

THE OUTCOME AND REPAIR INTEGRITY OF COMPLETELY ARTHROSCOPICALLY REPAIRED LARGE AND MASSIVE ROTATOR CUFF TEARS

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Background: The impact of a recurrent defect on the outcome after rotator cuff repair has been controversial. The purpose of this study was to evaluate the functional and anatomic results after arthroscopic repair of large and massive rotator cuff tears with use of ultrasound as an imaging modality to determine the postoperative integrity of the repair.

Methods: Eighteen patients who had complete arthroscopic repair of a tear measuring >2 cm in the transverse dimension were evaluated at a minimum of twelve months after surgery and again at two years after surgery. The evaluation consisted of a standardized history and physical examination as well as calculation of the preoperative and postoperative shoulder scores according to the system of the American Shoulder and Elbow Surgeons. The strength of both shoulders was quantitated postoperatively with use of a portable dynamometer. Ultrasound studies were performed with use of an established and validated protocol at a minimum of twelve months after surgery.

Results: Recurrent tears were seen in seventeen of the eighteen patients. Despite the absence of healing at twelve months after surgery, thirteen patients had an American Shoulder and Elbow Surgeons score of ≥ 90 points. Sixteen patients had an improvement in the functional outcome score, which increased from an average of 48.3 to 84.6 points. Sixteen patients had a decrease in pain, and twelve had no pain. Although eight patients had preoperative forward elevation to $< 95^\circ$, all eighteen regained motion above shoulder level and had an average of 152° of elevation. At the second evaluation, a minimum of twenty-four months after surgery, the average score, according to the system of the American Shoulder and Elbow Surgeons, had decreased to 79.9 points; only nine patients had a score of ≥ 90 points, and six patients had a score of ≤ 79 points. The average forward elevation decreased to 142° .

Conclusions: Arthroscopic repair of large and massive rotator cuff tears led to a high percentage of recurrent defects. The minimum twelve-month evaluation showed excellent pain relief and improvement in the ability to perform activities of daily living despite the high rate of recurrent defects; however, at a minimum follow-up of two years, the results deteriorated with only twelve patients who had an American Shoulder and Elbow Surgeons score of ≥ 80 .

Level of Evidence: Therapeutic study, Level IV (case series [no, or historical, control group]). See Instructions to Authors for a complete description of levels of evidence.

Surprisingly little information has been reported on the relationship between the integrity of a rotator cuff repair and the final outcome. The relatively few studies that have evaluated the integrity of surgical repair¹⁻⁸ have demon-

strated a substantial recurrence rate for larger tears when treated with either open or mini-open techniques, although the use of nonvalidated imaging modalities and protocols has clouded data interpretation. Operative repair of the cuff through a completely arthroscopic approach has become increasingly popular. Although the long-term results of this technique have not been established, the short-term results of arthroscopic repair in two series of heterogeneous tears ap-



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peared promising^{7,9}. Reported benefits included less postoperative pain, a decreased risk of deltoid dehiscence, and possible accelerated recovery and rehabilitation^{7,9}. The purpose of the present study was to evaluate the short-term results of arthroscopic repair in a focused group of patients with large and massive rotator cuff tears and to correlate these results with the integrity of the cuff as determined by ultrasonographic evaluation. Ultrasound accuracy has been validated at our institution for the evaluation of cuff tear size both preoperatively and postoperatively^{10,11}.

Materials and Methods

Inclusion and Exclusion Criteria

Between 1997 and 2000, 170 complete arthroscopic rotator cuff repairs were performed at the Shoulder and Elbow Service by the senior author (K.Y.). Patients with a primary tear measuring >2 cm in the transverse dimension and who had been followed for a minimum of two years were considered for inclusion in this study. The tear size was chosen in order to include patients with tears involving at least two tendons^{11,12}. Eighteen patients met the inclusion criteria. Fifteen of the eighteen patients had tears of >3 cm in the transverse dimension and involved the teres minor. The other tears measured between 22 and 28 mm. The indication for surgery was the failure of nonoperative treatment of a chronic tear for a period of at least three months in twelve patients and more immediate repair of an acute tear in six younger patients (less than sixty years old). Patients undergoing revision procedures were excluded. No rotator cuff repairs were performed through an open or mini-open approach during this time-period.

