Arthroscopic Treatment of Anterior-Inferior Glenohumeral Instability

Two to Five-Year Follow-up*

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Abstract

Background: **Previous studies on arthroscopic treatment of anterior-inferior glenohumeral instability have focused on the repair of lesions of the anterior-inferior aspect of the labrum (Bankart lesions) and have demonstrated failure rates of as high as 50 percent. The current investigation supports the concept that anterior-inferior instability is associated with multiple lesions and that success rates can be increased by treating all of the lesions at the time of the operation. We present the results of arthroscopic treatment of anterior-inferior glenohumeral instability after a minimum duration of follow-up of two years.**

Methods: **The study group consisted of fifty-three patients who had a mean age of thirty-two years (range, fifteen to fifty-eight years) at the time of the operation. There were forty-four male and nine female patients. The mean interval from the time of the operation to the final follow-up evaluation was thirty-three months (range, twenty-six to sixty-three months). The scores on the American Shoulder and Elbow Surgeons (ASES) Shoulder Index and the rating systems of Constant and Murley, Rowe et al., and the University of California at Los Angeles (UCLA) were recorded preoperatively and at the time of the final follow-up.**

Results: **Preoperatively, none of the patients had an overall rating of good or excellent according to the system of Rowe et al.; however, 92 percent (forty-nine) of the fifty-three patients had a rating of good or excellent at the time of the final follow-up. The mean score improved from 45.5 points to 91.7 points on the ASES Shoulder Index, from 56.4 points to 91.8 points with the system of Constant and Murley, from 11.3 points to 91.9 points with the system of Rowe et al., and from 17.6 points to 32.0 points according to the UCLA Shoulder Score (p = 0.001 for all comparisons). The mean passive external rotation with the shoulder in 90 degrees of abduction measured 88.2 degrees. Thirty-four of thirty-eight patients returned to their desired level of sports activity following the operation. Four patients who had persistent instability were considered to have had a failure of the index operation, and one of them had a second operative procedure.**

Conclusions: **The results of the present study suggest that our technique of arthroscopic treatment of anterior-inferior glenohumeral instability is better than previous arthroscopic techniques and is equivalent to open repair. We believe that the improved rate of success demonstrated in the present study was the result of repair not only of the anterior-inferior (Bankart) lesion but also (where necessary) of inferior and superior labral tears. Additionally, soft-tissue tension within the capsule and ligaments was corrected with use of a suture technique but was supplemented by laser thermal capsulorrhaphy in forty-eight of the fifty-three shoulders. Rotator interval repair was considered a critical factor in fourteen of the fifty-three shoulders.**

Operative techniques have advanced sufficiently so that surgeons can repair anterior-inferior glenohumeral instability arthroscopically. The proposed advantages of arthroscopic stabilization include smaller skin incisions, more complete inspection of the glenohumeral joint, the ability to treat intra-articular lesions, access to all areas of the glenohumeral joint for repair, less soft-tissue dissection, and maximum preservation of external rotation[33,34,49]. Early arthroscopic repairs were performed with use of a staple to advance Bankart lesions superiorly and medially and were associated with failure rates of up to 50 percent[21,29]. Because of complications related to the placement of staples within the glenohumeral joint[60], later investigators reported on suture repair of Bankart lesions[49,58]. The essential element of these suture techniques was the passage of sutures through the avulsed labrum and then through drill-holes in the scapular neck, where the sutures were tied over soft tissue or bone[36]. The initial success rate in twenty-five shoulders was 100 percent, but these results deteriorated with a longer duration of follow-up[36].

Later studies documented two flaws with this approach: the location of the repaired labrum and the failure to address capsular laxity. Neviaser[41] was the first, as far as we know, to report on the anterior labroligamentous periosteal sleeve avulsion (ALPSA) lesion. He

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identified this lesion in shoulders with anterior-inferior glenohumeral instability. The labrum-ligament complex had detached and healed medially on the scapular neck and allowed excessive humeral translation. It was apparent that the staple and suture techniques, described above, repaired the labrum medially and created an anterior labroligamentous periosteal sleeve avulsion lesion. Caspari and Savoie[10] arthroscopically examined shoulders that had had a failed arthroscopic stabilization (with the labrum repaired five millimeters medial to the glenoid rim), and they were the first, to our knowledge, to point out that the attachment of the repaired ligaments was critical. Their technique was modified to move the entry position from the medial aspect of the scapular neck to the glenoid articular surface. Savoie et al.[49] reported improved results with the newer technique. Wolf et al.[58] pioneered the use of bone-suture anchors in the arthroscopic treatment of instability. Those investigators were able to repair the detached labrum directly to the glenoid rim. Further investigation, however, called into question the concept of whether the Bankart lesion was solely responsible for anterior-inferior instability. Rodosky et al.[46] investigated the role of the biceps-labrum complex and found that detachment of the superior aspect of the labrum (a tear of the superior part of the labrum from anterior to posterior [a SLAP lesion]) allowed increased anterior translation of the humeral head. Speer et al.[51], in a cadaveric study, found that while a Bankart lesion allowed increased translation of the humeral head it did not allow the humeral head to dislocate. Those authors suggested that capsular stretch or elongation may also be necessary for dislocation. Bigliani et al.[6] studied the tensile properties of the shoulder capsule in patients with an acute dislocation and noted that capsular damage was almost always present to some extent, even in the face of a Bankart lesion. Baker et al.[5] arthroscopically inspected the shoulders of forty-five patients within ten days after an acute dislocation and found that the capsule had been stretched or torn in all patients with or without an associated Bankart lesion. This information was elegantly summarized by Altchek et al.[3].

Previous arthroscopic techniques have not included treatment of the rotator interval. The role of the rotator interval in shoulder instability was described by Neer and Foster[39] and by Rowe and Zarins[48]. The latter investigators reported that a large opening between the supraspinatus and the subscapularis was found in twenty of thirty-seven shoulders in which the superior aspect of the musculotendinous cuff was explored.

We believe that the high failure rates in prior studies of arthroscopic repair were due to technical factors (medial repair of the anterior portion of the labrum) and also to the failure to treat other lesions that are responsible for glenohumeral instability. The purpose of the present study was to determine if the results of arthroscopic treatment of instability could be improved with use of a technique in which all of the components of anterior-inferior glenohumeral instability are evaluated and repaired. We repaired lesions of the anterior, inferior, and superior portions of the labrum; restored capsular tension with a combination of sutures and thermal capsulorrhaphy; and repaired the rotator interval, if necessary.

Materials and Methods

We report the results of a prospective study of fifty-three patients who were managed with arthroscopic treatment of glenohumeral instability between January 1994 and February 1997.

