Arthroscopic Versus Mini-Open Rotator Cuff Repair: A Comparison of Clinical Outcome

Andreas M. Sauerbrey, M.D., Charles L. Getz, M.D., Marco Piancastelli, M.D., Joseph P. Iannotti, M.D., Ph.D., Matthew L. Ramsey, M.D., and Gerald R. Williams, Jr., M.D.

Purpose: To compare the outcome of patients who underwent rotator cuff repair using all arthroscopic or mini-open repair techniques. **Type of Study:** Retrospective comparative study. **Methods:** We retrospectively reviewed 54 patients who underwent either mini-open or arthroscopic rotator cuff repair. Twenty-six patients underwent mini-open repair and 28 patients had arthroscopic repair. Follow-up averaged 33 months (range, 18 to 48 months) for the mini-open group and 19 months (range, 13 to 26 months) for the arthroscopic group. The patient groups were similar with regard to age, activity level, mechanisms of injury, associated findings at surgery, and tear size measured in square centimeters. The outcome for the 2 groups was evaluated using a modified American Shoulder and Elbow Society (ASES) score. Statistical analysis was performed using Pearson correlations and the Student *t* test. **Results:** The tear size averaged 2.7 cm^2 for the mini-open group and 2.0 cm^2 for the arthroscopic group ($P = .754$). All patients showed significant improvement in their scores for pain, satisfaction, and function at the time of follow-up. The average preoperative and postoperative scores for the mini-open group were as follows: pain 17 and 27 (30 possible points), satisfaction 3 and 9 (10 possible points), function 32 and 53 (60 possible points), and total 52 and 89 (100 possible points) ($P < .05$). For patients who underwent arthroscopic repair, average preoperative and postoperative scores were as follows: pain 12 and 26, satisfaction 2 and 9, function 28 and 51, and total, 42 and 86 ($P < .05$). Improvement in scores within each group was significant, but the difference in total scores between the 2 techniques was not statistically significant. **Conclusions:** This study confirms that short-term results for arthroscopic and mini-open rotator cuff repair are similar and supports continued use of arthroscopic repair techniques. **Level of Evidence:** Level III, retrospective comparative study. **Key Words:** Mini-open rotator cuff repair—Arthroscopic rotator cuff repair.

With the introduction of new instruments and techniques, all arthroscopic rotator cuff repairs have become technically possible. The ability to evaluate, mobilize, prepare, and secure the torn tendons with arthroscopic surgery has led to concerns about the quality of arthroscopic repair and patient outcome. Despite the challenges of this technique, the short-term results of arthroscopic rotator cuff repair have been promising and compare favorably with results obtained with the open and mini-open technique.[1-8] However, direct comparisons of mini-open versus arthroscopic rotator cuff repair have been limited.[9] The purpose of this study was to compare the outcome of patients who underwent rotator cuff repair using all arthroscopic versus mini-open repair techniques in a comparable patient population.

METHODS

A retrospective review compared the results of patients who had undergone mini-open and arthroscopic

From the Shoulder and Elbow Service, University of Pennsylvania (A.M.S., C.L.G., M.L.R., G.R.W.), Philadelphia, Pennsylvania; the University of Bologna (M.P.), Bologna, Italy; and the Department of Orthopaedic Surgery, Cleveland Clinic Foundation (J.P.I.), Cleveland, Ohio, U.S.A.

Address correspondence and reprint requests to Gerald R. Williams, Jr., M.D., Shoulder and Elbow Service, 1 Cupp Pavilion, Presbyterian Hospital, 39th and Market Sts, Philadelphia, PA 19104, U.S.A. E-mail: Gerald.Williams@uphs.upenn.edu

0749-8063/05/2112-4316$30.00/0

doi:10.1016/j.arthro.2005.09.008

rotator cuff repairs. Patients were identified by a database of all patients treated operatively by one of the 3 senior authors (G.R.W., J.P.I., M.L.R.) for full-thickness rotator cuff tears between January 1, 1997 and December 31, 1999. Patients who were followed-up for less than 1 year after the index procedure were excluded.

The database search identified 548 patients who had surgery to address rotator cuff pathology during the study period. Of the 548 patients, 377 patients underwent open acromioplasty and rotator cuff repair. The remaining 181 patients had arthroscopically assisted rotator cuff procedures; 69 of these 181 patients had rotator cuff repair. Six patients were followed-up for less than 1 year. Therefore, 63 patients met the inclusion criteria. Seven patients were lost to follow-up and 2 patients died. Consequently, 54 patients were included in the study. At the study institution, mini-open rotator cuff repair was only performed for a finite period of time (1993 to 1999). The study period represents a transition from mini-open to arthroscopic rotator cuff repair.