All patients but one had a full-thickness rotator cuff tear documented by preoperative ultrasonography performed by one of two experienced ultrasonographers. Some also had a preoperative magnetic resonance imaging scan. The one patient without a preoperative ultrasound study had a magnetic resonance imaging scan that unequivocally demonstrated a massive cuff tear. All patients had a postoperative ultrasound study performed by the same ultrasonographers at a minimum of twelve months following surgery. Eighteen patients met these criteria for inclusion and were further evaluated in the present study.

The average age of the eighteen patients at the time of the surgery was sixty-one years (range, fifty to eighty-seven years). The average duration of follow-up was thirty-six months (range, twenty-four to forty-two months). The surgery was performed in the dominant extremity in eleven patients and in the nondominant extremity in seven. There were eleven men and seven women.

Patient Evaluation

The patients were initially evaluated at a minimum of twelve months after surgery. Ultrasound examinations were performed at that time. Patients were subsequently reevaluated at a minimum of twenty-four months after surgery. All patients underwent a standard history and physical examination according to the American Shoulder and Elbow Surgeons guidelines³

preoperatively. All patients completed a standardized questionnaire, containing evaluation scales of pain and function, preoperatively and at the one and two-year time-points. Pain and subjective weakness were rated from 1 to 10 on visual analog scales. Ten activities of daily living were rated on a numeric scale, according to the patients' ability to perform them, as "no difficulty," "some difficulty," or "can't do at all." Information gathered allowed calculation of both a preoperative and a postoperative American Shoulder and Elbow Surgeons score¹³, which is based primarily on the activities of daily living scale and pain score and has a maximum of 100 points.

All ultrasonograms were performed in real time with use of an ATL HDI 3000 scanner (Advanced Technologies Laboratories, Bothell, Washington) or a Siemens Elegra scanner (Siemens Medical Systems, Issaquah, Washington) and a variable high-frequency linear-array transducer (7.5 to 10 MHz). All patients had standardized ultrasonography of the shoulder, performed by one of two experienced musculoskeletal radiologists as previously described¹¹. Images of the rotator cuff and biceps tendons were made.

Strength-Testing

Manual strength of the rotator cuff was assessed before and after surgery. In addition, quantitative strength measurements were obtained with use of a portable, handheld isometric dynamometer (Isobex 2.0; Cursor AG, Bern, Switzerland) at a minimum of twenty-four months postoperatively^{14,15}. External rotation strength was tested with the patient in the seated position with the arm at the side in neutral rotation. The patient was instructed to externally rotate the arm with maximal force and hold for five seconds. Three separate trials were performed, and the average of the results of the three trials was used. Both shoulders were tested in order to compare the involved and the contralateral side.

Surgical Procedure

All procedures were performed with the patient under general anesthesia with an adjunctive interscalene block and placed in the upright beach-chair position. A posterior portal was established for the initial assessment of the joint. An anterior portal through the rotator interval was established as the working portal for intra-articular débridement. The biceps tendon was assessed. Three patients had an absent biceps tendon. Ten patients underwent a biceps tenotomy with use of either an electrocautery device or basket forceps. An absolute indication for biceps tenotomy was fraying, tearing, or attenuation involving $\geq 25\%$ of the tendon. A relative indication included a massive rotator cuff tear in an individual who was more than sixty years old. A biceps tenotomy was performed in order to eliminate the proximal portion of the biceps tendon as a source of pain after repair of a massive rotator cuff tear¹⁶. Any adhesions between the superior portion of the labrum and the retracted rotator cuff were released with use of an electrocautery device.

A coracoacromial ligament release and subacromial decompression was performed in fifteen patients. It should be

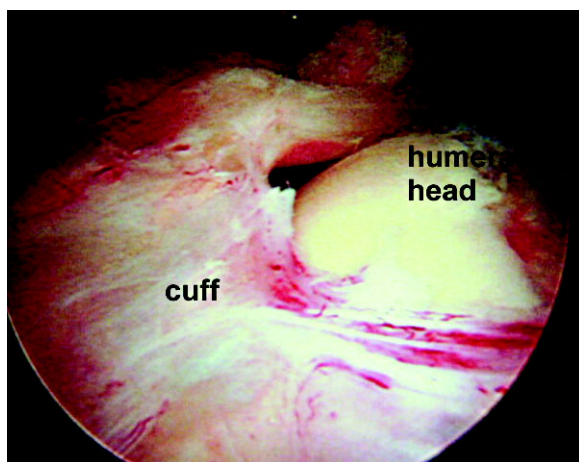


Fig. 1-A

Figs. 1-A and 1-B A patient with a typical massive tear of the rotator cuff in our series. **Fig. 1-A** Preoperative arthroscopic view.

