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TECHNIQUE

Arthroscopic Assisted Rotator Interval Closure

STEPHEN J. O'BRIEN, M.D.
MARK C. DRAKOS, B.A.
ANSWORTH A. ALLEN, M.D.
STEPHEN FEALY, M.D.
Department of Sports Medicine & Shoulder Service
The Hospital for Special Surgery
New York, New York, U.S.A.

Summary: Arthroscopy has revolutionized the way shoulder surgeons have addressed intra-articular pathology. Continued advancements in technique and instrumentation have resulted in more and more procedures being performed on an all-arthroscopic basis. Appropriate caution has been taken with regard to applying arthroscopic techniques for all shoulder procedures, particularly instability. We describe an arthroscopic assisted rotator interval closure technique that, in the appropriately selected patient, is effective for treating particular shoulder instability.

HISTORICAL PERSPECTIVE

Although there have been many studies on the role of the rotator interval in glenohumeral stability, the anatomic description and the biomechanical function of the rotator interval are still evolving (1–6). Most authors agree that the rotator interval is the triangular space bordered inferiorly by the superior border of the subscapularis tendon, superiorly by the anterior border of the supraspinatus tendon, medially by the base of the coracoid process, and laterally by the bicipital sulcus at the level of the transverse humeral ligament (7). Cooper and Boardman (8,9) found that the superior glenohumeral ligament (SGHL) was consistently present and was the major component of the rotator interval that was responsible for its biomechanical function. More recently, Jost et al. (10) concluded that the coracohumeral ligament (CHL) was always present and more prominent and robust than the SGHL.

Lesions of the rotator interval can be variable (5). There may be an obvious defect or hole in the capsule of the rotator interval. In cases of shoulder instability, there may be excessive laxity of the capsular tissue in the interval. The SGHL and the CHL may be traumatically torn or ruptured in cases of traumatic instability. There may be a localized area of thin, elastic, membranous tissue that may compromise the function and stability of the rotator interval. Field et al. (1) identified 15 patients with recurrent instability who were noted to have an isolated rotator interval defect as the only identifiable cause at surgery. Each patient underwent isolated closure of the rotator interval defects. Follow-up at an average of 3.3 years revealed no recurrence of instability and statistically significant improvements in pain, motion, strength, stability, and function.

Experimental and clinical studies have shown that defects or injury to capsular structures lead to instability, and scarring, thickening, or contracture of the rotator interval may result in loss of motion (11). In a cadaveric study, Harryman et al. (12) showed that sectioning of the rotator interval capsule increased instability and frank dislocation of the glenohumeral joint inferiorly and posteriorly. Specifically, sectioning of the rotator interval capsule, SGHL, and the CHL allowed a 50% increase in posterior humeral head translation and a 100% increase in inferior humeral head translation. Tightening of the rotator interval capsule served as a significant restraint to inferior and posterior translation. They concluded that the rotator interval capsule, together with its associated ligaments, is a primary restraint to inferior and posterior translation of the adducted shoulder.

Nobuhara et al. (5) identified 84 patients with extensive inflammation of the rotator interval associated with shoulder instability. They described the tension in the structures constituting the rotator interval as constant during downward traction regardless of whether the humerus was held in internal or external rotation. However, in patients with rotator interval lesions, downward traction of the upper extremity caused an inferior subluxation or instability of the humeral head. This disappeared when the CHL was pulled taut in external rotation. Furthermore, in the elevated position, the humeral head

Address correspondence and reprint requests to Dr. Stephen J. O'Brien, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021, USA.
E-mail: Obriens@hss.edu

showed posterior and inferior subluxation and instability. Nobuhara et al. closed the rotator interval in these patients with excellent results.

There are other reports of isolated rotator interval closure or imbrication to supplement concomitant stabilization procedures in the literature. Rowe et al. (7) identified large rotator interval defects in 20 of 37 patients (54%) undergoing open stabilization procedures for transient subluxation of the shoulder. In a later series, they reported that 6 of 32 revisions for failed anterior shoulder stabilizations were associated with a separation between the subscapularis and supraspinatus tendons extending laterally to the lesser tuberosity (6). They included closure of these rotator interval defects in their stabilization procedures. Gartsman et al. (13) identified 53 patients with anterior inferior glenohumeral instability in whom all glenohumeral lesions were treated at the time of the operation. They determined that rotator interval repair was the critical factor for 14 of the 53 patients.

