloligamentous laxity, which is required for normal shoulder mobility, the humeral head remains precisely centered in the glenoid fossa during active motion of the normal shoulder. This centering is necessary in order for the hand to be precisely and securely positioned in space. If the relative position of the humeral head and glenoid fossa were not secure and precise, the hand could not write, paint, throw, lift, hit, or operate with accuracy. The fact that the humeral head remains precisely centered, even in the shoulders of a gymnast with ex-
treme joint laxity who is performing a vault or holding the iron-cross position, demonstrates the remarkable ability of the shoulder to be stabilized by concavity-compression.

Stability of the glenohumeral joint is critical for precise and strong function of the upper extremity. In the past, the mechanisms providing stability have been categorized as “static” and “dynamic” or as “active” and “passive.” We now recognize that the entire system functions as an integrated whole. For example, in the past it was stated that the anteroinferior glenohumeral ligament is the primary static stabilizer of the shoulder. This is patently not the case because when we sleep or rest in a chair the inferior glenohumeral ligament is not under tension (and thus is not functional) and, although the muscles around the shoulder are relaxed, the glenohumeral joint is not unstable. Similarly, the rotator cuff muscles have been called “dynamic stabilizers” of the shoulder, but, even in an anesthetized shoulder, the passive tension in these muscles provides sufficient compression to stabilize the ball in the socket (as observed in the operating room when the shoulder muscles are paralyzed).

The glenohumeral stabilizing system has a number of key elements. The concavity of the glenoid, the muscles that compress the humeral head into the glenoid, the coracoid process, the capsules-ligamentous restraints, and adhesion-cohesion of the articular surfaces all contribute to stability. Deficiencies or defects in any of these structures can lead to instability.

Glenoid Concavity

A ball sitting on a flat table has no tendency to center itself. Even a slight displacing force causes it to slide or roll. If the table has a concavity, the ball will sit at the base of the concavity. The deeper the concavity, the more force it takes to move the ball out of it. The stability is increased if a greater force presses the ball into the concavity (Fig. 1). This mechanism is known as concavity-compression.

The glenoid concavity has three components: the osseous glenoid, which is slightly concave; the articular cartilage, which is thicker at the periphery and thinner in the center and thus makes the concavity deeper; and the glenoid labrum, which further deepens the glenoid concavity (Fig. 2). Because of its increased compliance, the glenoid labrum optimizes the surface area of glenohumeral contact and creates a conforming seal with the head of the humerus. This flexible periphery enables small deviations from fixed ball-and-socket kinematics without compromising the intrinsic stability of the articulation. The glenoid center line is perpendicular to the glenoid articular surface and points slightly posterior to the plane of the scapula (Figs. 3-A and 3-B).

The adequacy of the glenoid concavity in different directions can be assessed with use of three related measures. We use the term glenoidogram to describe the path taken by the center of the humeral head as it is translated over the surface of the glenoid in a given direction. It normally has a gull-wing shape with a medially pointing apex at the glenoid center line (Figs. 4-A and 4-B). This shape results from the fact that when the humeral head moves away from the center of the glenoid concavity its center displaces laterally. A glenoid lacking a lip has a flattened glenoidogram: when the head moves toward the flattened part of the glenoid lip, it does not...
move laterally. The lateral movement of the humeral head as it is translated across the face of the glenoid can be noted on physical examination of the normal shoulder.

The stability ratio is the force necessary to displace the head from the glenoid divided by the load compressing the head into the concavity (Fig. 5). The stability ratio is greatest when the head is at the center of the glenoid fossa because that is where the concavity is deepest. The stability ratio is lower when the humeral head is not centered in the glenoid. The stability ratio is calculated from the slope of the glenoidogram. The so-called load-and-shift test is a clinical analogue of the stability ratio. The load-and-shift test is performed by pressing the humeral head into the glenoid fossa and, while the compression is maintained, noting the resistance to translation of the head toward the lip in different directions.

The balance stability angle is the maximal angle between the glenoid center line and the net humeral joint-reaction force before the humeral head dislocates from the glenoid (Fig. 6).