Study Hypotheses

As the purpose of this study was to evaluate the final outcome of arthroscopic treatment of glenohumeral instability, we decided, on the basis of a review of the literature[2,4,7,11,25,33,47,48], that a final mean score of more than 85 points according to the system of Rowe et al.[47] was a satisfactory result. We made this decision because either functional limitation (in work or sports) or discomfort when the arm is examined for apprehension leads to the deduction of 15 points, resulting in a maximum possible score of 85 points. We believed that the presence of either functional limitation or discomfort on apprehension-testing was unacceptable. Therefore, the null (primary) hypothesis (H_0) of this study was that arthroscopic repair of anterior-inferior glenohumeral instability results in a final mean Rowe score of 85 points or less (H_0: $\mu \leq 85$). The alternative hypothesis (H_a) was that the final mean Rowe score would be greater than 85 points (H_a: $\mu > 85$). The alpha level was set at 0.05. The effect size was selected on the basis of a literature review[33,34,49]. We estimated that a mean score that was greater than 10 points from $\mu = 85$ would result in an unfavorable outcome. On the basis of this, an effect size of 0.60 was estimated. A power analysis was then performed to quantify the number of patients required to reject our null hypothesis if, in fact, it were to be rejected. With use of an effect size of 0.60, with a one-tailed or unidirectional analysis at a desired power of 0.95, it was determined that approximately thirty-five patients were required[12].

Inclusion and Exclusion Criteria

The inclusion criterion was a preoperative diagnosis of anterior-inferior glenohumeral instability that was confirmed at the time of the arthroscopic operation. The diagnosis was made on the basis of a combination of signs and symptoms: (1) the patient's description of shoulder dislocation or a sensation of looseness and slipping, (2) pain or apprehension, or both, on anterior-inferior instability tests, (3) radiographic evidence of glenohumeral instability, and (4) findings during the arthroscopic operation that documented anterior-inferior glenohumeral instability. We operated on patients who had a clinical diagnosis of anterior-inferior glenohumeral instability and made no attempt to exclude patients who had particular lesions of the shoulder. Each shoulder was evaluated for lesions at the time of the operation, and specific approaches were selected to treat the different lesions that were encountered.

The exclusion criteria included multidirectional instability (thirty-eight patients), posterior instability (twelve patients), a prior operation for instability (twenty-six patients), and repair of a full-thickness rotator-cuff tear (two patients). Patients with multidirectional instability demonstrated painful, excessive translation of the humeral head anteriorly, inferiorly, and posteriorly on physical examination. Patients with posterior instability demonstrated painful, excessive translation posteriorly and often inferiorly but not anteriorly. Thirty-one patients who were receiving Workers' Compensation also were excluded because of various issues that adversely affected the outcome. Misamore et al.[35] and other investigators[18,26] have documented inferior results following shoulder operations in this population.

Sixty-four patients met the criteria for inclusion in the study. Four patients declined to participate because they did not think that they could attend the number of clinic visits required for the minimum duration of follow-up. Seven patients did not return for the final follow-up evaluation. However, the demographic data and operative findings demonstrated that they were representative of the entire study-group population. Four of them did not return for the one-year follow-up evaluation. The three other patients were examined one year after the operation, but they did not return for the minimum two-year follow-up evaluation. Therefore, the results of fifty-three shoulder operations were included in our analysis. The only exceptions to the requirement for a two-year-minimum follow-up interval were patients who were considered to have had a failure of the index operation but who did not return for the two-year evaluation. These patients demonstrated postoperative subluxation or dislocation and were included irrespective of the time to failure. We believed that exclusion of these patients would have resulted in selection bias and would have distorted our results.

Study Group

The study group consisted of forty-four male and nine female patients. The mean age at the time of the operation was thirty-two years (range, fifteen to fifty-eight years). The dominant shoulder was involved in twenty-five patients and the nondominant shoulder, in twenty-eight.

The preponderance of our patients participated in sports at a recreational level; specifically, thirty-five patients described their level of sports activity as recreational, seven participated in high-school sports (four played football, two played basketball, and one played softball), one participated in college sports (as a football defensive lineman), and ten did not participate in sports. No professional or semiprofessional athletes were included in our study, and none of us were the designated physician for any high-school, college, or professional sports team.

The patients were recruited from the private practice of a single orthopaedic surgeon who performed all of the operations at a private hospital. We gathered no information about annual income or ethnicity, but all of the patients had private health insurance.

Preoperative Assessment

We collected sufficient data to rate the shoulders according to the American Shoulder and Elbow Surgeons (ASES) Shoulder Index[44], the scoring system of Constant and Murley[13], the scoring system of Rowe et al.[47], and the University of California at Los Angeles (UCLA) Shoulder Score[15]. The system of Constant and Murley typically is used to evaluate patients with rotator cuff lesions or osteoarthritis, but it was included in this study in order to allow our results to be compared with those of future studies as well as with those for patients who have other shoulder conditions.

Prior to the operation, all patients completed a self-assessment questionnaire to document their levels of satisfaction and function. The patients recorded their pain level with use of a visual analog scale as well as with use of a separate ordinal scale in order to allow us to rate the shoulder according to the ASES Shoulder Index and the UCLA Shoulder Score. Patients who had sustained the injury as a result of a specific traumatic event were questioned about the mechanism of injury and were asked to recall, if possible, the position of the arm at the time of the traumatic event. The amount of pain at the time of the initial injury and during the recovery period was noted. All patients were questioned about the position of the arm or the activity that reproduced the symptoms. In order to define the sports activity accurately, we classified sports according to the method described by Allain et al.[1]. Type 1 indicated nonimpact sports, which consisted of swimming the breaststroke, rowing, running, or sailing; type 2, high-impact sports, including riding a bicycle, downhill skiing, soccer, or waterskiing; type 3, sports that required overhead use of the arm with hitting movements, such as swimming the crawl or butterfly stroke, golf, tennis, throwing, and weight lifting; and type 4, sports that involve overhead hitting movements and sudden stops, such as basketball, handball, ice hockey, judo, karate, kayaking, lacrosse, polo, rodeo, volleyball, windsurfing, and wrestling. The level of sports participation was categorized as high-school team sport (level 1), college team sport (level 2), or recreational (level 3).

We measured active range of motion, which included forward elevation, abduction, external rotation in abduction, and behind-the-back internal rotation, according to the Constant and Murley rating system[13]. Passive elevation and external rotation (with the arm adducted), as well as external rotation and internal rotation with the arm abducted 90 degrees, were measured with use of a handheld goniometer and recorded by the examiner to the nearest 5 degrees. The operating surgeon recorded all measurements during the initial physical examination and at subsequent clinic visits. We made no attempt to increase the precision of the measurements by employing techniques such as having the evaluation performed by a blinded examiner, evaluating test-retest validity, measuring interobserver and intraobserver reliability, instructing the patient before the measurement, or asking the patient to perform warm-up exercises before the evaluation. The strength of elevation was measured with use of a dynamometer with the arm elevated 90 degrees in the scapular plane and internally rotated; the result was recorded in pounds. We did not inject an anesthetic into the shoulder before strength-testing, so we were unable to quantify how much of the loss of strength was due to pain.