Several studies have elucidated that other factors, including adhesion–cohesion factors and atmospheric pressure, affect shoulder stability (2,14,15). Itoi et al. (16) revealed that although venting of the rotator interval capsule had a significant effect on inferior stability with the arm in internal rotation and in the neutral position, further sectioning of the capsule with the CHL intact had no effect on inferior instability. They concluded that the rotator interval has no direct mechanical stabilizing function, but that the capsule indirectly stabilizes the shoulder by maintaining the intra-articular pressure.

Jost et al. (10) ascribed different functions to the two distinct parts of the rotator interval. The medial part, consisting of the CHL, SGHL, and joint capsule, is a primary restraint for laxity and controls inferior translation of the adducted arm, with a secondary limitation of external rotation to a certain extent. In contrast, O'Brien et al. (17) described the inferior glenohumeral ligament complex as a region of capsule consisting of an anterior band, a posterior band, and an interposed axillary pouch. When the humerus is externally rotated, the inferior glenohumeral ligament complex fans out and supports the humeral head like a hammock, with the bands reciprocally tightening as the head is rotated in the abducted position.

Most reported methods for rotator interval closure have involved open techniques (1,3,5,7,18). Arthroscopic methods have been described for Bankart reconstructions, labral repairs, and capsular shift procedures (19–22). Arthroscopic closure of the rotator interval is a relatively novel approach to this condition; our literature search yielded only two reports describing surgical technique (23,24). Arthroscopic closure is advantageous with regard to morbidity, recovery, cosmesis, and postoperative range of motion compared with an open procedure. In this article we describe the closure of the rotator interval using an arthroscopic assisted (cut down) technique and using a purely arthroscopic approach.

INDICATIONS: CLOSURE OF THE ROTATOR INTERVAL

Perform rotator interval closure in patients with an obvious inferior component to their instability pattern. This intervention can be used as an adjunct to stabilization procedures or as an isolated procedure in selected patients. Perform arthroscopic closure of the rotator interval for all patients who have an element of inferior glenohumeral instability. This statement does not apply, however, to patients with acute anterior band avulsion, or pure anterior instability. In this setting, anterior band repair is possible because of the nature of the tissue. The thick, collagenous bands of the inferior glenohumeral ligament complex lend themselves to repair, and rotator interval closure is unnecessary.

Rotator interval closure is indicated in patients with anteroinferior shoulder instability who have had Bankart repairs with residual laxity in the rotator interval, specifically the SGHL. Close the rotator interval in all patients with a significant inferior component to the instability pattern. Although we do not routinely perform arthroscopic repair for patients with multidirectional instability, the rotator interval should definitely be closed in these patients.

In patients who are having open posterior shoulder stabilizations, we routinely evaluate the glenohumeral joint arthroscopically before performing a posterior arthrotomy. This affords the surgeon the option of closing the rotator interval arthroscopically if indicated. Rotator interval closure may be contraindicated in patients with acute anterior band avulsions who have no obvious inferior laxity or visible injury to the rotator interval. Exercise caution with older patients who have posttraumatic anterior instability and associated rotator cuff pathology. If shoulder stabilization and rotator cuff surgery are contemplated, closure of the rotator interval may result in shoulder stiffness.

PREOPERATIVE PLANNING

In the patient workup, include a careful history documenting instability and the mechanism of injury. Upon physical examination, the patient should demonstrate an instability pattern including a sulcus sign in adduction and external rotation (25). Plain radiographs of the glenohumeral joint are necessary to evaluate glenohumeral joint arthritis, cromioclavicular joint arthritis, joint spurs, superior migration of the humeral head, and acromial shape. Magnetic resonance imaging (MRI), although not a routine recommendation, can be used to evaluate the

muscles of the rotator cuff, integrity of the glenohumeral ligaments, and status of the glenoid labrum. Arthrography is not routinely used clinically, although it has been in the past; it has been useful in confirming a rotator interval defect by demonstrating contrast medium within the subscapularis fossa (14,26).