Experimentally, the contribution of the glenoid shape to glenohumeral stability can be measured by orienting the glenoid with the center line pointing vertically upward and then tipping it until an unconstrained ball rolls out. In this case, the net force on the ball is the vertically oriented force of gravity, so the angle of tip at the moment of dislocation is the balance stability angle. The so-called jerk test, in which the humeral head slips out the back of
the glenoid with cross-body adduction, is a clinical analogue of the laboratory measurement of the balance stability angle.

**Scapular Factors in Instability**

**The Glenoid**

The glenoid faces slightly posteriorly. A line perpendicular to the glenoid concavity is the glenoid center line. This line normally is approximately 10° from the plane of the scapula (Figs. 3-A and 3-B). Anterior deviation of this line laterally is referred to as anteversion; posterior deviation of this line laterally is retroversion. When maximal shoulder stability is needed—for example, when performing a bench press—the scapula and glenoid rotate forward to ensure that all forces remain aligned with the glenoid center line.

A scapula that is malaligned because of poor shoulder kinematics may increase the angle between the glenoid center line and the net humeral joint-reaction force to a point where the centering of the humeral head is compromised. Clinically, problems of scapular misalignment are suggested when the scapulothoracic muscles fail to position the glenoid to best align it with the net humeral joint-reaction forces.

An anteverted or retroverted glenoid is less effective in centering the humeral head because the glenoid center line is no longer aligned with the forces generated by the scapulohumeral muscles. Glenoid version can be estimated clinically from standardized axillary radiographs or from computed tomography scans.

A flattened glenoid may not provide sufficient concavity for effective concavity-compression. The glenoid may be flattened in a given direction because it is dysplastic, because the glenoid labrum and peripheral cartilage are excessively small or compliant, because the glenoid labrum and peripheral cartilage are worn, because the labrum is avulsed from the glenoid lip, or because the glenoid lip is fractured. A flattened glenoid is suggested when the humeral head translates without a feeling of going over a lip, when there is diminished resistance to the load-and-shift test, or when there is a positive jerk test.

**The Muscles**

The humeral head is compressed into the glenoid by the muscles of the rotator cuff and other scapulohumeral and thoracohumeral muscles. The line of action of each of these muscles is not, as is often described, one of “depression” of the humeral head away from the acromion; rather, it is one of compression of the humeral head into the glenoid concavity (Fig. 5).

The subscapularis muscle is the primary anterior compressor. Its effec-

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**Figs. 4-A and 4-B** The glenoidogram. **Fig. 4-A** The glenoidogram is the path taken by the center of the humeral head as it translates across the face of the glenoid. (Reproduced, with permission, from: Matsen FA 3rd, Lippitt SB. Principles of glenoid concavity. In: Matsen FA 3rd, Lippitt SB, DeBartolo SE. Shoulder surgery: principles and procedures. Philadelphia: Saunders; 2004. p 100.) **Fig. 4-B** Translation anteriorly and posteriorly across a normally concave glenoid traces a gull-wing-shaped path. (Reproduced, with permission, from: Matsen FA 3rd, Lippitt SB. Principles of glenoid concavity. In: Matsen FA 3rd, Lippitt SB, DeBartolo SE. Shoulder surgery: principles and procedures. Philadelphia: Saunders; 2004. p 101.)
tive strength is assessed by positioning the arm in maximal internal rotation (with the elbow flexed to a right angle and the hand behind the back) to minimize the contribution of other internal rotators, such as the pectoralis major, the latissimus dorsi, and the teres major, and then noting the amount of isometric internal rotation torque that can be generated. This is known as the lumbar push-off test.

The supraspinatus muscle is the primary superior compressor. Its effective strength is assessed by positioning the arm in 90° of elevation in the plane of the scapula and in internal rotation (so that the supraspinatus lies over the top of the humeral head) and then noting the amount of isometric elevation torque that can be generated. This is known as the supraspinatus test.

The infraspinatus is the primary posterior compressor (assisted to a degree by the teres minor). Its effective strength is assessed by positioning the arm in neutral rotation and slight elevation in the plane of the scapula with the elbow bent to a right angle and then noting the amount of isometric external rotation torque that can be generated. This is known as the infraspinatus test.

