



Arthroscopic revision cuff repair: do tendons have a second chance to heal?

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Background: Few studies have investigated postoperative tendon integrity after reoperation for failed rotator cuff repair. The purpose of this study was to evaluate the anatomic and clinical outcomes of arthroscopic revision rotator cuff repair (AR-RCR) and identify the risk factors related to re-reatar.

Methods: Sixty-nine consecutive patients (mean age, 55 years) with primary failed open (38%) or arthroscopic (62%) cuff repairs underwent AR-RCR and were reviewed regarding clinical examination findings and imaging studies. Patients with massive cuff tears and upward humeral migration (acromiohumeral distance < 6 mm) or glenohumeral osteoarthritis were excluded. Revision repair was performed by a single, experienced shoulder surgeon. Complete footprint coverage was achieved in all cases using a single-row (70%), double-row (19%), or side-to-side (11%) technique. The primary outcome measure was tendon healing assessed with magnetic resonance imaging (57 cases) or computed tomography arthrogram (12 cases) performed at minimum 1-year follow-up. Secondary outcome measures included functional outcome scores, subjective results, and complications. The mean follow-up period was 43 months (range, 12–136 months).

Results: The cuff tendons did not heal to the tuberosity in 36% of the shoulders (25 of 69) following revision cuff surgery. Absence of tendon healing was associated with poorer shoulder function (average Constant score, 69 ± 20 vs. 54 ± 18; $P = .003$) and a decreased Subjective Shoulder Value (72% vs. 54%, $P = .002$). Factors that were negatively associated with tendon healing were age ≥ 55 years (odds ratio [OR], 4.5 [95% confidence interval, 1.6–12.5]; $P = .02$), tendon retraction of stage 2 or higher (OR, 4.4 [95% confidence interval, 1.4–14.3]; $P = .01$), and fatty infiltration index > 2 (OR, 10.2; $P < .0001$). No differences in re-tear rates were found between single-row and double-row cases. In 36 shoulders, tissue samples were harvested and submitted for bacteriologic culture analysis; 13 (36%) showed positive findings for infection (*Cutibacterium acnes* in 12 of 13) and associated antibiotic treatment was given. Overall, 25% of patients had unsatisfactory clinical results and 22% were disappointed or dissatisfied. At last follow-up, 4 patients (5.7%) underwent reoperations, with a second AR-RCR in 1 and conversion to reverse shoulder arthroplasty in 3.

Conclusion: Despite careful patient selection and intraoperative complete footprint coverage, in this study the tendons did not heal to bone in 36% of cases after revision cuff surgery. The absence of tendon healing is associated with poorer clinical and subjective results. Patients aged ≥ 55 years and patients with larger tears (stage 2 or higher) and/or muscle fatty infiltration (fatty infiltration index > 2) have significantly lower rates of healing. Surgeons should be aware that structurally failed cuff repair may also be associated with low-grade infection.

Institutional review board approval was received from Institut Universitaire Locomoteur et du Sport (IULS) (no. IULS-2017-12). This research was conducted in accordance with the ethical guidelines of our institution and the principles of the Declaration of Helsinki; informed consent was obtained from all patients.

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Despite great technical advances over the past decade, rotator cuff repair (RCR) is still associated with significant retear rates, ranging from 13% to 79%.^{1-3,5,7-11,13,18,23,25,26,30,35,38-41,44,49,51} As the rate of primary RCR increases, the number of failures and subsequent revision cuff repairs is increasing accordingly. Prospective studies have shown that most recurrent rotator cuff tears occur within 3-6 months after surgery.^{3,22} It is interesting to note that although healing failure does not necessarily translate directly to clinical failure, tendon retear is consistently correlated with poorer clinical outcomes and decreased shoulder function. When recurrent tears remain symptomatic, patients may seek further treatments to improve pain and/or shoulder function.

After attempted conservative treatment, revision cuff repair may be appropriate for selected patients with symptomatic failed RCRs, with viable rotator cuff tissue, and in the absence of glenohumeral osteoarthritis.^{10,22} The goal of revision cuff repair is to restore rotator cuff integrity and shoulder function. However, little information is available concerning the effectiveness of reoperation for failed repairs. Most published series have reported that although pain often could be improved, motion was unlikely to increase.^{9,12,29,32,36,48} To our knowledge, only a few series have evaluated the structural integrity and the rate of tendon healing following arthroscopic revision rotator cuff repair (AR-RCR).^{7,29,34,45,54,56}

The purpose of this study was to assess the healing rate of the cuff on the greater tuberosity after AR-RCR and identify the risk factors related to the absence of tendon healing. We hypothesized that, in selected patients with previous failed cuff repair, AR-RCR would result in tendon healing and significant improvements in clinical outcome measures and subjective results.