Individualize the surgical approach for each patient. Overhead athletes, in general, require greater ranges of motion with the arm abducted. For example, baseball pitchers require a supraphysiologic range of motion to generate the velocity necessary to compete. Similarly, for most football players the primary need is stability rather than mobility.

■ SURGICAL TECHNIQUE

In general, we use interscalene regional anesthesia at our institution. Regional anesthesia allows for decreased concentrations of anesthetic agents and limited side effects. It also permits the patient to remain awake during the procedure and provides excellent postoperative pain relief, allowing the patient to begin physical therapy immediately.

Examination Under Anesthesia

Perform a careful examination under anesthesia. Ascertain the amount of humeral head translation relative to the glenoid as described by Warren (27). Note and grade the sulcus sign. Patients with a sulcus sign of grade I or greater usually have an inferior component to their instability pattern (25). Perform shoulder arthroscopy with the patient in the beach chair position. This position allows easy access to the anterior, posterior, and lateral aspects of the shoulder. Position the arm using a McConnell arm holder (McConnell Orthopedics; Greenville, TX, USA). This allows excellent control of the arm without the need for an assistant.

Diagnostic Arthroscopy

Perform a diagnostic arthroscopy through a standard posterior portal. Evaluate the glenoid labrum, rotator interval capsule, CHL, SGHL, anterior and posterior bands of the IGHLC, and tendons of the rotator cuff for lesions and tissue integrity. Evaluate the glenohumeral joint for spurs, loose bodies, and intra-articular injury. We frequently perform a dry scope of the joint and evaluate these structures before distention of the joint with fluid. This allows better definition of the anatomic structures without distortion because of joint distention. Inability to appreciate the rotator interval defect arthroscopically may be because of the fact that there is temporary closure of the defect after distention of the joint. Furthermore, when looking at the rotator interval arthroscopically, one may be viewing through the actual defect.

Once the diagnostic arthroscopy has been performed, establish two anterior portals by direct visualization. We prefer to use a spinal needle to locate the anterior portals. The anterosuperior portal is placed just inferior to the acromioclavicular joint and approximately 1 cm lateral to the glenoid. The anteroinferior portal is located just above the subscapularis tendon approximately 1 cm lateral to the coracoid process. There should be adequate spacing between these two portals. It is important to avoid damage to the glenohumeral ligaments during portal placement. Address other capsular and labral pathologies working from inferiorly to superiorly. Address Bankart lesions, labral tears, and inferior capsular laxity with standard techniques using biodegradable tacks, arthroscopic sutures, and suture anchors. The rotator interval is the last capsular structure to be addressed.

Arthroscopic Rotator Interval Closure

Treacy et al. (24) was the first to describe an all-arthroscopic approach to rotator interval closure. This was later modified by Gartsman et al. (13). Treacy performed a rotator interval closure with the help of the McConnell arm holder. Position the arm in the McConnell arm holder at 25° abduction and 30° external rotation. Place the arthroscope in the posterior portal. Insert a transporter or suture transporter device through the anterior inferior portal, capturing the capsule adjacent to the subscapularis tendon and through the most medial portion of the middle glenohumeral ligament complex. Pass a spinal needle through the anterior superior portal, adjacent to the anterolateral border of the acromion and through the capsule bordering the supraspinatus tendon. Pass a #1 absorbable monofilamentous suture through the spinal needle and retrieve it through the anteroinferior portal using the previously placed transporter device.

Place clamps at each end of the sutures. Place the transporter device through the anteroinferior cannula medially and superiorly to the previous stitch. Place the spinal needle again through the capsular border of the supraspinatus tendon, but more medially than the initial stitch. Retrieve it again with the transporter device from the anteroinferior portal. In general, only two sutures are required, but additional sutures can be placed as necessary. If the sutures have been adequately positioned, tension on the two limbs will close the rotator interval and eliminate any intra-articular laxity. This can be assessed by direct arthroscopic viewing from the posterior portal.