The important characteristic of the muscles of the rotator cuff is that they can function as head compressors in almost any position of the glenohumeral joint. Other muscles, such as the deltoid, long head of the biceps, pectoralis, latissimus, teres major, and pectoralis major, can contribute to humeroglenoid compression in certain glenohumeral positions. For example, when the arm is elevated 90° in the plane of the scapula, the deltoid becomes a strong compressor of the head into the glenoid.

The effectiveness of concavity-compression can be dramatically demonstrated by first performing an anterior-posterior drawer test on the relaxed shoulder and noting the ability of the head to translate on the glenoid. The same drawer test is then repeated while the arm is held in abduction by the patient, increasing the net humeral joint force vector pressing the humeral head into the glenoid fossa in the normal shoulder. Even with the minimal compressive force generated by gentle active abduction, the humeral head can no longer be translated by the examiner.

Paralysis, detachment, or dysfunction of the subscapularis, supraspinatus, and/or infraspinatus result in loss of concavity-compression. Instability in the direction of the affected tendon may result. As an example, supraspinatus deficiency is commonly associated with superior displacement of the humeral head relative to the glenoid.

The Coracoacromial Arch

As Codman recognized in the 1920s, the glenohumeral joint is not the only important articulation between the humerus and the scapula. Of comparable importance is the articulation between the coracoacromial arch and the proximal humeral convexity (the spherical contour provided by the external surface of the tuberosities and the rotator cuff).

The principle of concavity-compression applies to the ball-and-socket joint between the proximal humeral convexity and the coracohumeral arch. The primary compressor of this articulation is the deltoid. Compression into the arch also results when the arm presses down, such as when the arms are used to rise from an armchair, during walking with a cane or crutches, and when an athlete performs bar dips, activities in which stability of the shoulder is essential. The marvel of the design of the shoulder is that the centers of rotation for the humeral head, the proximal humeral convexity, the glenoid fossa, and the coracoacromial arch are all superimposed in the normal stable shoulder (Fig. 7).

The critically important stabilizing effect of the articulation between the coracoacromial arch and
the proximal humeral convexity is demonstrated by the devastating anterosuperior instability that results when an acromioplasty is performed in the presence of rotator cuff deficiency. Even when the rotator cuff is intact, disruption of the coracoacromial arch may compromise the ability of the joint to remain centered in the presence of a superiorly directed force.

The Glenohumeral Ligaments and Capsule

In mid-range positions, the gleno-humeral capsule and its associated ligaments are lax and do not exert a centering effect. At the extremes of motion, however, these structures become important contributors to humeral centering. First, they prevent humeral rotation beyond the point where the muscles are effective. As is the case for muscles in general, the rotator cuff muscles are able to generate the most force when they are in mid-exursion. They become less effective when they are maximally extended. It is the job of the capsule and ligaments to prevent the rotator cuff muscles from becoming overstretched. Second, the ligaments come under progressively greater tension at the extremes of motion. This tension creates a compressive force that is essentially collinear with the force that would otherwise be exerted by the muscle overlying it. This force takes over in positions where the muscle force drops off (Fig. 8).

Third, the ligaments substitute for muscle forces in positions where no muscle is present. For example, the coracohumeral ligament and rotator interval capsule that lie between the supraspinatus and the subscapularis tendons provide a compressive force when the arm is in adduction. Another example is the inferior glenohumeral ligament complex that lies in the tendon-free zone beneath the glenohumeral joint and provides a compressive force when the arm is abducted. These capsuloligamentous forces are able to prevent the humeral head from lateral translation.

The balance stability angle is the maximal angle that the net force on the humeral head forms with the glenoid center line before dislocation occurs. The net humeral joint-reaction force is the vector sum of the displacing force and the compressive load. The tangent of the balance stability angle is the stability ratio. (Reproduced, with permission, from: Matsen FA 3rd, Lippitt SB. Principles of glenoid concavity. In: Matsen FA 3rd, Lippitt SB, DeBartolo SE. Shoulder surgery: principles and procedures. Philadelphia: Saunders; 2004. p 108.)
effects are energy-efficient. For example, the compressive effect of the tension in the coracohumeral ligament and the rotator interval capsule centers the humeral head when the arm is at rest by the side without consuming muscular energy. Similarly, the compressive effect of the inferior glenohumeral ligament helps to center the humeral head when the arm is in the cocking and early acceleration phases of the throw without consuming additional energy.

