Original Article

Clinical and radiographic factors influencing the results of revision rotator cuff repair

Robert U. Hartzler, John W. Sperling, Cathy D. Schleck[1], Robert H. Cofield

Access this article online

Website: www.internationalshoulderjournal.org

DOI: 10.4103/0973-6042.114221

Quick Response Code:

Department of Orthopedic Surgery, and [1]Division of Biomedical Statistics and Informatics, Mayo Clinic, Rochester, MN 55905, USA

Address for correspondence:
Dr. Robert H. Cofield,
Department of Orthopedic Surgery, 200 First Street, SW, Rochester MN 55905, USA.
E-mail: cofield.robert@mayo.edu

ABSTRACT

Purpose: Historically, results of open revision of rotator cuff repair have been mixed and often poor. We reviewed the outcomes of revision rotator cuff repair with a detailed analysis of clinical and radiographic risk factors in order to improve patient selection for this type of surgery.

Materials and Methods: Thirty-six patients (37 shoulders) underwent first-time, open revision rotator cuff repair between 1995 and 2005. Average follow-up was 7.0 years (range 1-14.9 years). The tear size was small in 1 shoulder, medium in 8, large in 22 and massive in 6. Associations of 29 clinical and radiographic factors with the outcomes of pain, motion, and function were assessed.

Results: Satisfactory outcome occurred in 22 shoulders (59%): An excellent result in 2, a good result in 7, and a fair result in 13. Unsatisfactory, poor results occurred in 15. Pain was substantially reduced in 25 (68%). Median pain scores decreased to five from a pre-operative eight ($P = 0.002$). Median motion did not change from pre-operative to post-operative. The chance of a satisfactory outcome and improved post-operative motion were associated with males, greater pre-operative motion, increased acromial humeral distance, the absence of glenohumeral arthritis, or a degenerative re-tear.

Conclusions: Revision rotator cuff repair, although a safe operation, with a low re-operative rate, has very mixed overall results. By knowing the factors associated with success, surgeons can better counsel patients and with this increased knowledge, consider alternative treatment choices.

Key words: Factor analysis, revision, rotator cuff, shoulder

INTRODUCTION

Primary, open rotator cuff repair yields substantial improvements;[1-4] however, 4-5% will require revision repair.[1,5] The results of revision rotator cuff repair have been mixed.[6-9] At our institution, the earlier results for revision repair were disappointing.[7] Reverse shoulder arthroplasty is now an option for rotator cuff tear arthropathy,[10] and other complex shoulder problems with rotator cuff insufficiency.[11,12] Therefore, the ability to predict the likelihood of success or failure for revision repair would be valuable. Currently, substantial importance is attached to rotator cuff tear, size, tendon quality, remaining muscle volume, and the degree of fatty infiltration seen on imaging. The purpose of the study is to investigate whether additional clinical, radiographic, or intraoperative findings are associated with success or failure in the repeat operation.

MATERIALS AND METHODS

A search of the surgical database at our institution was performed to identify patients who had undergone first-time, open revision rotator cuff repair from the January 1995 to December 2005. The operations were performed by four surgeons, including one of the senior authors. The minimum duration of follow-up was 1 year, either by clinical visit or the use of a validated shoulder survey.[13] Patients who had undergone prior revision rotator cuff repair, who were treated for a partial-thickness re-tear, or who had a revision rotator cuff repair associated with arthroplasty or labral reconstructive procedures were excluded. Patients who were deceased and did not have minimum follow-up were excluded. Patients who underwent tendon transfers were also excluded. Thirty-six patients (37 shoulders) from our database met the inclusion

Please cite this article as: Hartzler RU, Sperling JW, Schleck CD, Cofield RH. Clinical and radiographic factors influencing the results of revision rotator cuff repair. Int J Shoulder Surg 2013;7:41-5.

criteria and were included in the study. Fourteen other patients who otherwise met inclusion criteria were unable to be included in the study, three who refused survey participation and 11 who were otherwise lost to follow-up. Of the included patients, the most recent follow-up was by clinical visit for 12 patients and by survey for 24. Overall, the mean follow-up was 7.0 years (range 1-14.9 years).