Place the arthroscope in the subacromial space and redirect the anteroinferior portal into the subacromial space along the line of the sutures. Externally rotating the arm makes the sutures are visible at the anterior margin of the supraspinatus tendon. Use a crochet hook to retrieve the more lateral of the sutures sequentially out through the anterior cannula. Then place the arthroscope

in the glenohumeral joint, allowing viewing from the posterior portal, and give tension to the sutures. This should close the rotator interval and eliminate any capsular laxity. Tie the sutures individually, using arthroscopic knots, in the subacromial bursa. If necessary, the arthroscope can again be placed in the subacromial space to view the knots.

Gartsman et al. modified this approach by not entering the subacromial space. Use a shuttle relay to bring both ends of the sutures through the anteroinferior portal. In this way, the interval can be closed without the subacromial space being entered. Load a Spectrum suture passer (Linvatec; Largo, FL, USA) with a No. 1 absorbable, monofilament suture and place it through the anteroinferior portal, piercing the middle glenohumeral ligament (MGHL) and capsule. Advance the suture in the joint and retrieve it via the superior cannula with a crochet hook. Load the spectrum suture passer with a shuttle relay (Linvatec; Largo, FL, USA). Place it through the superior cannula. Withdraw the cannula along with the spectrum suture passer. Pass the suture passer through the capsule medial to the supraspinatus tendon. Advance the shuttle relay into the joint and retrieve it through the anteroinferior cannula. Then thread the level of the suture in the superior cannula through the eyelet of the shuttle relay. Place traction on the shuttle relay limb that exits the inferior cannula. This pulls the shuttle relay and the suture from the superior portal through the superior capsule and out the inferior cannula. Tension on both arms of the suture will close the rotator interval. A second suture can be passed in a similar fashion. Assess the adequacy of the repair before tying the sutures. Use an arthroscopic knot to tie the sutures and an arthroscopic knot cutter to cut the knots.

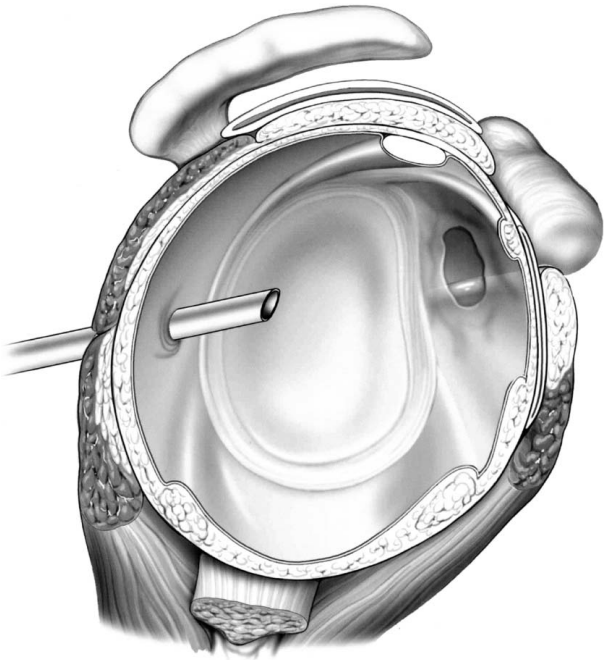

FIG. 1. Intra-articular depiction of glenohumeral joint. Arthroscope is posterior in the joint. Note the anterior rotator interval defect, through which the tendinous portion of the subscapularis muscle can be seen.

Arthroscopic Assisted Rotator Interval Closure

We have developed an arthroscopic assisted technique for rotator interval closure that employs a stepwise approach to closing the interval. This is accomplished primarily using arthroscopic technique, but is complemented with a small open procedure at the end of the case. In instability cases that require closure of the rotator interval, all other areas of glenohumeral pathology are addressed prior to rotator interval closure.