Both shoulders were examined for stability. We compressed (loaded) the humeral head into the glenoid during all maneuvers. Anterior translation was assessed by applying an anterior force to the shoulder with the arm in 90 degrees of abduction. Inferior-anterior translation was evaluated with use of the Rowe test[16]. For this examination, the patient stands and flexes the trunk from the hips approximately 30 degrees. In this relaxed position, the shoulders are effectively elevated 30 degrees. The examiner then applies a distraction force to the shoulder. Inferior translation was assessed by applying an inferior force to the shoulder with the arm in 0 degrees of abduction (the sulcus test). Posterior translation was examined with the arm elevated 90 degrees, adducted slightly, and internally rotated approximately 30 degrees. A posterior force was applied, and then the shoulder was extended. We recorded the presence or absence of pain and apprehension during each instability maneuver. We graded the amount of humeral head translation on the glenoid surface as 0 (stable or trace laxity), 1 (up to 50 percent translation), 2 (more than 50 percent translation but not dislocatable), and 3 (dislocatable)[14]. The grading of instability was subjective, as we made no attempt to measure the degree of translation with fluoroscopic observation. We recorded the presence of laxity in the contralateral shoulder and the elbows and assessed the ability of the patient to bring the thumb to the forearm. We did not utilize any formal system to grade the degree of generalized ligamentous laxity; laxity was categorized simply as present or absent on the basis of this examination. We excluded other sources of shoulder pain (rotator cuff lesions, acromioclavicular joint arthritis, thoracic outlet syndrome, brachial plexus lesions, and glenohumeral arthritis) on the basis of the patient's history, physical examination, and radiographic analysis.

Anteroposterior glenoid, axillary, and supraspinatus outlet[40] radiographs were made routinely. Imaging studies such as magnetic resonance imaging, computer-assisted tomography, and arthrography were not routinely performed. Direct radiographic evidence of glenohumeral instability consisted of a finding of a dislocated humeral head. Indirect radiographic evidence of instability included calcification adjacent to the anterior portion of the glenoid, an osseous Bankart lesion, or a Hill-Sachs lesion. Evidence of instability on magnetic resonance imaging and computer-assisted tomography studies (ordered by the referring physician) included not only the above findings but also detachment of the glenoid labrum from the glenoid bone, capsular stripping from the glenoid, or ligamentous insufficiency.

The primary indication for the operation was persistent shoulder pain due to anterior-inferior glenohumeral instability that had not responded to a program of at least six months of nonoperative treatment, consisting of avoidance of painful activities, use of nonsteroidal anti-inflammatory medication, and participation in a home physical therapy program designed to maintain or improve the strength in the shoulder girdle. Our goal was to improve the strength of the muscles responsible for glenohumeral stability. Therefore, patients performed resistive exercises for the deltoid, internal rotators, external rotators, biceps, triceps, and scapular muscles with use of surgical tubing and light weights (maximum, five pounds [2.3 kilograms])[9]. The only exceptions were the three patients who desired operative repair acutely (within six weeks after the onset of symptoms). The patients were evaluated at five postoperative intervals within the first year (at two weeks, six weeks, three months, six months, and one year) and then yearly thereafter.

Classification of Instability

In order to increase diagnostic precision, we classified each shoulder with regard to the chronicity, degree, and etiology of the instability. The chronicity of the instability was classified, according to the patient's description, as chronic (present for six weeks or more) or acute (present for less than six weeks). The degree of instability was classified as recurrent dislocation, recurrent subluxation after a single dislocation, or recurrent subluxation without prior dislocation. The etiology of the instability was classified as either traumatic (if the instability had developed after a traumatic event of sufficient magnitude to damage the glenohumeral ligaments) or atraumatic. The guidelines that were used to determine the etiology were similar to those described by Wirth et al.[57]. A traumatic etiology was suggested when the injury had occurred with the arm forcefully abducted and externally rotated and extended and there had been sudden, sharp pain, the need for manipulative reduction, and residual aching in the shoulder for several weeks. Atraumatic instability was characterized by either an insidious onset or the development of symptoms after minor trauma and was associated with mild pain and spontaneous reduction.

We also evaluated the shoulder with regard to the direction and degree of instability. During the preoperative physical examination, we noted the arm position that produced pain or apprehension and recorded the amount of humeral head translation that occurred in association with each provocative maneuver. These findings, combined with radiographic findings and the patient's description of the position and the activity that produced pain or apprehension, allowed us to categorize the direction and degree of the instability. We observed movement of the humeral head under direct arthroscopic visualization and also found the location of intra-articular lesions to be helpful in the determination of the predominant direction of instability. The lesions were located in the humeral head and the glenoid (chondral or osteochondral defects), the labrum (fraying or separation from the glenoid), and the capsular ligaments (tearing or laxity).

Patient Compliance

We constructed a compliance scale to measure the completion of the postoperative protocol. The components of the scale, which had a possible maximum score of 100 points, were the appropriate use of the sling (10 points), attendance at the five scheduled appointments during the first postoperative year (10 points per visit, for a total of 50 points), and performance of the prescribed rehabilitation exercises (10 points per four phases of rehabilitation exercises, as reported by the patient during office visits).

Operative Approach

Since our arthroscopic technique differs from those reported in the literature, we describe our operative rationale, operative technique, and intraoperative decision-making process in detail.

Operative Rationale

The underlying principle of our arthroscopic technique was to identify and repair all lesions that contributed to glenohumeral instability. Our technique included débridement, repair of ligamentous and labral tears, capsular tensioning, and, if needed, repair of the rotator interval.

The goals of débridement were to remove the sources of mechanical irritation or functional instability[43]. Only minor labral flap tears (those involving less than 50 percent of the labral thickness) were removed, and every attempt was made to repair the lesions.

The purpose of reattachment of the ligaments and the labrum to bone was twofold. First, adequate capsular tension was impossible to achieve unless the labrum and the ligaments were securely attached to the glenoid. Therefore, we repaired all traumatic tears of the superior, anterior, and inferior aspects of the labrum. We identified these lesions at the time of the operation and believed that they all contributed to glenohumeral instability. Second, anatomical repair of the ligaments and the labrum restores concavity-compression to the glenohumeral joint. Lippitt et al.[31] demonstrated that compression of the humeral head into the glenoid by muscular force is an effective stabilizer to humeral translation and that resection of the labrum decreases stability by 20 percent. However, reattachment of the anterior-inferior aspect of the ligament-labrum complex to the glenoid may not restore sufficient stability to the glenohumeral joint. Speer et al.[51] observed only a small increase in humeral translation in association with a simulated Bankart lesion and postulated that capsular stretching or elongation was necessary to produce glenohumeral instability. Therefore, the final portion of the operation was performed to restore capsular tension.