At the time of revision rotator cuff repair the average age was 58 years (range 41-80 years). There were 14 women and 22 men. There were 28 right shoulders and 9 left. The revision repair was done on the dominant arm in 24 shoulders and on the non-dominant arm in 13. The original rotator cuff tear was associated with a traumatic injury in 17 shoulders. The re-tear necessitating revision repair was associated with a patient-reported traumatic event in six shoulders. The original rotator cuff repair was open in 32 shoulders, mini-open in three shoulders, and all-arthroscopic in two. The average duration between rotator cuff repair and revision was 48 months (range 5 months to 20 years).

Plain radiographs and advanced imaging studies were reviewed by two of the authors. Pre-operative radiographs were available for 36 shoulders, and these were reviewed to record the acromiohumeral distance (AHD) measured with a ruler on supine 40° posterior oblique views in external rotation and grade of glenohumeral arthrosis.[14] The average AHD was 7.5 mm (range 2-12 mm), although this could only be determined in 21 shoulders due to changes from prior acromioplasty. The AHD was narrowed in 7 shoulders (2-5 mm) and wider in 14 shoulders (7-12 mm). Twenty-one shoulders had grade 0 of 3 glenohumeral arthrosis, 10 grade 1 arthrosis, two grade 2 arthrosis, and none grade 3 arthrosis.

Pre-operative magnetic resonance imaging (MRI) studies were reviewed for 17 shoulders, recording tendons torn. Five shoulders had tear in a single tendon. Eleven shoulders had a tear involving two tendons. One shoulder had a tear involving three tendons. Tear grade could be evaluated in 14 shoulders.[1] There were zero small tears, four medium tears, eight large tears, and two massive tears. Grade of atrophy (none, mild, moderate, severe)[15] and fatty degeneration (Grade 0-4)[16] of the supraspinatus, infraspinatus, and subscapularis was able to be evaluated in 17 shoulders. The supraspinatii had mean grade 2.4 fatty degeneration (range 1-4), with six having mild atrophy, eight having moderate atrophy, and three having severe atrophy. The infraspinatii had mean grade 2.3 fatty degeneration (range 0-4), with four having no atrophy, four having mild atrophy, seven having moderate atrophy, and two having severe atrophy. The subscapularis had mean grade 0.9 fatty degeneration (range 0-4), 10 having no atrophy, with five having mild atrophy, one having moderate atrophy, and one having severe atrophy.

The surgical procedure was an open, revision rotator cuff repair in all patients. Intraoperatively, the tears were small in one shoulder (<1 cm in longest length), medium in eight (1 to < 3 cm), large in 22 (3 to < 5 cm), and massive in 6 (>5 cm).[1] Six shoulders had involvement of a single tendon, 24 had two tendons involved, and seven had three tendons involved. The rotator cuff tissue was noted to be satisfactory, of firm quality and of at least one-half normal thickness, in 17 shoulders and unsatisfactory, of soft or friable quality and of less than one-half normal thickness, in 20 shoulders. Complete repair of the rotator cuff tear was achieved in all 37 shoulders. The repair was at the normal site on the humeral tuberosities, or ≤1 cm medial onto the adjacent humeral head. All but three shoulders underwent additional procedures. In addition to revision cuff repair, revision acromioplasty was done in 29, synthetic tendon augmentation in one to complete the repair, loose body removal in two, excision of heterotopic bone in two, and biceps tenodesis in one. Atrophy of the anterior deltoid or an area of thin scar tissue was found in seven shoulders, with one of those also having atrophy of the middle deltoid. Repair of the deficient deltoid could be performed in two shoulders. One shoulder was treated for pre-operative stiffness with a manipulation under anesthesia at the time of revision cuff repair. The post-operative rehabilitation protocol was surgeon directed. Patients were placed into either a shoulder sling or immobilizer with the arm near the side (n = 23), an abduction pillow brace (n = 12), or a shoulder spica cast (n = 2). Active assisted shoulder range-of-motion was delayed to a mean of 6.1 weeks (range 0-16 weeks). Strengthening exercises were started at eight to 12 weeks post-operatively for the majority of patients.