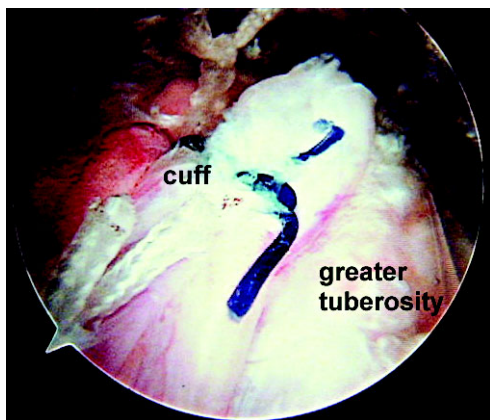


Fig. 1-B

Postoperative arthroscopic view. All cuffs were mobilized and repaired without undue tension on the tissue.

noted that our standard decompression is generally conservative, consisting of removal of only abnormal osteophytes and very little removal of native bone. In this context, at the time of the operations, most of the tears were found to have a repair that was structurally satisfactory; thus, healing was originally expected and decompressions were performed. In contrast, a decompression was not performed in three patients in order to preserve the coracoacromial arch and to prevent anterior-superior instability of the head as the rotator cuff in these three repairs was less structurally satisfactory. Also, in these patients, the undersurface of the acromion was thought to be flat and not in need of acromioplasty.

The rotator cuff repair was performed by first placing a suture shuttle through the tendon with use of a Caspari device (Linvatec, Largo, Florida). As in the study by St. Pierre et al.¹⁷, the greater tuberosity was gently débrided and smoothed of irregularities and the superficial bone was decorticated, but the medullary canal was not exposed. A formal bone trough was not made. A hole was punched in the greater tuberosity through an accessory superolateral portal. The suture anchor, a 5-mm

bioabsorbable corkscrew anchor (Arthrex, Naples, Florida) made of poly(L/D-lactide) acid, was inserted through the superior accessory portal. A suture grasper was then used to bring the sutures out through the working anterolateral portal. The shuttle was used to bring one end of the suture through the tendon. An arthroscopic knot was tied, reducing the tendon to the bone (Figs. 1-A and 1-B). From two to five anchors were used, depending on tear size and configuration. The anchors contained number-2 nonabsorbable suture. The arm was immobilized in a sling following routine portal closure.

Rehabilitation

On the first postoperative day, the patients began passive range-of-motion exercises, including passive forward flexion, external rotation, and pendulum and pulley exercises. Active-assisted motion was initiated at six weeks postoperatively. A return to recreational activity with heavy demands on the shoulder or to manual labor was delayed for six months.

Statistical Analysis

The Student t test was used to compare the range of motion, visual analog pain scores, and American Shoulder and Elbow Surgeons score. A p value of <0.05 was considered significant.

Results

Outcome Assessment

The average preoperative score according to the system of the American Shoulder and Elbow Surgeons was 48.3 points (range, 23 to 93 points), and the average postoperative score at one year was 84.6 points (range, 35 to 98 points) (see Appendix). The activities of daily living score increased in all but one patient. Of a maximum possible score of 30 points, the average score increased from 14.8 to 24.8 points at a minimum follow-up of twenty-four months. At that time, the average American Shoulder and Elbow Surgeons score was 79.9 points; only nine patients had a score of ≥ 90 points, and six patients had a score of ≤ 79 points. Sixteen of the eighteen patients still demonstrated an improvement in the American Shoulder and Elbow Surgeons score.