We classified capsular elongation as primary or secondary. Primary elongation refers to permanent deformation of the capsular fibers due to a single traumatic event or to multiple episodes of instability. The rate of speed of the injury may determine where the capsular ligament is damaged. In a laboratory study, Bigliani et al.[6] showed that a faster strain rate was associated predominantly with ligamentous injuries, whereas testing at a slower strain rate was associated with a higher percentage of failures at the ligament insertion site. Secondary elongation develops when there is a tear at the insertion site, thereby decreasing capsular tension. This may occur within the anterior-inferior aspect of the capsule after development of a Bankart lesion, but it may also occur because of a tear of the superior part of the labrum. The biceps-labrum complex contributes to anterior-inferior stability, and its detachment results in increased humeral translation[46]. On the basis of this data, we believed that we should repair all traumatic detachments of the superior part of the labrum. Tears of the rotator interval and the superior glenohumeral ligament also affect glenohumeral stability. In a laboratory study, Harryman et al.[24] found that tightening of the rotator interval decreases inferior and posterior translation of the humeral head. We observed, at the time of the operation, that repair of the rotator interval decreased inferior translation of the humeral head. If the repair also incorporated the superior portion of the middle glenohumeral ligament, tension in the anterior part of the capsule was increased. Thus, we restored capsular tension with two methods: primary capsular elongation required an operation directly on the capsule, and secondary elongation responded to repair of tears at the insertion site.

We corrected primary capsular elongation with three techniques, which were used singly or in combination: (1) advancement of the capsule to the labrum, (2) advancement of the capsule to the glenoid with suture anchors, and (3) thermal capsulorrhaphy. The goal of this portion of the procedure was to restore ligamentous and capsular tension and to eliminate excessive translation of the humeral head (defined as translation involving more than 25 percent of the glenoid surface).The middle glenohumeral ligament, the anteroinferior glenohumeral ligament, the inferior aspect of the capsule, the posteroinferior glenohumeral ligament, and the posterior aspect of the capsule were tightened as necessary.

Our preference was to advance the capsule to the intact or repaired labrum with use of monofilament sutures; only if the labrum was small or absent was the capsule repaired to the glenoid rim with bone-suture anchors. Drill-holes for the suture anchors were placed through the glenoid articular surface, approximately one to two millimeters from the lateral margin of the glenoid. The detached labrum was sutured so that it was in contact with the scapular neck and extended onto the glenoid articular surface in order to establish the labrum as a bumper and to recreate optimal conditions for concavity-compression. We estimated the appropriate amount of tightening on the basis of both the degree and the direction of translation, according to guidelines similar to those described by Warner et al.[55] for open repairs. A soft-tissue grasper was used to apply traction to the various portions of the capsule while translation forces were applied with the arm in varying degrees of abduction and external rotation. We were technically unable to perform the repair with the arm in complete abduction or external rotation, so we estimated the appropriate amount of tension, returned the arm to 20 degrees of abduction and 30 degrees of external rotation, and then completed the arthroscopic repair.

If areas of the capsule did not advance adequately, after suture repair we used laser thermal application (Versalink Laser holmium: YAG; Coherent Medical Group, Santa Clara, California) to contract the capsule and the ligaments. We believe that it is not appropriate to perform thermal capsulorrhaphy before suture repair for two reasons. First, as the ligaments shorten with thermal capsulorrhaphy, they are more difficult to repair to the glenoid rim. Second, we believe that it is more difficult to determine the appropriate amount of ligamentous advancement after thermal application. The use of thermal shrinkage was limited to shoulders in which capsular suture tightening failed to restore adequate soft-tissue tension to all areas of the capsule. This was a common finding, and although thermal application was not the primary operative technique during this study it was used for the majority of patients.

We believed that one reason for the high rates of failure reported by other investigators[20,54] was that they failed to address the quality of the ligaments. Although suture tightening can increase ligamentous tension, it may, in certain individuals, serve only to tighten attenuated soft tissue and does not address plastic deformation at the cellular level. The findings of laboratory studies have supported the concept that thermal contraction accomplishes this goal[27,32,42]. In our experience, the effectiveness of laser application has been variable in that some ligaments have responded well while others have shown minimal response. Although the long-term effectiveness of thermal application has not been described in the literature as far as we know, we thought that there was enough evidence in laboratory studies[17,23,53] to justify its use. We also recognized that thermal capsulorrhaphy added another variable to this study. Our goal, however, was not to compare the efficacy of capsular suture repair with that of thermal capsulorrhaphy but rather to determine the success of an arthroscopic operation (comprising multiple techniques) to restore glenohumeral instability.

Operative Technique

Prior to being placed under general anesthesia, all patients received an interscalene block to diminish postoperative pain. The anesthesiologist administered one gram of cephalosporin intravenously. We placed the patient in the sitting position and examined both shoulders as described above.

The shoulder joint was entered with a cannula and a blunt trocar through a posterior skin incision placed 1.5 centimeters inferior and 1.5 centimeters medial to the posterolateral border of the acromion. An anterior portal was identified with a spinal needle so that the cannula entered the shoulder joint immediately superior to the subscapularis tendon and one centimeter lateral to the glenoid. The glenohumeral joint was inspected. We reexamined the shoulder for translation while viewing the shoulder through the arthroscope. The arthroscope was removed and inserted through the anterior cannula to allow more complete inspection of the posterior part of the glenohumeral joint. The arthroscope was then returned to the posterior cannula. An arthroscopic probe was used to assess labral attachment and ligamentous tension accurately. All structures within the glenohumeral joint were examined systematically, and any signs of instability were recorded. Such signs were variable and included partial and complete tears of the rotator cuff, the rotator interval, and the biceps tendon. We noted, as have others[22,59], that the glenohumeral ligaments may tear at their insertion on either the glenoid or the humeral head. In order to evaluate the glenohumeral ligaments for mid-substance tears or plastic deformation, we also assessed them for laxity by directly observing and palpating them (with an arthroscopic probe) and applying translational stresses as we rotated the shoulder. We documented the location on the glenoid and the extent (superior to inferior and medial to lateral) of labral detachment. Labra that were frayed or had mid-substance tears were noted. The cartilage was inspected for damage to the glenoid and the humeral head (a Hill-Sachs lesion). The presence or absence of loose bodies was recorded. Once the diagnosis of glenohumeral instability had been confirmed, an anterosuperior portal was created and a second cannula was placed through the rotator interval one centimeter lateral to the glenoid.

Intraoperative Decision-Making and Indications

Débridement: We removed only minor labral flap tears. Flap tears involving at least 50 percent of the labral thickness were repaired with absorbable monofilament sutures. We found that palpation of the labrum with a probe was necessary to adequately determine the presence of minor flap tears, cleavage tears that existed within the labral substance, and minor separations of the labrum from the glenoid. Loose bodies were removed with surgical forceps.