When the capsuloligamentous restraints are deficient, the joint can over-rotate into positions in which the muscles are less able to provide adequate compression. As a result, patients with a substantial avulsion of the capsule from the glenoid often describe weakness of the arm when it is abducted and externally rotated. Similarly, patients with a deficiency of the inferior glenohumeral ligament have difficulty throwing because muscular contraction cannot substitute for the compressive forces provided by the intact ligament.

Adhesion-Cohesion and the Suction Cup
There are two other centering mechanisms that do not require energy. One is adhesion-cohesion, a process in which the wettable surfaces of the humeral and glenoid cartilage and the wettable surfaces of the coracoacromial arch and the proximal humeral convexity adhere to each other because of the adhesive and cohesive properties of water molecules. These properties enable the two sets of surfaces to glide easily on each other while simultaneously preventing them from separating. The power of adhesion-cohesion can be demonstrated by placing a drop of water between two microscope slides and noting the ease...
with which they slide and the difficulty of distracting them. The second mechanism is the glenohumeral suction cup\textsuperscript{12}. The center of a suction cup is noncompliant while the periphery is flexible. This is exactly the structure of the glenoid surface: thin cartilage overlies bone in the center, and compliant capsule, labrum, and thicker cartilage are at the periphery (Fig. 2). As a result, the glenoid can stick to the humeral head, like a child's suction-cup arrow can stick to a glass window. The suction-cup mechanism is enhanced by the slightly negative intra-articular pressure within the joint.

Neither the adhesion-cohesion nor the suction-cup mechanism consumes energy, and both provide so-called low-cost centering when the arm is at rest. These mechanisms also have the convenient property of working in any position of the shoulder.

When the conforming glenoid lip is lacking or when the joint surfaces are no longer covered with smooth wettable hyaline cartilage, the shoulder will often feel “out of place.” For example, in a total shoulder replacement, the polyethylene glenoid component neither conforms to the humeral head, to allow a suction-cup effect, nor is wettable, to allow adhesion-cohesion. As a result, patients treated with total shoulder arthroplasty may experience less secure centering of the humeral head on the glenoid than those with a normal shoulder. The adhesion-cohesion and suction-cup mechanisms may also be disrupted when there is a joint effusion or hemarthrosis.

**Evaluation of the Shoulder for Instability**

**History**

Shoulder stability is the ability to keep the ball centered in the socket. The diagnosis of instability is based on a carefully elicited history and on direct observation of the shoulder’s centering capability\textsuperscript{13}.

When one obtains the patient’s history, it is useful to start with an open-ended question such as “How does your arm bother you?” and then give the patient plenty of opportunity to reply while one listens for descriptions suggestive of mechanical symptoms, such as “slip,” “goes out,” or “gives way.” The history is more indicative of instability if these symptoms are episodic with interspersed periods of relatively normal function. It is helpful to have the patient describe or show the arm positions in which these episodes of instability occur. Instability in abduction, extension, and external rotation is usually anteroinferior, whereas instability in flexion, internal rotation, and adduction is usually posterior. The severity of the instability is indicated by the frequency of these episodes, the functional disruption that they cause, and whether the patient can recenter the humerus without help. A description of the initial episode can also indicate the likelihood of traumatic injury to the stabilizing structures. Here, a little understanding of basic mechanics is helpful (Fig. 9). When a 33-lb (147-N) force is applied to the hand of the abducted, externally rotated upper extremity, its lever arm to the center of the humeral head is about 30 in (76 cm). In opposition to this torque is the tension in the anterior-inferior glenohumeral ligament that works through a lever arm of 1 in (2.5 cm). The torque equilibrium equation indicates that essentially 1000 lb (4448 N) of tension in the inferior glenohumeral ligament would result from the 33-lb force exerted on the outstretched arm, clearly enough to avulse the capsulolabral complex.