1. Use the posterior portal to visualize the anterior glenohumeral structures (Fig. 1). The first step requires separation of the subscapularis tendon from the anterior glenohumeral capsule. This is performed with the help of either an arthroscopic rasp or arthroscopic heating device (Fig. 2). Develop a plane between the subscapularis and posterior aspect of the capsule at the superior margin of the subscapularis tendon laterally. Then develop and continue this plane medially to the glenoid margin. Take care not to damage the anterior labrum as the release continues medially.
2. Continue the plane developed between the subscapularis and capsule medially beyond the anterior glenoid margin. Free the capsule from the anterior glenoid neck as medial as possible. Taking advantage of the inherent drive-through sign in these patients, move the arthroscope anteriorly in the joint; the ocular should face medial over the anterior edge of the glenoid. This view allows the surgeon the ability to visualize and control medial capsular release as it is performed. Using the previously established anterosuperior portal, pass four #0 PDS sutures arthroscopically through the mobilized anterior capsule (Fig. 3). We use the Spectrum tissue repair system to pass these sutures (Linvatec; Largo, FL, USA). Place sutures initially lateral to medial through the capsule. There should be adequate purchase obtained with these sutures because they will be used to tension and mobilize the capsule superiorly. It is important to distinguish whether there is a labral injury anteriorly and whether the labrum needs to be mobilized superiorly in conjunction with the capsule, or whether there is an isolated anterior labral detachment that only needs to be repaired directly to the adjacent glenoid. Place sutures through both the capsule and labrum medially if there is a labral detachment that needs to be mobilized

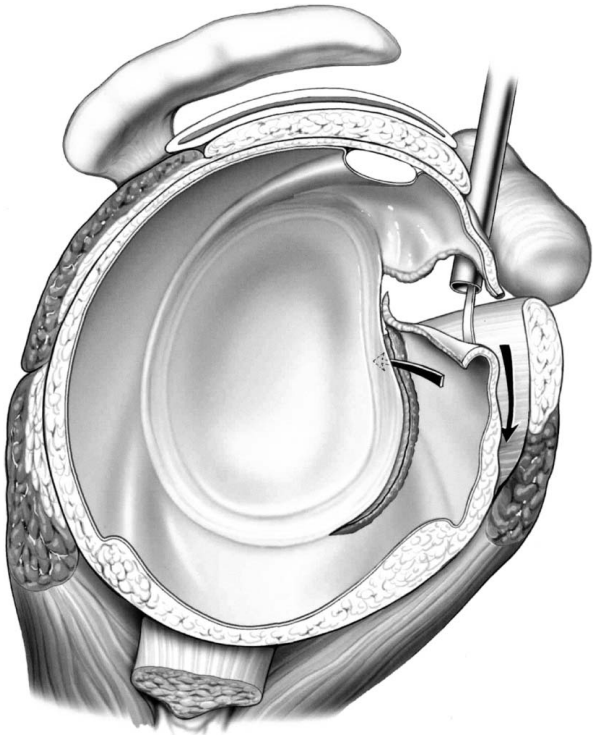

FIG. 2. Through an anterior arthroscopic portal, the capsule is freed and mobilized away from the posterior portion of the subscapularis tendon and medially along the glenoid neck. It is important to carry the capsular release of the glenohumeral capsule inferiorly along the glenoid margin to below the region of the anterior band of the inferior glenohumeral ligament complex.