Labral repair: The labrum normally is attached securely to the glenoid bone anteriorly, inferiorly, and posteriorly, distal to the glenoid equator, and we considered separations in these areas as lesions. The anterosuperior aspect of the labrum is usually not well attached to the glenoid, and separation in this area was considered to represent a normal anatomical variant known as a sublabral foramen[56]. The attachment of the superior part of the labrum is variable[30,52], and when the superior part of the labrum was mobile without evidence of trauma it was not classified as a tear of the superior part of the labrum from anterior to posterior (a SLAP lesion)[50]. When the separation of the superior part of the labrum is a normal variant, the superior part of the glenoid is covered with smooth cartilage and the labrum shows no evidence of trauma. Signs of traumatic separation include tears within the substance of the superior part of the labrum, cartilage loss with exposed bone at the site of labral attachment, and an increase in separation of the superior part of the labrum with abduction and external rotation of the arm[8,37]. We repaired the superior part of the labrum anatomically. We made no attempt to shift the anterior part of the labrum superiorly, but we did, if necessary, shift the anterior part of the labrum laterally so that it projected onto the glenoid surface and reestablished the labrum as a bumper and an aid in concavity-compression. The inferior part of the labrum was shifted superiorly onto the glenoid surface for the same reasons.

Capsular tensioning: The ligament repair site (and therefore the ligamentous tension) was estimated by grasping the ligament and placing it at different locations on the glenoid. Translation of the humeral head was performed with the torn ligament positioned at each possible repair site until humeral head translation involved less than 25 percent of the glenoid surface. Typically, five to fifteen millimeters of lateral and superior ligamentous advancement was required. The position of the arm affects tension within the ligaments and the capsule, so we routinely maintained the shoulder in 20 degrees of abduction and 30 degrees of external rotation during this portion of the operation. We altered the arm position when we performed the operation on the dominant arm of a patient who was a competitive throwing athlete. In these patients, we determined the ligament repair site after positioning the arm in 60 degrees of external rotation.

Rotator interval: If the shoulder demonstrated persistent, excessive translation after débridement, labral repair, and capsular tensioning, we turned our attention to the rotator interval. If the direction of translation was inferior or inferior-posterior, we passed a monofilament suture through the soft tissue immediately adjacent to the anterior border of the supraspinatus and then through the soft tissue superior to the subscapularis tendon. We placed the suture as far laterally as possible so as not to interfere with postoperative external rotation. Traction was applied on the suture, and we again assessed the translation of the humeral head. If the correction was adequate, the suture was tied. If the correction was inadequate, the suture was removed and placed in a more medial position until excessive translation was corrected. If the direction of persistent translation was inferior-anterior, the inferior limb of the suture was passed through the superior portion of the middle glenohumeral ligament to increase tension in that portion of the capsule.

Thermal capsulorrhaphy: If persistent translation was not corrected after labral and capsular suture repair and application of tension on the rotator-interval suture, we performed a thermal capsulorrhaphy. We used the laser to contract areas of the capsule that corresponded to the direction of excessive movement of the humeral head.

The repair sequence varied and depended on the specific combination of lesions identified. In general, we followed a pattern of débridement, ligamentous or labral reattachment, and capsular tensioning.

Débridement was performed to smooth frayed labral fragments or to remove torn labral fragments and, if necessary, to identify the depth of partial-thickness rotator-cuff tears. Loose bodies were removed.

We then treated labral or ligamentous insertion-site tears. The labral tear or tears were then repaired, beginning with the inferior part of the labrum and proceeding as necessary to the anterior and superior aspects of the labrum. Technical considerations dictated the order of labral repair. As the labrum (and its attached ligaments) was repaired, our ability to displace the humeral head and to insert bone-suture anchors and soft-tissue sutures was compromised. We repaired the inferior part of the labrum first, as access to this lesion became difficult after repair of the superior or anterior aspect. We identified three types of anterior labral detachment. Type A indicated that the labrum was separated from the glenoid bone but remained at the level of the glenoid articular surface; type B, that the labrum was separated and retracted medially; and type C, that the labrum was retracted and had healed medially on the glenoid (an ALPSA lesion[41]). Type-B and type-C lesions required us to dissect the labrum from the glenoid so that we could move the labrum laterally and place it on the glenoid articular surface. We performed this procedure with a combination of a thermal probe, a power burr, and blunt dissection. We repaired forty-four tears of the anterior part of the labrum (twenty-five type-A, fifteen type-B, and four type-C lesions) and two tears of the inferior part of the labrum.

If the anterior or middle glenohumeral ligament was retracted and adherent to the subscapularis, we released the ligament prior to repair of the insertion site. We made an incision along the superior border of the middle glenohumeral ligament. We then inserted a blunt instrument (posterior to the capsule and anterior to the subscapularis tendon) in order to separate the two structures. After we completed labrum-and-ligament mobilization, the scapular neck was abraded to a depth of one to two millimeters. The abraded area began at the level of the glenoid cartilage and extended two centimeters medially on the scapula. Drill-holes for the suture anchors were placed through the glenoid articular surface approximately one to two millimeters from the lateral glenoid margin. Drill-holes were created in the anterior and inferior parts of the glenoid with a power drill that was inserted through the anterior-inferior cannula. The first suture anchor was inserted into the most inferior drill-hole. The detached labrum was sutured so that it was in contact with the scapular neck and extended onto the glenoid articular surface. The suture strands were then tied. The number of suture anchors varied and was dependent upon the size of the labral detachment.

After the inferior or anterior aspect of the labrum, or both, had been repaired, the site of the labral tear from the superior part of the glenoid bone was identified and abraded with a power burr and two bone suture-anchors were inserted. The location of the suture anchors varied and was dependent on the anatomy of the lesion, but in general we placed one suture anchor one-third of the tear length from the posterior margin and the second anchor one-third of the tear length from the anterior margin of the tear. Nonabsorbable number-2 braided suture was utilized[5,9,37]. During the period of this study, a wide variety of suture anchors, including metallic screw-in anchors, metallic expandable anchors, and polyethylene expandable anchors, were used. We currently use a metallic screw-in anchor (ROC 5; Orthopedic Biosystems, Scottsdale, Arizona) exclusively.

We modified the repair technique when the labrum was intact but the glenohumeral ligament had torn from the labrum. If the labrum was of sufficient size to allow suture placement within its substance, the ligament was repaired directly to the labrum with monofilament suture. If the labrum was absent, the capsule was advanced onto the glenoid articular cartilage surface and repaired with suture anchors (as described above) in order to create a labral bumper. A mechanical arm-holder greatly facilitated this step.

If the labrum-ligament complex was well attached to the glenoid but the ligament lacked sufficient tension to contain the humeral head, we operated directly upon the capsule with use of the methods described above. The goal of this portion of the procedure was to restore ligamentous and capsular tension and to eliminate excessive translation of the humeral head.

Repair of the rotator interval was the last step performed within the glenohumeral joint, as a cannula could not be inserted anteriorly once this repair was completed. A suture-passer was used to place a monofilament suture through the capsular tissue immediately anterior to the supraspinatus tendon and then through the capsule superior to the subscapularis tendon. If a greater degree of tightening was required, then the superior capsular tissue was sutured to the middle glenohumeral ligament. A sliding knot was used to tie the suture extra-articularly. The details of this technique have been described previously[18].

If excessive translation remained after we had applied traction to the rotator interval suture, the suture was not tied and we inserted the laser. We identified the areas of the capsule that corresponded to the direction of excessive translation (usually inferior or inferior-anterior). Heat was applied over a very limited area of the capsule until the capsule contracted. We always left normal capsule between any two areas of laser application in order to avoid thermal necrosis. If further capsular tension was necessary, we then tied the rotator interval suture.