Of the 54 patients included in the final study, 26 had mini-open cuff repair and 28 had arthroscopic cuff repair. An institutional protocol collected patient data by use of a standardized intake form at initial, operative, and final evaluations. These forms were used to calculate the modified American Shoulder and Elbow Society (ASES) scores.

The average age of the patients in the mini-open group was 57 years (range, 40 to 84 years) and that of the patients in the arthroscopic group was 56 years (range, 38 to 86 years). Sixteen patients (57%) in the mini-open group were men, compared with 16 (73%) in the arthroscopic group. Nine (32%) patients with arthroscopic repairs and 16 (62%) with mini-open repairs participated in sports at the time of treatment. The mechanisms of injury for patients in the mini-open group were as follows: fall 6, lifting 4, sports 3, not specified 4, motor-vehicle accident 3, and insidious, 6. For patients in the arthroscopic group, the mechanisms of injury were as follows: fall 7, lifting 5, sports 3, not specified 6, and insidious 7. Four patients in each group had previous surgery on the same shoulder. The follow-up period averaged 33 months (range, 18 to 48 months) for the patients in the mini-open group and 19 months (range, 13 to 25 months) for patients in the arthroscopic group.

Surgical treatment was recommended to patients with severe pain and/or loss of function unresponsive to at least 3 months of conservative treatment. Nonoperative intervention included subacromial steroid injection, nonsteroidal anti-inflammatory medication, and physical therapy. At the time of surgery, tear size, additional findings, and procedures were documented. Tear size was measured after bursectomy and complete exposure of the rotator cuff. A calibrated probe was used for all measurements. The mediolateral measurement was made from the greater tuberosity to the medial extent of the tear. The anteroposterior measurement was made from the edge of the tear anteriorly (usually at the margin of the rotator interval) to the posterior edge of the tear (usually at or into the infraspinatus tendon). The final tear dimension in square centimeters is the product of these 2 measurements.

Surgical Technique

After administration of an interscalene block and induction of general anesthesia, all patients were placed into the beach-chair position. For both techniques, standard anterior and posterior portals were used to evaluate the glenohumeral joint and to treat intra-articular lesions as necessary. The arthroscope was introduced into the subacromial space and an anterolateral portal located in line with the anterior border of the clavicle was established as a working portal. Acromioplasty and, when indicated, distal clavicle excision were performed before rotator cuff repair. The mini-open technique with acromioplasty was performed as previously described.[10,11] For the mini-open repair, the rotator cuff was secured to the tuberosity using sutures through bone in all cases.

For the arthroscopic repair, a posterolateral portal located midway between the anterolateral and posterior portals was used for visualization of the rotator cuff. An extensive bursectomy was performed. When needed, articular-sided capsular release and coracohumeral ligament release were performed arthroscopically. The edge of the tear was debrided to remove macroscopically friable and degenerated tissue, leaving a smooth edge for repair. The tuberosity was freed of soft tissue with electrocautery or a shaver, then was lightly contoured with an arthroscopic burr to expose bleeding bone but without creating a trough. The configuration of the rotator cuff tear was determined to decide on the need for side-to-side sutures and anchor placement.

For arthroscopic repairs and 7 mini-open repairs, patients required side-to-side sutures using anterior or posterior rotator interval slides or the margin convergence technique described by Burkhart et al.[12] In all cases, the edge of the rotator cuff was secured to the

tuberosity using anchors with nonabsorbable simple sutures. In no case was the repair site medialized onto the articular surface. In all cases, the repair could be accomplished with the arm at the side.

Postoperative Management

Patients were placed into a sling for small and medium size tears. Patients with large and massive tears were placed in an abduction pillow to help protect the repair for 4 to 6 weeks. This decision was not based on the method of repair. All patients were instructed in a home exercise program by a physical therapist before surgery. Two patients who underwent mini-open repair were admitted to the hospital overnight. While in the hospital, they received instruction from a therapist on pendulum and passive range of motion exercises. Passive range of motion exercises consisted of forward elevation and external rotation for all patients. All patients who had arthroscopic rotator cuff repair were discharged the day of surgery with an instruction sheet for pendulum and passive range of motion exercises.

On the first postoperative visit, patients reviewed the home exercise program with a therapist. Passive range of motion exercises continued for 6 weeks. Active range of motion exercises and progressive strengthening with Therabands (Hygienic Corp, Akron, OH) were begun at 6 weeks and continued until final follow-up. If the patient displayed full range of motion and good function of the rotator cuff, full activity was allowed at 5 to 6 months.