Pain and Weakness

Initially, fifteen patients had a decrease in the pain score and two had no change as assessed by the visual analog scale. The scores decreased from an average of 5.2 points preoperatively to 1.3 points postoperatively ($p = 0.0001$). At the one-year follow-up examination, twelve patients had no pain and two rated the pain as 1 of a possible 10 points. According to the patient rating of subjective feelings of weakness, the average score was 4.6 of a possible 10 points preoperatively and 2.2 points postoperatively ($p = 0.009$). Individually, the sense of weakness decreased after surgery in fifteen patients. Eight patients did not have any subjective feeling of weakness.

At the two-year follow-up examination, the pain scores were still decreased from an average of 5.2 points preoperatively to 2.3 points postoperatively ($p = 0.002$). At the time of the final evaluation, six patients had no pain and six rated the

pain as 1 to 2 points. At the twenty-four-month follow-up examination, the average rating of subjective feeling of weakness increased only slightly to 2.3 points.

Strength and Range of Motion

A significant difference was detected between the affected and unaffected sides with respect to the postoperative quantitative measurements of strength with use of the Isobex dynamometer ($p = 0.02$) at the final evaluation. The range of motion increased substantially following surgery. The average forward flexion was 92° preoperatively, increased to 152° at the initial follow-up examination, and decreased slightly to 142° at the time of the twenty-four-month follow-up. Preoperatively, eight patients had $<95^\circ$ of elevation. Postoperatively, all patients could elevate the arm to shoulder level and above regardless of pain or functional outcome at the time of the final follow-up. The average external rotation increased slightly from 44.7° preoperatively to 53.2° at the time of the final follow-up.

Tear Size

Recurrent tears were visualized by ultrasonographic evaluation in seventeen of the eighteen patients (Figs. 2-A and 2-B). Only one repair was completely intact while all of the others had recurrent defects, many of which measured the same size as before surgery. The transverse dimension or the width of the tear as it was detached from the bone of the greater tuber-

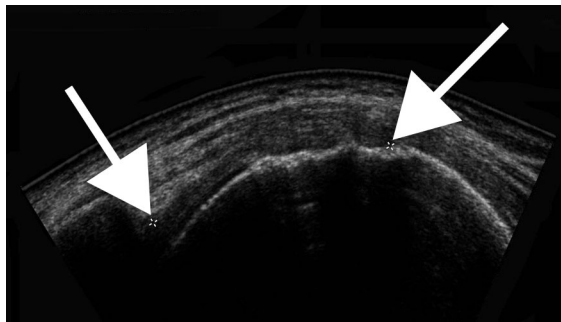


Fig. 2-A



Fig. 2-B

Preoperative (Fig. 2-A) and postoperative (Fig. 2-B) ultrasound images of the patient in Figures 1-A and 1-B, demonstrating no visualization of the rotator cuff. The greater tuberosity is located at the arrow on the right. The arrow on the left indicates the medial aspect of the humeral head at the level of the glenoid.

osity was evaluated. The recurrent defects were categorized as the “same size” if the defect was within 2 mm of the size on the preoperative ultrasound, as “larger” if the defect was >2 mm larger, or as “smaller” if the defect was >2 mm smaller than the preoperative transverse dimension. One patient did not have a preoperative ultrasound but had a recurrent tear measuring >3 cm. Of the remaining patients, three had recurrent tears that were smaller than they were before surgery and thirteen had recurrent tears of the same size.

Patient Satisfaction

Patients were asked whether they were satisfied with the operation and whether they would undergo the procedure again. All were satisfied. None of the patients stated that they would decline the procedure. At the time of writing, none of the patients had undergone subsequent procedures.

Complications

There were no surgical complications.

Discussion

To our knowledge, none of the previous studies in which this type of investigation has been attempted^{1,5,8} have focused on arthroscopically treated shoulders. Many used arthrography as the means of assessing the integrity of the repair^{1,2,6}. While this imaging technique can be reliable in detecting defects, it provides little information with regard to tear size and configuration¹⁸. A leak of contrast medium may not always indicate that a repair has failed and to what extent. Conversely, bursal scarring may falsely limit leakage of contrast medium in shoulders that have been repaired. Also, in some reports, only a subset of the patients was studied with postoperative imaging⁶. The prevalence of recurrent tears in the present study was higher than that previously reported in studies of larger tears^{1,5}. This may have been due to the increased accuracy of modern ultrasound techniques^{10,11}. It was difficult to compare our study with those in which arthrography was used because of the greater specificity and accuracy of ultrasound³. An additional consideration is that arthroscopic repair of the rotator cuff may not yield as strong a repair as traditional open or mini-open techniques. This may be especially true with poor-quality tissue. Additionally, our rehabilitation protocol with the immediate use of active-assisted pulley exercises may have contributed to failure.