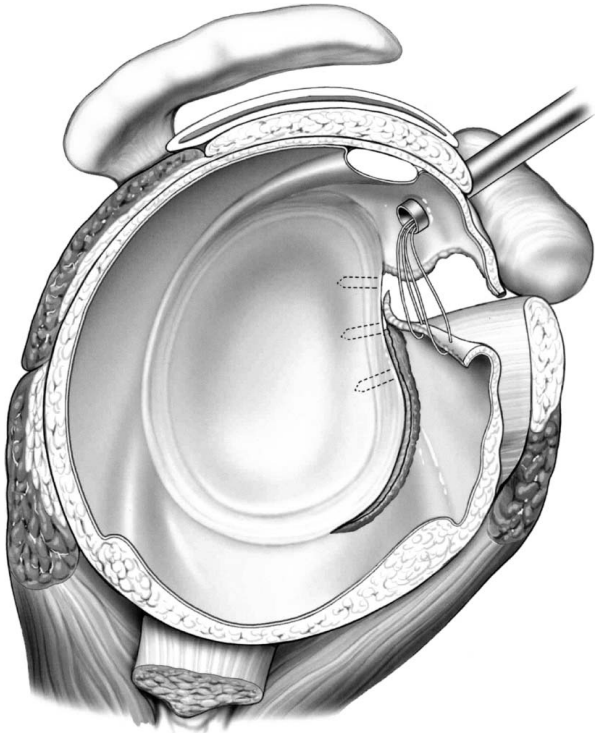

FIG. 3. The anterior glenoid margin is pre-drilled at the articular margin to eventually accept arthroscopic anchors. The superior margin of the capsule is grasped with tagging sutures from a lateral to medial direction for eventual mobilization.

as well. Bring out passed sutures through the superior–anterior cannula and clamp them. Keep sutures separate because they will later be used to directly close the rotator interval.

3. At this point, prepare the glenoid in anticipation of placement of transfixing glenoid anchors. Make a second anterior portal inferior to the first cannula. We use Suretac anchors (Acufex Microsurgical; Mansfield, MA, USA) to fix the capsulolabral structures medially. Pre-drill the anterior glenoid at the articular margin where the Suretac will transfix the anterior capsule and labrum (Fig. 4). If there is not labral pathology present, we drill through the labrum into the glenoid. Use two to three anchors anteriorly along the articular margin of the glenoid. (Placement of anchors precisely at the articular margin is essential. Medial placement of anchors does not correctly restore glenohumeral anatomy and will lead to failure in the form of recurrent instability.) At this point, pull the grasping sutures through the capsule superiorly (Fig. 5). Place the guide pin from the Suretac system through the anteroinferior portal, through the mobilized capsule and labrum, and into the pre-drilled anchor sites. Place Suretac anchors, securing the mobilized capsule and labrum to the glenoid. Place anchors in an inferior to superior fashion.
4. Both anterior cannulas should be removed now, and a small arthrotomy connecting the portals should be made. This limited deltopectoral approach allows direct access to the grasping sutures, which were passed through the superior cannula. Close the interval to the inferior margin of the supraspinatus with the sutures that were passed at the beginning of the capsular mobilization. We close the rotator interval under direct visualization through this small arthrotomy (Fig. 6). We routinely keep the arthroscope in the posterior portal to arthroscopically visualize this rotator interval closure from within the joint, making sure that the drive-through is eliminated. Imbricate the inferior capsule to the superior capsule of the supraspinatus in pants-over-vest closure, taking care not to include the biceps tendon in the closure. Close the rotator interval in a functional position (45° abduction, 45° external rotation) without limiting external rotation. Failure to do so may result in a permanent loss of external rotation. Apply thermal energy to redundant capsular tissue if necessary (Fig. 7).

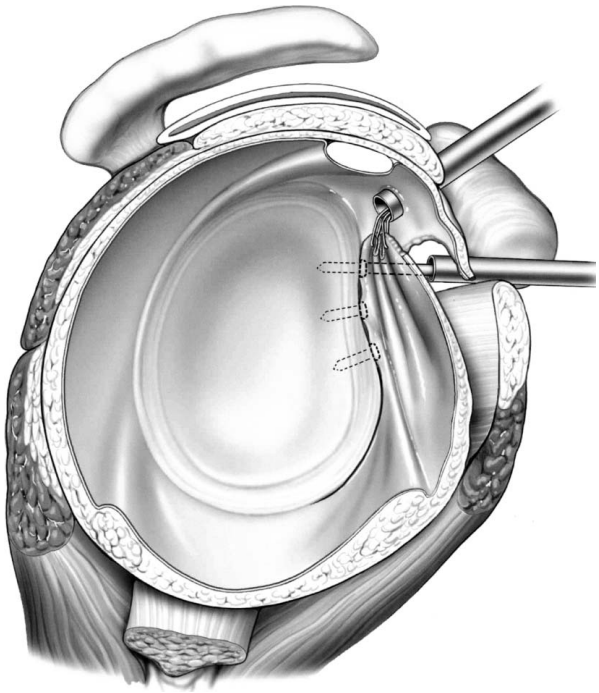

FIG. 4. The glenohumeral capsule is mobilized and tensioned superiorly as arthroscopic anchors are placed medially to secure capsule.