Preoperative and Postoperative Assessment

The modified ASES score was used to assess outcome in all of our patients. The modified ASES score is a 100-point score that is the sum of scores for pain (30 points), satisfaction (10 points), and function (60 points). Patients were asked to rate their pain at rest, during activities of daily living, and strenuous activity using a 10-point visual analog pain scale with 10 representing no pain and 0 severe pain. The pain score was the sum of the 3 results. Patients were asked to rate overall satisfaction with their current level of shoulder function from 0 (not satisfied) to 10 (completely satisfied). Patients rated their function based on the ability to perform activities with the involved shoulder. A 4-point Likert scale, range 0 to 3, was used with response options ranging from cannot do at all to no difficulty, respectively. Activities included the ability to tuck in a shirt tail, dressing (including putting on a coat), wash the back of opposite shoulder, comb hair, use the arm at shoulder level, carry objects with the arm to the side, use the hand overhead, do overhead sporting activities, perform household chores, do the usual work, and do the usual sport. The function score of each patient was determined by totaling these numeric responses.

Statistical Analysis

Pearson's correlations were used to compare patient age, type of surgery, and preoperative and postoperative modified ASES scores. Statistical significance between preoperative and postoperative scores was calculated using the Student t test.

RESULTS

A summary of the modified ASES scores is shown in Table 1. All patients showed improvement in their modified ASES scores with surgery. The initial modified ASES score for patients in the arthroscopic group averaged 42, and this improved to an average final score of 86 ($P < .05$). For patients in the mini-open group, the initial score averaged 52, improving to an average final score of 89 ($P < .05$). The preoperative and postoperative modified ASES scores were not significantly different between groups ($P = .252$ and $P = .333$, respectively). The average preoperative and postoperative scores based on tear size are provided in Table 2.

In addition, the individual scores for pain, satisfaction, and function showed significant improvement for

Table 1. *Preoperative and Postoperative Modified ASES Scores (range) for Each Group*

	Arthroscopic		Mini-Open	
	Preoperative	Postoperative	Preoperative	Postoperative
Pain (30 points)	12 (1-27)	26 (15-30)	17 (4-26)	27 (16-30)
Satisfaction (10 points)	2 (0-10)	9 (1-10)	3 (0-9)	9 (5-10)
Function (60 points)	28 (7-47)	51 (18-60)	32 (14-46)	53 (25-60)
Total (100 points)	42 (9-47)	86 (43-100)	52 (17-75)	89 (56-100)

TABLE 2. *Preoperative and Postoperative Scores for Varying Rotator Cuff Tear Sizes for Each Technique*

	Tear Size and Modified ASES Score		
	1-3 cm^2	>3-6 cm^2	>6-12 cm^2
Arthroscopic (preop/postop)	44/84 (22)*	55/91 (3)	17/99 (3)
Mini-open (preop/postop)	52/92 (17)	43/80 (6)	67/93 (3)

*Number of patients.

both groups. Patients who underwent arthroscopic repair had an average improvement in pain, satisfaction, and function scores from 12 to 26 ($P < .05$), 2 to 9 ($P < .05$), and 28 to 51 ($P < .05$), respectively. For patients who underwent mini-open repair, the average pain, satisfaction, and function scores improved from 17 to 27 ($P < .05$), 3 to 9 ($P < .05$), and 32 to 53 ($P < .05$), respectively.

Additional Procedures

At the time of rotator cuff repair, 16 patients (57%) had additional procedures in the arthroscopic group and 15 patients (58%) had additional procedures in the mini-open group. Several patients in both groups had more than 1 additional procedure concurrent with the rotator cuff repair. In both groups, 5 patients had distal clavicle excision. In the arthroscopic group, 3 patients had arthroscopic capsular release, and 2 patients had arthroscopic capsular release in the mini-open group. Nine patients had procedures related to the biceps in both groups. In the arthroscopic group, 3 patients had tenotomy, 4 patients had arthroscopic tenodesis, and 2 patients had type 1 SLAP lesion debridement. In the mini-open group, 7 patients had open tenodesis and 2 patients had type 1 SLAP debridement. One patient in the arthroscopic group had debridement of a 2×3 cm osteochondral defect of the humeral head.