Our primary outcome measure was a published but unvalidated shoulder outcome rating system specific for revision rotator cuff repair.[8] Results were evaluated based on pain level, active range of motion, and function and graded as excellent, good, fair, or poor.[8] For an excellent result, pain must be minimal, active forward elevation and external rotation must be within 10° of normal in all planes, and function must be unrestricted activities. For a good result, pain must be limited to occasional soreness or aching, active forward elevation must be greater than 140° and active external rotation must be greater than 30°, and function must be limited only with repetitive or strenuous overhead activities. For a fair result, pain must be limited to intermittent episodes of pain necessitating occasional use of analgesics, active forward elevation must be at least 90° and active external rotation at least 5°, and function must have improved somewhat after the operation. Excellent, good, and fair outcomes were deemed to be "satisfactory," with poor outcome deemed "unsatisfactory." Secondary outcome measures were post-operative pain and range of motion for elevation and external rotation.

Statistical methods

Descriptive results are reported as median and range. Associations of clinical and radiographic factors with the outcomes of pain, elevation, and external rotation were assessed using a Wilcoxon rank sum test. The association of the patient factors with the outcome, categorized as satisfactory

versus unsatisfactory, were assessed using Fisher's exact test. The alpha-level was set at 0.05 for statistical significance. Clinical and radiographic factors used in the analysis were as follows: Sex, age at time of operation, body mass index (<30 vs. ≥30), dominant arm, workman's compensation claim, type II diabetes, smoker at the time of repair, traumatic original rotator cuff injury, traumatic reinjury of rotator cuff, time to revision (<1 year vs. ≥1 year), tear size (small/medium/large vs. massive and small/medium vs. large/massive), number of tendons torn (1 vs. 2-3 and 1-2 vs. 3), cuff tissue quality (at least one have normal thickness vs. deficient), repair quality (partial vs. complete), deltoid status (intact vs. deficient), grade of glenohumeral arthrosis (none versus mild/moderate), number of tendons torn (1 vs. ≥2), pre-operative pain, pre-operative elevation, and external rotation.

RESULTS

Complications and reoperations

No intraoperative or post-operative complications occurred. Two patients underwent additional operations. The first sustained a proximal humerus fracture and underwent conversion to shoulder hemiarthroplasty 11.5 years after the revision rotator cuff repair. The last follow-up appointment prior to the trauma occurred at 3.8 years post-operatively, at which time the patient had a fair outcome. The second underwent conversion to a reverse shoulder prosthesis at 11.3 years after the revision rotator cuff repair. The outcome at the last follow-up prior to the revision was poor with active elevation to 40°.

Pain and motion

Post-operative pain decreased to median 5.0 from pre-operative median 8.0 (P = 0.002). Eighteen shoulders (49%) had slight pain or none, nine (24%) had occasionally moderate pain, seven (19%) had moderate pain, and three (8%) had severe pain. Final pain score was associated with better pain reduction in men (P = 0.040), and in those with a degenerative re-tear (P = 0.043).

Post-operative active elevation decreased to median 110° from pre-operative median 130°, but this difference was not significant (P = 1.00). Greater post-operative active elevation was associated with male gender (median 131 ± 47°) versus female gender (median 95 ± 52°), (P = 0.036), and AHD ≥ 7 mm versus < 7 mm (median 168 ± 31° vs. median 60 ± 49°, P = 0.016). Greater post-operative active elevation was weakly associated with no glenohumeral arthrosis (median 137 ± 46°) versus mild or moderate arthrosis (median 104 ± 50°, P = 0.074). Post-operative elevation was weakly correlated with pre-operative elevation (P = 0.055). Post-operative active external rotation decreased to median 41° from pre-operative median 50°, but this difference was not significant (P = 0.30). Greater post-operative external rotation was associated with no glenohumeral arthrosis (median 51 ± 27°) versus mild or moderate arthrosis (median 31 ± 23°, P = 0.015). Greater post-operative external rotation was weakly associated with 1 or 2 supraspinatus fatty infiltrates (median 60 ± 29°) versus 3 or 4 (median 20 ± 14°), (P = 0.056). Post-operative external rotation was weakly correlated with pre-operative external rotation (P = 0.053).