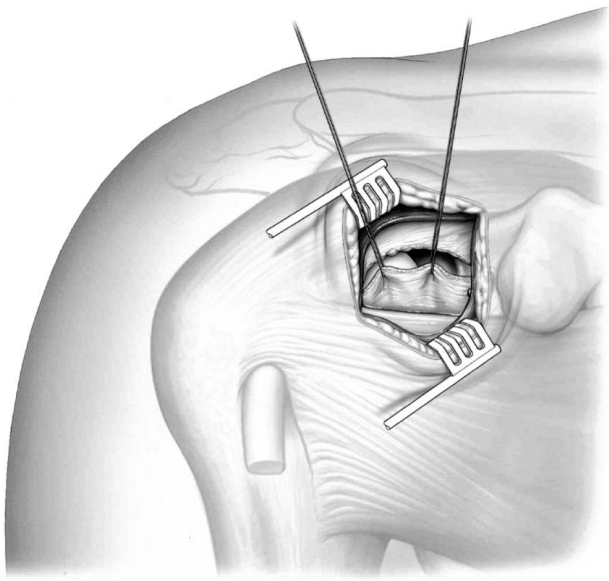

FIG. 5. After the mobilized capsule has been secured with arthroscopically placed anchors medially, a small anterior approach to the glenohumeral joint is performed. The previously tagged superior aspect of the capsule is now mobilized superiorly, effectively closing the rotator interval. This will then be sutured to the leading edge of the proximal capsule in a pants-over-vest fashion.

The concept in designing this procedure is to create a hammock within a hammock. Pulling up the strong, collagenous tissue of the anteroinferior capsule creates a more sturdy support against glenohumeral translation. The extent of this imbrication is decided at the time of closure of the interval, taking into account the amount of inferior translation during the examination under anesthesia.

■ COMPLICATIONS

Complications of this procedure include a failure to adequately tension the interval closure, which leads to failure of surgical technique. Failure of fixation, stiffness, and loss of range of motion are also potential complications. Careful surgical technique can be used to limit inadequate tension. Maintaining the arm in 45° external rotation minimizes the loss of range of motion postoperatively.

■ POSTOPERATIVE MANAGEMENT

The patient is placed in a sling 24 hours per day for 1 week. The patients continue to wear the sling at bedtime for the next 2 weeks. Physical therapy is started after 3 weeks. To avoid stiffness, the physical therapy is adjusted at the beginning to the patient's response. Range

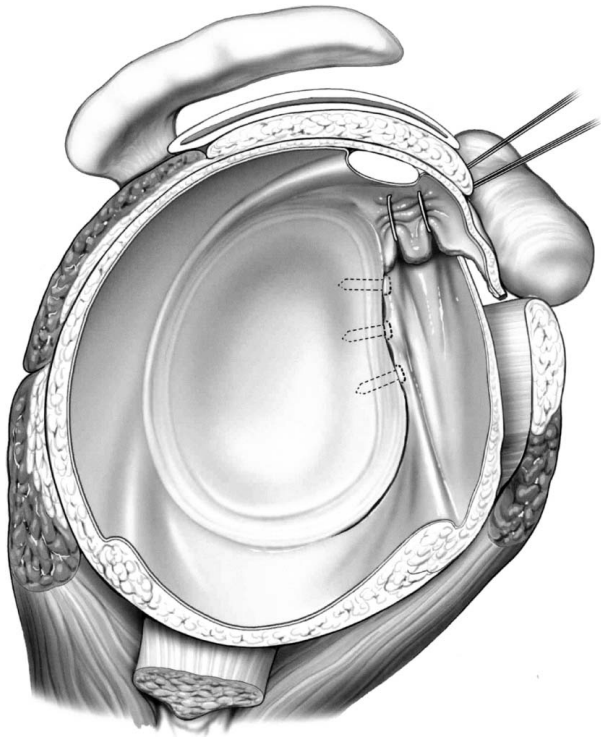

FIG. 6. Intra-articular depiction after arthroscopically assisted rotator interval closure has been completed. Note that the capsule is anchored medially and then tensioned superiorly, effectively closing the rotator interval defect.