Tear Size

Tear size averaged 2.0 cm^2 (range, 1 to 12 cm^2) for the arthroscopic group and 2.7 cm^2 (range, 1 to 8 cm^2) for the mini-open group. The tear sizes were not significantly different between groups ($P = .754$). The average anteroposterior tear dimension was 1.5 cm and the average mediolateral tear dimension was 1.3 cm for the arthroscopic group. For the mini-open group, the average anteroposterior tear dimension was 1.8 cm and the average mediolateral tear dimension was 1.5 cm. Four patients in the arthroscopic group and 7 patients in the mini-open group required side-to-side repair.

DISCUSSION

Although arthroscopic rotator cuff repair is a relatively new technique, several investigators have published reports of their short-term results for arthroscopic repair of full-thickness rotator cuff tears.[1-4,6,9,12-16] Mini-open repair represented an attempt to combine the best features of arthroscopic and open repair. The ability to address intra-articular pathology and still repair the tendon with bone tunnels without taking down the deltoid origin has made mini-open repair a popular technique. Short-term results of mini-open repair have been encouraging.[4,5,11]

Gartsman et al.[1] reported on a series of 73 patients who had undergone arthroscopic rotator cuff repair and were followed-up for a minimum of 2 years. Patients improved their ASES scores from an average of 30.7 to 87.6. Based on Constant and Murley scores, 84% of patients had either a good or excellent result.[1] These results were similar to the results obtained with either open or mini-open repair and have provided a basis for the continued use of this technique.[5,7,10,11,17-19] However, these studies do not provide a direct comparison between techniques in a similar patient population.

Servud and his colleagues[9] compared 35 patients who had undergone mini-open repair with 29 patients with arthroscopic repair. At final follow-up, which averaged 44.6 months, there was no significant difference in function or range of motion. However, they reported that 4 of the 29 patients developed stiffness. Final outcome as measured by the ASES, UCLA, and SST scores were similar.

There are several weaknesses to the present study, including differences in length of follow-up, tear-size, patient demographics, and the small number of patients. The patients who underwent arthroscopic rotator cuff repair had a shorter length of follow-up. However, maximum improvement from arthroscopic rotator cuff repair occurs in the first year and, therefore, may allow for accurate comparison between the study groups.[2] Another weakness of this study is the lack of anatomic data. Harryman et al.[20] reported that patients who have undergone open rotator cuff repair have improvement in their symptoms even if the repair fails. Patients whose repairs heal, however, have better results than those who do not. Therefore, the functional data and anatomic data need to be corre-

lated for arthroscopic and mini-open techniques to truly assess there effectiveness.

A universal classification of rotator cuff tears does not exist. Two common methods are to report the number of tendons involved or the anterior to posterior dimension. The shortcoming of such classification systems are failure to reflect the degree of retraction. This study presents tear size as represented by the area of the tear to reflect not only the anterior to posterior dimension, but also the degree of retraction.

The study period occurred during a transition to all-arthroscopic rotator cuff repair. In the beginning of the study period, all patients were undergoing mini-open repair, and by the end, all were undergoing arthroscopic repair. In the overlap period, selection bias may have been introduced. There were more men and tear sizes were smaller in the arthroscopic group, whereas patients in the mini-open group had a higher activity level. Patient demographics were similar in age, mechanism of injury, and previous surgeries. The effect of the group variability on the final results is difficult to estimate. The selection of smaller tears in less active patients may inflate the final modified ASES scores for patients with arthroscopic repair. Ideally, a randomized prospective study could balance the groups and prevent selection bias.

The use of bone tunnels for mini-open repair may have influenced results in several ways. The effect of healing of transosseous repair compared with suture anchors on cuff healing is not known, but introduces another variation between techniques. Familiarity with bone tunnel repair technique used may have influenced the selection of larger tears to be repaired by the mini-open technique.

The relatively small number of patients who had tears larger than 3 cm^2 did not allow for meaningful intragroup comparison. Similarly, comparing patients with tears of similar size between groups was not possible because of the small sample size. Therefore, only the results of statistics comparing the entire group's outcome are presented. Both groups had a similar number of additional procedures. Previous studies have not reported additional procedures when presenting results of arthroscopic rotator cuff repair; 58% of patients in this study required additional procedures in both groups at the time of cuff repair. In our experience, it is common to need to address additional pathology with rotator cuff repair. The exclusion of patients with additional procedures would not represent the most common clinical scenario. Because the percentage and type of procedures for patients in each group were similar, the outcome of both groups was probably similarly affected. One exception may have been the patient who required arthroscopic debridement of a 2 $\times$ 3 cm osteochondral defect during arthroscopic rotator cuff repair. His preoperative and postoperative scores were 40 and 74, respectively.