**Fig. 10**

Radiographic views of the glenohumeral joint. The anteroposterior view in the plane of the scapula shows loss of the glenoid surface line inferiorly (arrow) (a), and the axillary view shows an anterior defect of the glenoid rim (arrow) (b). (Reproduced, with permission, from: Matsen FA 3rd, Lippitt SB. Principles of glenoid concavity. In: Matsen FA 3rd, Lippitt SB, DeBartolo SE. Shoulder surgery: principles and procedures. Philadelphia: Saunders; 2004. p 117.)
from the anterior-inferior aspect of the glenoid, producing a Bankart lesion. In contrast, a rear-end motor-vehicle collision, even with a relative velocity of 30 mi/hr (48.2 km/hr), would not be expected to produce a Bankart lesion in the driver whose hands were on the steering wheel. Similarly, a hard fall on the outstretched hand might apply enough force to avulse the posterior aspect of the labrum, whereas lifting a moderately sized box might not. The clinician needs to visualize what the suggested mechanism might produce at the tissue level.

If there is a substantial tissue injury, surgical intervention may be needed to achieve strong anatomic healing. If there is no reason to suspect a tissue injury, rehabilitation of the strength and coordination of the stabilizing musculature rather than surgery is likely to be the treatment of first choice.

While there are many other critical elements of the history, three key questions need to be answered: (1) Is the humeral head really becoming uncentered during the symptomatic episodes or is something else going on? (2) In which direction is the head moving when it leaves the glenoid center? (3) Is the instability the result of a substantial tear or detachment and, if so, what tissues are likely to be involved? It is often easier to sort out these questions by carefully obtaining a history than by any other means.

**Physical Examination**

The physical examination should try to answer these same three questions. An easy way to start is to have the patient demonstrate the position of the shoulder when the initial injury occurred and the mechanism of the initial injury as well as the subsequent episodes. It is most useful if the patient can say, “My shoulder goes out when I do this.” Close observation prevents one from making a misdiagnosis of glenohumeral instability when, in fact, the problem is scapulothoracic snapping, for example. This “no touch” part of the examination is non-threatening for the patient and informative for the physician.

When the “no touch” examination is inconclusive, the examiner can then look for apprehension and statements of recognition when the shoulder is placed in positions characteristic of common instability patterns. The examiner should start with the contralateral shoulder so that the patient will know what to expect during the examination of the involved shoulder. The anterior apprehension test is conducted by placing the arm in abduction, extension, and external rotation. The posterior apprehension test is conducted by placing the arm in adduction, midflexion, and internal rotation. Instability or a...
sensation of impending instability in one of these positions can help confirm whether the instability is anterior or posterior. Tests for instability are most conclusive when the patient volunteers, "That’s how my shoulder feels when it’s ready to go out." Pain alone on these tests is insufficient evidence of instability.

A second important element of the physical examination for stability is to determine the status of the glenoid concavity, particularly in the direction of the instability. This is conveniently accomplished by having the seated patient relax with the forearm resting on the thigh. First, the anterior and posterior translatability of the humeral head is determined as a measure of joint laxity. Next, the humeral head is pressed into the glenoid fossa while anterior and then posterior translation is attempted (the load-and-shift test). Easy translation of the head while it is being pressed into the glenoid center suggests that the lip of the glenoid concavity is deficient in that direction. Anterior deficiency of the glenoid lip is most commonly the result of a Bankart lesion or a glenoid lip fracture. Posterior lip deficiency may result from deficiency or detachment of the posterior aspect of the labrum or a posterior glenoid fracture. In traumatic instability, translation of the humeral head over the edge of the glenoid lip may be accompanied by a grinding sensation as the head moves over the area from which the labrum has been avulsed or the osseous lip has been fractured. If the patient recognizes this sensation as what he or she feels when the shoulder goes out of place, the diagnosis is reinforced.