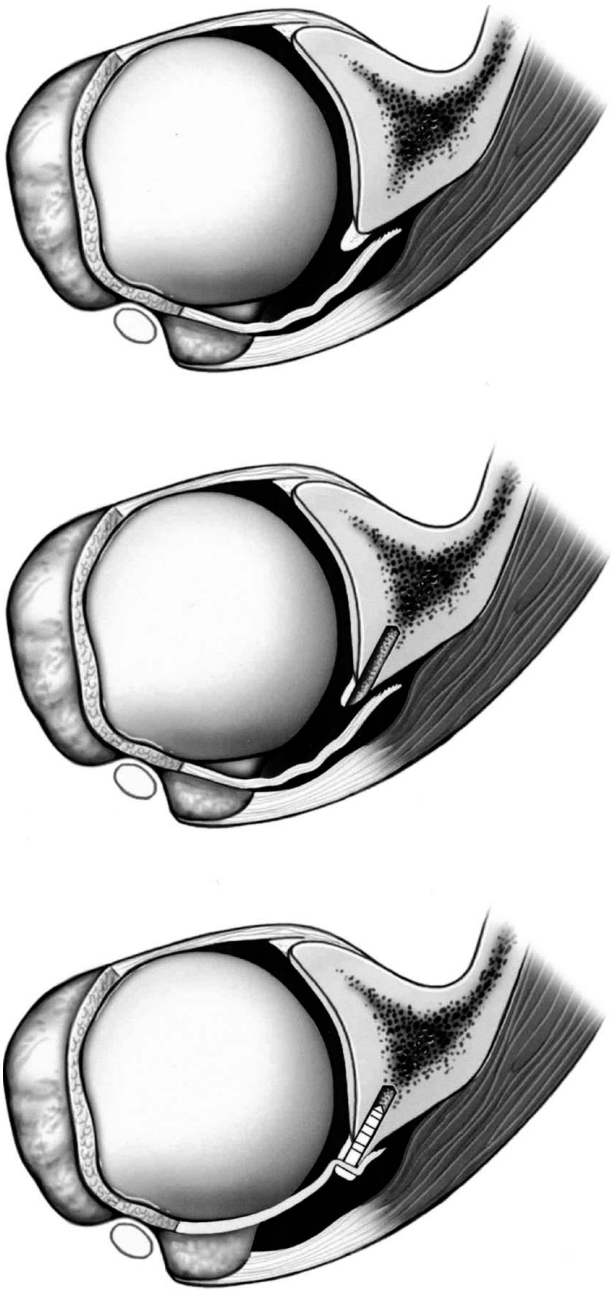

FIG. 7. Axial cartoon depicting the three phases of capsular release and fixation medially. In the top cartoon, the capsule is freed along its medial glenoid margin. The glenoid is pre-drilled to allow for placement of an arthroscopic anchor. The anchor then captures the released capsule, securing it medially.

of motion without strengthening exercises are performed for 4 weeks (weeks 4–7). Range of motion with strengthening exercises are performed for 4–6 weeks after that (weeks 8–13). Full return to activity is initiated 3 months postoperatively. The key is to restore range of motion and customize it to the activity. Baseball pitchers need a supraphysiologic range of motion, whereas football players need to have stability with range of motion.

DISCUSSION

We contend that the capsular tissue from the level of the subscapularis tendon to the level of the anterior border of the supraspinatus tendon may be structurally deficient. When present, the tissue in this region is mechanically weak and probably unable to withstand loads inducing humeral head translation in patients presenting with symptomatic anteroinferior instability. We recommend that surgeons carefully evaluate the integrity of the rotator interval capsule, giving consideration to imbrication with stronger tissue immediately adjacent to the region. We propose that the critical factor in the instability is not the presence or absence of the rotator interval capsule, but that this region is vulnerable and developmentally deficient. These characteristics can contribute to the instability, and reinforcement of this structure can aid in preventing anteroinferior instability.

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