CONCLUSIONS

Mini-open and arthroscopic rotator cuff repair both improved the function of patients who failed nonoperative treatment, but no difference was found between groups. Both techniques were effective in patients with various tear sizes from 1 cm^2 up to 12 cm^2. Furthermore, there was concurrent intra-articular pathology in a large percentage of the patients (58%) undergoing rotator cuff repair. The effectiveness and the ability to address concurrent pathology with arthroscopic and mini-open rotator cuff repair was also reinforced. However, neither could be shown to be more effective. Further anatomic data are needed to more fully evaluate the effectiveness of arthroscopic and mini-open rotator cuff repair techniques.

REFERENCES

1. Gartsman GM, Khan M, Hammerman SM. Arthroscopic repair of full-thickness tears of the rotator cuff. *J Bone Joint Surg Am* 1998;80:832-840.
2. Gartsman GM, Brinker MR, Khan M. Early effectiveness of arthroscopic repair for full-thickness tears of the rotator cuff: An outcome analysis. *J Bone Joint Surg Am* 1998;80:33-40.
3. Tauro JC. Arthroscopic rotator cuff repair: Analysis of technique and results at 2- and 3-year follow-up. *Arthroscopy* 1998;14:45-51.
4. Hata Y, Saito S, Murakami N, Seki H, Nakatsuchi Y, Takaoka K. A less invasive surgery for rotator cuff tear: Mini-open repair. *J Shoulder Elbow Surg* 2001;10:11-16.
5. Hersch JC, Sgaglione NA. Arthroscopically assisted mini-open rotator cuff repairs. Functional outcome at 2- to 7-year follow-up. *Am J Sports Med* 2000;28:301-311.
6. Gleyze P, Thomazeau H, Flurin PH, Lafosse L, Gazielly DF, Allard M. [Arthroscopic rotator cuff repair: a multicentric retrospective study of 87 cases with anatomical assessment]. *Rev Chir Orthop Reparatrice Appar Mot* 2000;86:566-574.
7. Bigliani LU, Cordasco FA, McIlveen SJ, Musso ES. Operative repairs of massive rotator cuff tears: Long-term results. *J Shoulder Elbow Surg* 1992;1:120-130.
8. Hoffman F, Schiller M, Reif. G. Arthroscopic rotator cuff reconstruction. *Orthopade* 2000;29:888-894.
9. Severud EL, Ruotolo C, Abbott DD, Nottage WM. All-arthroscopic versus mini-open rotator cuff repair: A long-term retrospective outcome comparison. *Arthroscopy* 2003; 19:234-238.
10. Paulos LE, Kody MH. Arthroscopically enhanced "miniapproach" to rotator cuff repair. *Am J Sports Med* 1994;22:19-25.
11. Blevins FT, Warren RF, Cavo C, et al. Arthroscopic assisted rotator cuff repair: Results using a mini-open deltoid splitting approach. *Arthroscopy* 1996;12:50-59.
12. Burkhart SS, Danaceau SM, Pearce CE Jr. Arthroscopic rotator cuff repair: Analysis of results by tear size and by repair

technique—Margin convergence versus direct tendon-to-bone repair. *Arthroscopy* 2001;17:905-912.
13. Bennett WF. Arthroscopic repair of massive rotator cuff tears: A prospective cohort with 2- to 4-year follow-up. *Arthroscopy* 2003;19:380-390.
14. Ellman H, Kay SP, Wirth M. Arthroscopic treatment of full-thickness rotator cuff tears: 2- to 7-year follow-up study. *Arthroscopy* 1993;9:195-200.
15. Bennett WF. Arthroscopic repair of full-thickness supraspinatus tears (small-to-medium): A prospective study with 2- to 4-year follow-up. *Arthroscopy* 2003;19:249-256.
16. Jones CK, Savoie FH III. Arthroscopic repair of large and massive rotator cuff tears. *Arthroscopy* 2003;19:564-571.
17. Hawkins RJ, Misamore GW, Hobeika PE. Surgery for full-thickness rotator-cuff tears. *J Bone Joint Surg Am* 1985;67:1349-1355.
18. Ellman H, Hanker G, Bayer M. Repair of the rotator cuff. End-result study of factors influencing reconstruction. *J Bone Joint Surg Am* 1986;68:1136-1144.
19. Shinners TJ, Noordsij PG, Orwin JF. Arthroscopically assisted mini-open rotator cuff repair. *Arthroscopy* 2002;18:21-26.
20. Harryman DT II, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA 3rd. Repairs of the rotator cuff. Correlation of functional results with integrity of the cuff. *J Bone Joint Surg Am* 1991;73:982-989.