A third important element of the physical examination for stability is the assessment of the muscles that compress the humeral head into the glenoid. These evaluations include tests for the isometric strength of the subscapularis, supraspinatus, and infraspinatus.

Other elements of the physical examination may include tests of laxity, such as assessments for the drawer and sulcus signs. It must be recognized, however, that the ability of the examiner to demonstrate that the joint is translatable (lax) does not mean that the shoul-

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Fig. 11-C

Fig. 11-D
der is unstable. It is important to recall that lax yet stable joints are essential for gymnasts.

**Imaging of the Shoulder**

The primary purpose of the radiographic examination is to determine, on standardized views, (1) whether the humeral head is seated well in the glenoid, (2) if there is a major glenoid osseous defect inferiorly or posteriorly, and (3) if there is a major humeral head defect posteriorly or anteriorly (Fig. 10).

It is tempting to perform a computed tomography scan for every patient with an unstable shoulder. However, often the relevant osseous anatomy can be assessed adequately on a plain anteroposterior radiograph in the plane of the scapula, which shows humeral centering along with anterior humeral head defects and anterior or posterior glenoid bone defects. If these studies do not show the bone anatomy adequately, a computed tomography scan is indicated.

Under certain circumstances, additional information may be desired regarding the capsular and labral tissues, the bone, the rotator cuff, or the neurological status of the muscles. In such cases, additional tests such as magnetic resonance imaging, computed tomography, electromyography, or diagnostic arthroscopy may be helpful.

The primary decision regarding whether to perform the surgical procedure in an open fashion or arthroscopically depends on whether the treatment is directed at deepening the fossa, reorienting a maloriented fossa, repairing or tightening the ligaments, reattaching torn tendons, or restoring osseous defects. Until the anatomic/mechanical objective is determined, discussion of the surgical approach is secondary.

**Treatment Principles**

Rather than describing the surgical techniques in detail, which we have done elsewhere, we will conclude by outlining the principles that can be applied to the treatment of specific mechanical problems.

When the concavity is deficient, many of the stabilizing mechanisms are compromised (Figs. 11-A through 11-D). When the instability is secondary to glenoid deficiency, this deficiency must be addressed. Soft-tissue repairs or reconstructions may be sufficient when the soft-tissue elements

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Fig. 12


of the concavity are compromised. However, it is difficult to compensate for a substantial osseous defect with a soft-tissue repair because soft tissue cannot withstand the compressive loads as well as bone can. When the osseous lip of the glenoid is flat but ample, it can be built up with use of a glenoid osteoplasty in which the bone beneath the lip is cut, lifted up, and held up with a wedge-shaped bone graft. Major bone loss at the glenoid periphery can be addressed with a bone graft placed so that the graft reestablishes the extent of the glenoid fossa. When the acromion and the coracoacromial ligament have been sacrificed, allowing anterosuperior escape of the proximal part of the humerus, no anatomic reconstruction has proved satisfactory, and a reverse shoulder prosthesis needs to be considered.

When the cartilage of the glenoid lip is eroded, the resulting loss of depth of the glenoid can be restored by repairing the labrum and capsule up on the surface of the glenoid at its lip. A labrum that is intact but not as high and stabilizing as desired can be augmented with capsulolabral plication and/or injection augmentation. When the glenoid labrum is avulsed from the osseous glenoid lip, the fossa-deepening effect of the labrum can be restored by securely reattaching it to the face of the glenoid (not the neck). When the capsule and the glenohumeral ligaments have been torn or avulsed from the glenoid, their integrity can be restored with a direct repair (Fig. 12). Reconstruction to address capsular or ligamentous deficiencies resulting from previous surgery or from chronic or recurrent injury may require the use of a tendon graft from the humerus to the glenoid.

When the tendon of an otherwise intact subscapularis is deficient, a hamstring tendon graft may enable secure reattachment of the muscle to the bone. In selected circumstances, muscle transfers such as a pectoralis major transfer to the lesser tuberosity or other more complex procedures may be considered.

When instability is due to denervation or irreparable detachment of the muscles that normally compress the humeral head into the glenoid fossa, surgical treatment other than glenohumeral arthrodesis may not be effective.

References