We found that seventeen of the eighteen repairs had recurrent defects at a minimum follow-up of one year. Nevertheless, thirteen patients (72%) had American Shoulder and Elbow Surgeon scores of ≥ 90 points. Those thirteen patients all had improvement with respect to pain relief, range of motion, the ability to perform activities of daily living, and the subjective sense of weakness. An excellent overall result despite a recurrent defect is consistent with the findings in other reports in which this relationship was studied. Harryman et al.⁵ found that only 57% of the repairs in which the tear had involved the supraspinatus and infraspinatus tendons were intact, and fewer than one-third of the tears that involved all

three major tendons were intact at the time of the final follow-up. Gazielly et al.⁴ had similar results and found that the prevalence of recurrence after a repair involving two tendons was 41%. That study contained tears of all sizes, and a strong correlation was found between the size of the initial defect and the size of a recurrent tear. The patients in both of those studies had open repair. Jost et al.⁸ studied a group of twenty patients with recurrent tears after an open repair. That study also included tears of all sizes, with only two involving three tendons. Despite structural failure, there was marked clinical improvement in comparison with the preoperative state. Harryman et al.⁵ and Gazielly et al.⁴ both concluded that patients with smaller tears had a higher rate of healing and that the functional outcome in patients with an intact cuff after open repair was better than the functional outcome in those with recurrent defects. In contrast, Liu and Baker¹ did not find that the integrity of the rotator cuff at the time of follow-up determined the functional outcome. That study involved patients who had arthroscopically assisted mini-open repairs. In that procedure, the deltoid was split rather than detached from the anterior acromion.


Because only two-thirds of the patients in our study had American Shoulder and Elbow Surgeons scores of ≥ 80 points, there may be a relationship between cuff integrity and functional outcome in some patients. Even more concerning was the apparent decline in functional outcome with the longer duration of follow-up. It is unclear whether the high rate of recurrent tears in the present study reflects the difference between arthroscopic and open repairs. Alternatively, the poor rate of healing seen in our study may be more reflective of the large size and chronicity of the tears and the average age of the individuals included in this study. This issue could be important. If a high recurrence rate after repair of massive tears is to be expected, regardless of the operative technique, there may be a benefit to preserving the anterior deltoid attachment to the acromion with the use of a less invasive approach. In experienced hands, deltoid detachment has been a rare but devastating complication of an open rotator cuff repair^{19,22}. In less experienced hands, deltoid complications may be more common. Furthermore, rehabilitation of the shoulder after repair is less restricted when the possibility of a deltoid dehiscence is eliminated. A complete arthroscopic repair may offer advantages over both the open and mini-open repair in terms of morbidity associated with the deltoid. During a mini-open repair, retractors are placed in the deltoid split. Retraction through the small, lateral muscle split can also cause deltoid injury, especially if there is prolonged surgical time, and this may be responsible for the increased rate of stiffness seen after mini-open repairs^{23,24}.

Our study has some inherent limitations. The number

of patients is relatively small, and extrapolation of the data to patients with small or medium-sized tears is not possible.

The indications for an arthroscopic rather than an open repair are unclear at this point. Also unclear is the explanation as to why two-thirds of our patients had such significant and persistent improvement. The potential reasons include the biceps tenotomy, débridement, or initial soft-tissue coverage of the humeral head followed by a careful rehabilitation program. As it is widely known that a large number of people in this age-group have asymptomatic rotator cuff tears, the goal in these patients may be to transform a symptomatic tear to an asymptomatic tear²⁵. An arthroscopic repair arguably may not be the most appropriate procedure for a younger person with a massive tear in whom long-term strength is more important, and a strong argument can be made for mini-open or open repair in this particular population. Future studies on arthroscopic repair methods and basic-science studies to improve the biological healing of the rotator cuff need to be performed before further recommendations can be made.

Appendix

 A table showing the American Shoulder and Elbow Surgeons scores for all patients is available with the electronic versions of this article, on our web site at www.jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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