Postoperative Management

Postoperative management was similar for all patients. A soft pillow-sling supported the arm in 15 degrees of abduction. An ice-pack wrap decreased postoperative shoulder swelling and pain. One gram of a cephalosporin was administered eight hours postoperatively. Patients went home the morning after the operation. Active range-of-motion exercises for the fingers, wrist, and elbow as well as isometric exercises for the deltoid muscle were started the morning after the operation and were continued at home for two weeks. At two weeks, an anteroposterior radiograph was made to document the position of any metallic suture anchors. The patients were allowed to remove the sling for active elevation and external rotation exercises twice daily but wore the sling at all other times. Active elevation was limited to 120 degrees and external rotation, to 40 degrees. The patients continued to wear the sling for six weeks, at which point it was removed and unrestricted active range-of-motion and strengthening exercises were begun. The range-of-motion and strengthening exercises were continued for one year.

At each follow-up visit, after arrival at the clinic but before the examination, each patient completed self-assessment forms to document shoulder pain, function, satisfaction, and level of sports activity. Active and passive ranges of motion as well as strength were documented. No postoperative radiographic imaging studies such as ultrasound, magnetic resonance imaging, or arthrography were per-

TABLE I
OPERATIVE FINDINGS

Lesion	No. of Lesions
Rotator cuff tear	
Partial thickness	
Grade 1	4
Grade 2	1
Grade 3	1
Full thickness	1
Biceps tear	
Transverse partial-thickness tear	1
Longitudinal partial tear	1
Rotator interval abnormality	16
Subscapularis tendon tear (partial)	1
Superior glenohumeral ligament tear	15
Middle glenohumeral ligament tear	33
Anteroinferior glenohumeral ligament tear	44
Posterior glenohumeral ligament tear	0
Superior portion of labrum	
Present	53
Absent	0
SLAP lesion*[50]	31
Type 2	28
Type 3	2
Type 4	1
Anterior portion of labrum	
Present	44
Absent	9
Bankart lesion	44
Type A	25
Type B	15
Type C	4
Inferior portion of labrum	
Present	45
Absent	8
Fraying	2
Separated	2
Posterior portion of labrum	
Present	52
Absent	1
Fraying	4
Separated	1
Hill-Sachs lesions	13
Loose bodies	9
Synovitis	10

*SLAP = tear of superior part of labrum from anterior to posterior.

formed routinely. The level of patient compliance was recorded at each clinic visit.

Data Analysis

Initial data screening was accomplished with use of scatterplots, histograms, and frequency tables for all variables. Additional diagnostics were completed on any potential outliers with use of regression diagnostics and studentized residuals. Violations of linearity, homoscedasticity, and independence were assessed on the scatterplots[28]. A chi-square goodness-of-fit test was utilized to evaluate our null hypothesis that the mean postoperative Rowe score would be 85 points or less. The alpha level was set at 0.05. Paired t tests were utilized to determine if there were any differences between preoperative and postoperative scores. Within-subject analyses of variance were used to evaluate whether there were any differences among items (such as degree of instability, patient compliance, and frequency of preoperative dislocations) with three variables or more. Tukey *post hoc* testing was completed for all possible pairwise comparisons, with the overall experimental alpha level maintained at 0.05. Standard statistical software (SPSS, Chicago, Illinois) was used to analyze the data.

Results

The mean duration of symptoms prior to surgery was fourteen months (range, one week to 120 months). The mean duration from the operation to the final follow-up evaluation was thirty-three months (range, twenty-six to sixty-three months).

Fifteen of the patients had had recurrent subluxation, thirty-three had had recurrent dislocation, and five had had recurrent subluxation after a single dislocation. Shoulder instability had developed after a single traumatic event in forty-eight patients, and it had developed without a traumatic event in five patients. We classified the instability as chronic in fifty patients and as acute in three.

Radiographic Analysis

All patients were evaluated preoperatively with use of standard radiographs. The radiographic findings were normal in thirty-six patients and abnormal in seventeen. The abnormalities included anterior-inferior dislocation in six patients, anterior-inferior dislocation and a nondisplaced fracture of the greater tuberosity in one, an osseous Bankart lesion in one, and a Hill-Sachs lesion in eleven; multiple abnormalities often were observed in the same patient. Two patients underwent computerized axial tomography prior to evaluation in our clinic; a tear of the anterior part of the labrum was identified in one of them and a Hill-Sachs lesion, in the other. Twenty-nine patients underwent preoperative magnetic resonance imaging. The results were normal in five patients and abnormal in twenty-four. The abnormal findings included a tear of the anterior part of the labrum in eight patients, a lesion of the superior part of the labrum in two, a Hill-Sachs lesion in eight, a large tear of the anterior aspect of the capsule in three, and a partial-thickness tear of the rotator cuff in three. The operative findings in the five patients with normal magnetic resonance imaging studies (all of which were done without contrast material) included a tear of the superior part of the labrum in one patient, a Bankart lesion in one patient, and a tear of the superior part of the labrum and a Bankart lesion in three patients. The mean final Rowe score for these five patients was 96.4 points (range, 83 to 100 points).

Findings on Physical Examination

Abduction and external rotation produced pain in forty-eight of the fifty-three patients and apprehension in thirty-eight. Five patients had negative findings on examination, but four of them had a Bankart lesion that was noted at the time of the operation. The Rowe test[16] produced pain in forty-four patients and apprehension in thirty-seven. The sulcus test was negative in thirty-four patients, and it produced pain in fifteen patients and apprehension in four.

Operative Findings

The operative findings varied, and most patients had more than a single lesion (Table I).

Correlation of Physical Examination and Operative Findings

When patients who had pain with abduction and external rotation were compared with those who had apprehension, we could find no difference in the operative findings. When patients who had negative findings on physical examination were compared with those who had apprehension, we noted a difference in the operative findings related to the anterosuperior aspect of the glenohumeral joint. Specifically, none of the patients who had negative findings on physical examination had a tear of the superior glenohumeral ligament or the rotator interval. Only one of the five patients who had negative findings on physical examination had a tear of the middle glenohumeral ligament, but all had a lesion of the anteroinferior aspect of the ligament-labrum complex. None of the patients who had negative findings on physical examination had loose bodies or synovitis, whereas eight patients who had positive findings on physical examination had such abnormalities. Patients who had a negative result on the Rowe or sulcus test also did not have any abnormalities of the superior glenohumeral ligament, rotator interval, or superior part of the labrum, while eighteen of the thirty patients who had a positive result on either of these tests had lesions in this area.

Operative Repair

A variety of lesions were repaired at the time of the operation, and most patients had more than one lesion (Table II). We inserted suture anchors in fifty-two patients. A mean of 2.4 anchors (range, zero to five anchors) were used in each patient. Thermal capsulorrhaphy was used to increase ligamentous or capsular tension after suture repair in forty-eight of the fifty-three shoulders. There were no cases in which we thought that thermal capsulorrhaphy without suture repair would have been adequate to restore soft-tissue tension.