Result ratings and factor analysis

There was a satisfactory outcome in 22 shoulders (59%) and an unsatisfactory outcome in 15 (41%) shoulders. An excellent result was achieved in two shoulders (5%), a good result in seven (19%), a fair result in 13 (33%), and a poor result in 15 (41%). Of the 15 poor results, 7 (47%) were rated as such for failure in a single criterion (pain in two, elevation in five), while the others were rated as such for failure in two or more criteria. Pre-operative elevation was associated with a satisfactory outcome in the factor analysis. Of those with a satisfactory outcome, pre-operative elevation was 142° versus 90° for those with an unsatisfactory outcome (P = 0.033). In addition, AHD (>7 vs. <7) was associated with a satisfactory outcome [Table 1].

DISCUSSION

Revision rotator cuff repair is safe without complications, at least in this group of patients, and there were only two reoperations, both done late, over a decade after the revision procedure. However, the results of this study show open revision rotator cuff repair continues to have a modest rate of satisfactory outcomes, with the majority of these being good or fair ratings. Revision repair was successful in decreasing pain (25 of 37 shoulders) but was not successful in increasing elevation or external rotation. We were able to identify several clinical factors associated or trending toward association with outcome, including males, greater pre-operative elevation, greater pre-operative external rotation, and a degenerative re-tear. From an imaging perspective, factors associated or trending toward association with outcome were the absence of glenohumeral arthritis, an increased AHD, and grade 1 or 2 supraspinatus fatty infiltration. Surprisingly, even with this number of shoulders studied, many other factors were not associated with outcome, including arm dominance, trauma initially, the quality of the rotator cuff tissue at surgery, a partial repair, thinning of the overlying portion of the deltoid muscle, workers' compensation issues, the presence of diabetes mellitus, or the history of smoking. In contrast to our previous report,[7] this series had a somewhat more favorable outcome for pain relief, a lower rate of unsatisfactory outcomes, even with our final outcome measure in this series being even stricter, and a very infrequent need for additional surgery.

Our results differed in several respects with those of Djurasovic *et al.*[8] Our rate of satisfactory outcomes was lower (59% vs. 69%). We also did not show significant improvements in active elevation or external rotation versus statistically significant increases of 25° and 14°, respectively. With regard

Table 1: Risk factor analysis for final result rating

Factor	Satisfactory (*N*=22) (%)	Unsatisfactory (*N*=15) (%)	Fisher's exact *P* value
Gender			0.169
Female	4 (42.9)	8 (57.1)	
Male	16 (69.6)	7 (41.2)	
Age at revision			1.000
<60	12 (60)	8 (40)	
≥60	10 (58.8)	7 (41.2)	
Workmans' comp			1.000
No	14 (60.9)	9 (39.1)	
Yes	8 (57.1)	6 (42.9)	
Diabetes mellitus			0.633
No	19 (57.6)	14 (42.4)	
Yes	3 (75)	1 (25)	
Interval from primary to revision			0.080
<1 year	4 (36.4)	7 (63.6)	
≥1 year	18 (69.2)	8 (30.8)	
Intraoperative tear grade			0.711
Small/med	6 (66.7)	3 (33.3)	
Large/massive	16 (57.1)	12 (42.9)	
Rotator cuff quality			1.000
Normal	10 (58.8)	7 (41.2)	
Deficient	12 (60)	8 (40)	
Repair			0.405
Partial	0 (0)	1 (100)	
Complete	22 (61.1)	14 (38.9)	
Deltoid status			0.377
Intact	20 (62.5)	12 (37.5)	
Deficient	2 (40)	3 (60)	
Arthrosis			0.322
Missing	0	1	
None	12 (70.6)	5 (29.4)	
Mild/moderate	10 (52.6)	9 (47.4)	
Torn tendons			0.408
1 or 2	19 (63.3)	11 (36.7)	
3	4 (47.1)	3 (42.9)	
Acromiohumeral distance			0.025
Missing	6	10	
<7	3 (42.9)	4 (57.1)	
≥7	13 (92.9)	1 (7.1)	
MRI torn tendon			0.353
1 or 2	11 (68.8)	5 (31.2)	
3	0 (0)	1 (100)	
Supraspinatus atrophy			1.000
None, mild	4 (66.7)	2 (33.3)	
Moderate, severe	7 (63.6)	4 (36.4)	
Infraspinatus atrophy			0.62
None, mild	6 (75)	2 (25)	
Moderate, severe	5 (55.6)	4 (44.4)	
Supraspinatus fatty infiltration			0.64
Grade 1,2	7 (70)	3 (30)	
Grade 3,4	4 (57.1)	3 (42.9)	
Infraspinatus fatty infiltration			0.62
Grade 1,2	6 (75)	2 (25)	
Grade 3,4	5 (55.6)	4 (44.4)	

to risk factors, we were not able to find similar associations between deltoid and cuff status and successful outcome. Of note, the patients in our series did differ in at least one important respect. Our population had a higher proportion of massive/large tears (76% vs. 64%) than medium/small tears (24% vs. 36%). Our results also differed from other prior studies. Bigliani[6] and Neviaser[9] both showed large improvements in active elevation (36° and 50°, respectively). Bigliani also reported an average increase in external rotation of 20° versus no significant difference in ours. Neviaser reported no or slight pain in 92% of patients versus 49% in this series. In addition, Neviaser reported only 12% of patients with final active elevation less than 90° versus 31% here.

There have been numerous studies assessing the prognostic factors related to a successful rotator cuff repair. Not all studies are concordant. We made an attempt to assess the importance of the previously reported factors to revision rotator cuff repair. Primary repair studies have larger number of cases and more contemporary studies will likely have consistent cross-sectional imaging leading to recognition of a greater number of important variables. Previously identified factors affecting success in primary repairs include: Age, sex, acute trauma, duration of symptoms, diabetes, smoking, relationship to work, inflammatory disease, number of steroid injections, previous surgery, weakness, lack of active motion, stiffness, upward humeral subluxation, glenohumeral arthrosis, tear size, number of tendons torn, muscle atrophy, fatty infiltration of the rotator cuff muscles, and the need for adjunctive procedures.[17] In this study focusing on clinical and plain X-ray data, a rather straight forward subset of variables largely concordant to those of a primary repair were identified – perhaps indicating a greater importance of these in predicting the success or failure of a revision rotator cuff repair. Currently, two important adjuncts to the material presented here are available. First, MRI or computed tomography arthrography are regularly included in the evaluation of these patients. This imaging adds information about tear size, tear location, the quality of tendon tissue, the amount of muscle atrophy, and the degree of fatty infiltration of the rotator cuff muscles. No doubt MRI findings are important, but this should not eliminate the importance of the clinical and plain X-ray evaluations. Second, many revision procedures will be accomplished arthroscopically with the attendant benefits of this treatment method, potentially resulting in improved outcomes.

There are weaknesses of the study. The majority of the clinical data was collected prospectively using a standard shoulder form, but, other data were collected retrospectively. Outcome data on 67% of the patients in this study was collected using a shoulder survey.[13] In an earlier study assessing the accuracy of this survey, patients who had surgery (using shoulder arthroplasty as the surgery example) were asked about their pain, motion and other parameters and then patient recorded responses were compared to physician recorded data obtained at the time of an office visit. Assessment of

intra-class correlation demonstrated almost perfect agreement between patients and physicians with regard to five of nine questions, including those related to pain and active elevation. Agreement with regard to external rotation was moderate. Calculation of mean differences between the patient and physician responses reveal that none of the mean differences were greater than one response category or 10° for any of the response items. It should be noted that a number of patients in the study did not have measurable AHD on pre-operative X-rays, fluoroscopic positioning to more accurately assess the exact AHD, or pre-operative MRI evaluations. Furthermore, the patients represent a relatively small cohort; however, all were treated at the same institution by a small group of surgeons using a relatively uniform treatment algorithm.

An additional strength is the focus of the study – factor analysis. Twenty-nine different factors that might affect the outcome were identified and assessed. Although many may have an effect, a much larger number of revisions would need to be performed to show this. Seemingly relevant factors have been identified that can guide a surgeon as to whether or not to perform this type of revision tendon surgery.

Revision repair of failed rotator cuff repair continues to have a large number of unsatisfactory results at our institution. Based on the results of this study, we will continue to counsel our patients on the unpredictability of outcomes following the operation. Conversely, revision rotator cuff repair is a relatively safe operation with a low rate of complications reported in this and in other series.[6-9] For patients with certain risk factors for failure such as female gender, poor pre-operative range of motion, mild/moderate glenohumeral arthrosis, decreased AHD, or a traumatic rotator cuff re-tear, consideration should be given to an alternative treatment option, perhaps reverse total shoulder arthroplasty.