TABLE II
OPERATIVE REPAIR

Repair	No. of Shoulders
Labral repair	
Superior	31
Anterior	48
Type A	25
Type B	15
Type C	8
Inferior	2
Posterior	0
Ligament suture imbrication	
Anterior	46
Middle	41
Inferior	31
Posterior	0
Thermal tightening	
Anterior	48
Middle	5
Inferior	11
Posterior	0
Rotator interval repair	14

Postoperative Shoulder Scores

All four rating systems revealed significant improvement in the status of the shoulder when the preoperative scores were compared with the scores that were recorded at the time of the most recent follow-up. Specifically, the mean score (and standard deviation) increased from 45.5 ± 18.6 points to 91.7 ± 13.7 points with the system of the American Shoulder and Elbow Surgeons (ASES)[44], from 56.4 ± 13.3 points to 91.8 ± 11.3 points with the system of Constant and Murley[13], from 11.3 ± 5.7 points to 91.9 ± 20.8 points with the system of Rowe et al.[47], and from 17.6 ± 4.8 points to 32.0 ± 4.7 points with the system of the University of California at Los Angeles (UCLA)[15] ($p = 0.001$ for all comparisons; paired t test). Neither the Constant scoring system nor the ASES scoring system includes a specific description of the scores that are considered to represent an excellent or poor rating. Ellman et al.[15] categorized a UCLA Shoulder Score of 29 to 35 points as good or excellent and a score of less than 29 points as fair or poor. Rowe et al.[47] rated a score of 90 to 100 points as excellent and a score of 75 to 89 points as good. In the present study, forty-nine (92 percent) of the fifty-three shoulders had an overall rating of good or excellent according to both the Rowe score and the UCLA Shoulder Score.

Primary Hypothesis Testing

The final mean Rowe score for all patients was 91.9 points. To evaluate the results of our null hypothesis (that arthroscopic treatment of instability results in a postoperative mean Rowe score of 85 points or less), a chi-square goodness-of-fit statistic was calculated. The chi-square statistic was 862.38 with 15 degrees of freedom ($p < 0.0005$). Therefore, we rejected the null hypothesis and accepted the alternative, namely, that an arthroscopic operation to treat instability produces a mean Rowe score of greater than 85 points.

Satisfaction

Patients rated their level of satisfaction with use of the UCLA Shoulder Score. Preoperatively, none of the patients rated their satisfaction as good or excellent (4 or 5 of a possible 5 points). Postoperatively, forty-eight (90 percent) of the fifty-three patients rated their satisfaction as good or excellent (4 or 5 points) and five (10 percent) rated it as fair or poor (0 to 3 points).

Pain

Preoperatively, ten patients rated the pain as minimal (a score of 0, 1, or 2 points) on the 10-point visual analog scale. All ten patients described the typical level of shoulder pain as minimal but rated the pain as severe (10 points) when the shoulder was dislocated. Postoperatively, pain was minimal (0, 1, or 2 points) in forty-eight patients (91 percent), mild (3 or 4 points) in four, and moderate to severe (5 to 10 points) in one.

Function

The patients completed a self-assessment questionnaire on shoulder function with use of the four shoulder-scoring systems. Preoperatively, no patient rated function as good to excellent (a score of 35 to 50 points) on the Rowe function subscale (maximum possible score, 50 points). Postoperatively, forty-eight patients (91 percent) rated function as good to excellent and five rated it as fair to poor. On the ASES Shoulder Index, significant improvement was demonstrated in all ten activities of daily living (function items) ($p = 0.0001$) and the score for total function improved from a mean of 24.4 points to a mean of 47.1 points ($p = 0.0001$).

Range of Motion

No patient lost more than 5 degrees of elevation. The mean external rotation with the shoulder in 90 degrees of abduction measured 88.2 degrees. External rotation measured 85 degrees in three patients and 70 and 60 degrees in one patient each. These five patients rated their satisfaction (according to the UCLA Shoulder Score) as 5 of a possible 5 points. The patient who had the operation on the dominant side was nonathletic. The four other patients had the operation on the nondominant side.

Strength

The strength of elevation improved 60 percent, from a preoperative mean of 12.9 pounds (5.9 kilograms) to a mean of 20.6 pounds (9.3 kilograms) at the final follow-up evaluation; this finding was significant ($p = 0.0001$). Since an anesthetic was not injected prior to strength measurement, this increase in strength was probably due to the postoperative program of strengthening exercises and to a decrease in the level of pain.

Return to Sports Participation

Forty-three patients had participated actively in sports prior to the onset of the shoulder symptoms. According to the sports category, none of the patients had participated in type-1 sports; five, in type-2 sports; thirty, in type-3 sports; and eight, in type-4 sports. Seven patients had participated at level 1 (high-school team sports); one, at level 2 (college team sports); and thirty-five, at level 3 (recreational sports). At the final follow-up evaluation, five patients reported that they did not participate in sports because of issues that were unrelated to the shoulder. The reasons most commonly cited were work or family commitments, graduation from high school or college (and the associated lack of team sports), and injuries to the knee or lumbar spine. At the final follow-up examination, thirty-eight patients who did not have such issues participated in sports. One patient participated in type-1 sports; six, in type-2 sports; twenty-six, in type-3 sports; and five, in type-4 sports. Three were involved in level-1 sports; none, in level-2 sports; and thirty-five, in level-3 sports. Four patients with persistent shoulder instability had decreased their level of participation.

Degree of Instability

The final mean Rowe score was found to be 90 points for the thirty-three patients with recurrent dislocation, 92 points for the five patients with recurrent subluxation after an initial dislocation, and 97 points for the fifteen patients with recurrent subluxation. The differences among these three groups (analyzed with a between-subjects analysis of variance) were not found to be significant ($p = 0.519$).

Traumatic Compared with Atraumatic Instability

The final mean Rowe score was 91.4 points for the forty-eight patients with shoulder instability that followed a traumatic event and 99.6 points for the five patients with an atraumatic etiology. The difference between these groups was found to be significant ($p = 0.01$). Four of the five patients who did not have a traumatic event were found, at the operation, to have a Bankart lesion.

Number of Preoperative Dislocations

The final mean Rowe score was tabulated according to the number of preoperative dislocations. We grouped patients into three categories on the basis of the number of reported dislocations; ten patients had had one or two dislocations, fifteen had had three to nine dislocations, and thirteen had had ten dislocations or more. No significant difference among the groups was identified, with the numbers available ($p = 0.8$). We noted a trend toward an increase in the severity of the lesion in the anteroinferior part of the labrum in association with an increase in the number of preoperative dislocations. Similar findings were noted by Habermeyer et al.[22]. Type-C labral tears were found only in shoulders with three dislocations or more. Operative correction of the inferior aspect of the capsule or labrum was required in only eight of the twenty-eight patients with three dislocations or more.