CONCLUSIONS

Revision rotator cuff repair, although a safe operation, with a low re-operative rate, has very mixed overall results. By knowing the factors associated with success, surgeons can better counsel patients and with this increased knowledge, consider alternative treatment choices.

REFERENCES

1. Cofield RH, Parvizi J, Hoffmeyer PJ, Lanzer WL, Ilstrup DM, Rowland CM. Surgical repair of chronic rotator cuff tears. A prospective long-term study. J Bone Joint Surg Am 2001;83-A: 71-7.
2. Ellman H, Hanker G, Bayer M. Repair of the rotator cuff. End-result study of factors influencing reconstruction. J Bone Joint Surg Am 1986;68:1136-44.
3. Galatz LM, Griggs S, Cameron BD, Iannotti JP. Prospective longitudinal analysis of post-operative shoulder function: A ten-year follow-up study of full-thickness rotator cuff tears. J Bone Joint Surg Am 2001;83-A: 1052-6.
4. Hawkins RJ, Misamore GW, Hobeika PE. Surgery for full-thickness rotator-cuff tears. J Bone Joint Surg Am 1985;67:1349-55.
5. Millett PJ, Horan MP, Maland KE, Hawkins RJ. Long-term survivorship and outcomes after surgical repair of full-thickness rotator cuff tears. J Shoulder Elbow Surg 2011;20:591-7.
6. Bigliani LU, Cordasco FA, McIlveen SJ, Musso ES. Operative treatment of failed repairs of the rotator cuff. J Bone Joint Surg Am 1992;74:1505-15.
7. DeOrio JK, Cofield RH. Results of a second attempt at surgical repair of a failed initial rotator-cuff repair. J Bone Joint Surg Am 1984;66:563-7.
8. Djurasovic M, Marra G, Arroyo JS, Pollock RG, Flatow EL, Bigliani LU. Revision rotator cuff repair: Factors influencing results. J Bone Joint Surg Am 2001;83-A: 1849-55.
9. Neviaser RJ, Neviaser TJ. Reoperation for failed rotator cuff repair: Analysis of fifty cases. J Shoulder Elbow Surg 1992;1:283-6.
10. Boileau P, Watkinson D, Hatzidakis AM, Hovorka I. Neer Award 2005: The Grammont reverse shoulder prosthesis: Results in cuff tear arthritis, fracture sequelae, and revision arthroplasty. J Shoulder Elbow Surg 2006;15:527-40.
11. Wall B, Nové-Josserand L, O'Connor DP, Edwards TB, Walch G. Reverse total shoulder arthroplasty: A review of results according to etiology. J Bone Joint Surg Am 2007;89:1476-85.
12. Mulieri P, Dunning P, Klein S, Pupello D, Frankle M. Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis. J Bone Joint Surg Am 2010;92:2544-56.
13. Smith AM, Barnes SA, Sperling JW, Farrell CM, Cummings JD, Cofield RH. Patient and physician-assessed shoulder function after arthroplasty. J Bone Joint Surg Am 2006;88:508-13.
14. Samilson RL, Prieto V. Dislocation arthropathy of the shoulder. J Bone Joint Surg Am 1983;65:456-60.
15. Warner JJ, Higgins L, Parsons IM 4th, Dowdy P. Diagnosis and treatment of anterosuperior rotator cuff tears. J Shoulder Elbow Surg 2001;10:37-46.
16. Goutallier D, Postel JM, Gleyze P, Leguilloux P, Van Driessche S. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. J Shoulder Elbow Surg 2003;12:550-4.
17. Matsen FA III, Fehringer EV, Lippitt SB, Wirth MA, Rockwood CA Jr. Rotator cuff. In: Rocwood CA Jr, Matsen FA III, Wirth MA, Lippitt SB, editors. The Shoulder. 4th ed., Vol. 2, Ch. 17. Philadelphia: Saunders, Elsevier; 2009. p. 771-889.

Source of Support: Nil, **Conflict of Interest:** Dr. Cofield receives royalties from Smith/Nephew and DJO.`