Age at Time of Operation

The final mean Rowe score was 84 points for the nine patients who were less than twenty years old at the time of the operation and 93 points for the forty-four patients who were twenty years or older. Both Grana et al.[20] and Savoie et al.[49] noted poorer results in younger patients. Although there was a tendency toward poorer results in younger patients in the present series, the difference was not found to be significant, with the numbers available (p = 0.240).

Gender

The final mean Rowe score was 92 points for the male patients and 91 points for the female patients. This difference was not found to be significant, with the numbers available (p = 0.850).

Arm Dominance

The final mean Rowe score was 91 points for the patients in whom the dominant side was involved and 93 points for the patients in whom the nondominant side was involved. This difference was not found to be significant, with the numbers available (p = 0.740).

Duration of Instability

The final mean Rowe score was 91.4 points for the fifty patients in whom the instability was classified as chronic (present for more than six weeks before the operation) and 100 points for the three patients in whom it was classified as acute. The difference was found to be significant (p = 0.007).

Ligamentous Laxity

The final mean Rowe score was 94 points for the forty-seven patients without evidence of ligamentous laxity and 74 points for the six patients with ligamentous laxity. This difference was found to be significant (p = 0.02). The inferior results in the patients with ligamentous laxity may have been the result of a technically inadequate repair or may suggest that patients with anterior-inferior instability and generalized ligamentous laxity require an open capsular reconstruction to achieve adequate soft-tissue tension.

Patient Compliance

The mean compliance score was 7.8 points (range, 2 to 10 points). Four patients had a low compliance score (0 to 3 points), twenty-five had a medium compliance score (4 to 7 points), and twenty-four had a high compliance score (8, 9, or 10 points). The final mean Rowe score was 88 points for patients with low compliance, 87 points for those with medium compliance, and 97 points for those with high compliance. The differences among the three categories (analyzed with a one-way analysis of variance) were not found to be significant, with the numbers available (p = 0.263).

Analysis of Unsatisfactory Results

The result in four patients was rated as fair or poor (a score of less than 29 points according to the UCLA Shoulder Score or a score of less than 75 points according to the system of Rowe et al.) at the final follow-up evaluation. Two patients (both of whom had a preoperative diagnosis of recurrent dislocation) continued to have dislocation of the shoulder after the operation. Two patients (one with a preoperative diagnosis of recurrent dislocation and one with a preoperative diagnosis of recurrent subluxation after a single dislocation) were noted to have recurrent subluxation after arthroscopic repair. We were unable to distinguish this subset of four patients on the basis of the operative findings or the repair technique. All four patients were male, and their mean age (twenty-one years; range, fifteen to thirty-one years) was lower than that for the rest of the study group. The mean compliance score of the four patients was 4.5 points, and the final mean Rowe score was 31 points (range, 10 to 53 points). The time to failure (defined as postoperative dislocation or subluxation) averaged thirteen months (range, nine to eighteen months). No patient who had a stable shoulder at eighteen months postoperatively had development of late instability after as many as five years of follow-up.

Complications

No major intraoperative or perioperative complications (permanent nerve injuries or wound infections) occurred. Two patients had paresthesias in the musculocutaneous nerve distribution that resolved by the six-week postoperative follow-up examination. One patient noted minor wound drainage that resolved within one week without the use of antibiotics. We did not observe any complications related to the use of suture anchors.

Revision Operations

One patient (with an original diagnosis of recurrent anterior-inferior subluxation) noted a return of the subluxation fourteen months after the index procedure. At the time of the revision operation, the original repairs (for a Bankart lesion, a SLAP lesion, and an abnormality of the rotator interval) were intact but we noted inferior and posterior capsular laxity. Since the insertion-site lesions that had been repaired at the time of the index operation were intact, the inferior portion of the capsule was tightened with monofilament sutures. We performed laser thermal capsulorrhaphy to further tighten the posteroinferior aspect of the glenohumeral ligament. The patient had a successful result with a return to full activities and normal stability on physical examination.

Discussion

The wide variety of lesions, the patient population, the operative techniques, the duration of follow-up, and the use of multiple scoring systems complicate comparison of the results of this report with the results of open repairs. However, on the basis of the level of improvement in the various parameters described in the present investigation, we concluded that the outcome of arthroscopic repair of anterior-inferior glenohumeral instability is better than that of previous arthroscopic treatments and is equivalent to that of open repair. Wirth et al.[57] described the results of open repair in a study of 138 patients (142 shoulders). They did not report mean scores, but 93 percent (132) of the 142 shoulders had a good or excellent result according to the Rowe scoring system.

The spectrum of operative findings in the present study did not support the concept of any "essential lesion." On the contrary, it appeared that the etiology of anterior-inferior glenohumeral instability was multifactorial and that successful treatment required that any operative approach be sufficiently flexible to deal with the variety of lesions found. Our arthroscopic approach allows the surgeon to identify and treat all of the lesions of shoulder instability. We believe that the success of our arthroscopic approach was due to our ability to perform an anatomical repair of tears of the anterior, superior, and inferior parts of the labrum; to correct capsular elongation; and, if necessary, to repair the rotator interval.

The present study has a number of weaknesses. Although the investigation was prospective, the patients were not randomized and the investigator was not blinded. In addition, the follow-up period was relatively short; we are continuing to follow these patients so that we can evaluate the results over a longer interval. We also believe that these results may deteriorate with time and may parallel the experience after open repair[38].

Currently, we use the arthroscopic technique whenever operative treatment of glenohumeral instability is indicated; no open repairs are performed. The arthroscopic technique allows us to inspect the entire glenohumeral joint and to avoid soft-tissue dissection. No division of the subscapularis is required. Although we are unable to document our impressions statistically, we believe that arthroscopic repair provides an improved cosmetic appearance, decreased postoperative pain, and more rapid gains in motion when compared with open operative treatment of similar lesions.

Our technique can be recommended only to experienced orthopaedic surgeons who are familiar with the normal and abnormal anatomy seen during both open and arthroscopic shoulder operations. A thorough understanding of the various conditions that produce pain in the shoulder is needed. Orthopaedic surgeons who infrequently perform open repair for glenohumeral instability should not undertake the arthroscopic procedure. The arthroscopic operation requires advanced arthroscopic techniques and is still in the developmental stage.

Arthroscopic repair for anterior-inferior glenohumeral instability produced good or excellent results in forty-nine of fifty-three patients. The mean external rotation with the shoulder in 90 degrees of abduction measured 88.2 degrees. Thirty-four of thirty-eight patients were able to return to their desired level of sports activity. Four patients who had persistent instability were considered to have had a failure of the index operation. We believe that the improved rate of success demonstrated in our study is the result of repair not only of anterior-inferior (Bankart) lesions but also (when necessary) of inferior and superior labral tears. Additionally, soft-tissue tension within the capsule and ligaments was corrected with use of a suture technique but was supplemented with laser thermal capsulorrhaphy, if necessary. Repair of the rotator interval was considered a critical factor in selected patients.

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