Methods

Study design

We performed a single-center retrospective investigation including all patients who underwent AR-RCR over a 10-year period (2006 to 2016). The inclusion criteria were (1) patients with a diagnosis of a full-thickness rotator cuff retear after prior arthroscopic or open repair, (2) persistent symptoms (shoulder pain or weakness) despite at least 6 months of rehabilitation and medical treatment, (3) arthroscopic revision cuff repair with intraoperative complete footprint coverage, and (4) minimum 1-year follow-up after the revision procedure with both clinical evaluation and imaging

evaluation by magnetic resonance imaging (MRI) or computed tomography (CT) arthrogram. We excluded patients with massive irreparable cuff tears or cuff tear arthropathy (Hamada stage 2, 3, 4, or 5),⁶ patients in whom only a partial cuff repair was performed during revision surgery, and patients with isolated subscapularis or infraspinatus tears. We also excluded patients with a history of ipsilateral shoulder surgery before the index rotator cuff procedure (eg, biceps tenotomy or tenodesis, acromioplasty, or cuff débridement). Between 2006 and 2016, 80 patients met the inclusion and exclusion criteria. One patient died before 1-year follow-up and 10 patients were lost to follow-up or had missing data, leaving 69 patients (69 shoulders) who constituted the basis of this cohort study. All patients underwent arthroscopic revision cuff repair, and all had intraoperative complete footprint coverage. All were reviewed regarding clinical examination findings and assessment of tendon integrity by an observer (M.A.) not involved in the surgical procedure. The mean follow-up period was 43 months (range, 12-136 months).

Clinical and radiologic assessment

Standard patient demographic information was collected: age, sex, hand dominance, smoking and workers' compensation status, and surgical history and timeline. All eligible patients were contacted to undergo clinical examination and imaging studies to assess tendon integrity. Pain was assessed with the visual analog scale score, whereas shoulder function and outcomes were assessed with the Constant score,¹⁴ Subjective Shoulder Value (SSV),²⁰ and subjective patient satisfaction questionnaires. The adjusted Constant score (ACS) was calculated as a percentage of normal values relative to sex and age.¹⁴ Range of motion (by means of a goniometer) and strength (using a dynamometer at 90° of abduction in the scapular plane) were also collected.

Preoperative and postoperative assessment included anteroposterior (3 rotational positions) and lateral radiographs. Either MRI or CT arthrogram was completed before and after revision surgery to characterize rotator cuff tears, fatty infiltration (FI), and tendon healing. Preoperative rotator cuff muscle FI was assessed on CT scans according to the Goutallier classification²² or on MRI according to the Fuchs classification.¹⁷ Coronal and sagittal tendon retraction was described according to the Boileau classification.⁵ Tendon healing following AR-RCR was assessed on MRI (82%) or CT arthrogram (18%) performed at least 1 year after revision surgery. Tendon healing was categorized according to the Sugaya classification⁵³; types 1, 2, and 3 were considered healed with tendon-to-bone attachment, whereas types 4 and 5 were classified as absence of healing. Three shoulder surgeons (M.A., N.P., and O.V.), not involved in surgery, separately assessed tendon healing. Interobserver and intraobserver reliability was not assessed; however, in case of disagreement, agreement was achieved through discussion.

Surgical technique

All surgical procedures were performed by the senior author (P.B.). Patients were positioned in the “lazy” beach-chair position, and AR-RCR was completed with patients under general anesthesia with an interscalene nerve block. The operative arm was left free and positioned using an articulated pneumatic arm holder (Spider; Smith & Nephew, Andover, MA, USA). Four standard arthroscopic portals were used, including posterior and lateral viewing portals and 2 anterior working portals (anterolateral and anteromedial); additional portals were used as necessary. After portal development, subacromial visualization was established by clearing bursal and scar tissue. During this process, tissue samples were submitted for bacteriologic culture analysis if the operating surgeon was concerned about infection based on the preoperative workup and/or intraoperative assessment. Although this was less common initially, as the senior author became increasingly aware of the number of revision cases associated with infection over the course of the study period, it became standard of practice to submit bacteriologic samples for all revision cuff repairs. Overall, bursal tissue samples were cultured for possible infection in 53% of cases (37 of 69). Next, the tear pattern was characterized, and tendon mobility and reducibility were assessed. Tendon release was achieved via posterosuperior capsular release and opening of the rotator interval with detachment of the coracohumeral ligament. Then, by use of a motorized burr, the greater tuberosity was abraded to create a bleeding cancellous bone bed for future tendon healing. Three different repair techniques were used depending on tear characteristics: single-row repair using a single-row tension-band technique (70%),⁵ double-row or double-layer repair⁵³ (19%), or side-to-side suture repair (11%). The goal was to obtain a repair without undue tension. Additional procedures (acromioplasty, acromioclavicular joint resection, and biceps tenotomy or tenodesis) were performed during revision surgery as deemed necessary by the operating surgeon.

Postoperative management

Postoperatively, the repaired cuff was protected in a sling for 6 weeks. The immobilization protocol was based on surgeon assessment of the need to protect the repair. Fifty-eight percent of repairs were protected in a 60° abduction brace for 3 weeks; the degree of abduction was then decreased by 10° every week thereafter through postoperative week 6. The remaining patients were immobilized in a sling in neutral rotation (11%) or internal rotation (31%). Pendulum exercises were started the day after surgery, prescribed for 5-minute intervals, 5 times a day. Formal physiotherapy started 6 weeks after surgery. Active exercises were authorized to start once complete passive motion was regained. Hydrotherapy was strongly encouraged.

Statistical analysis

Measurements are expressed as mean \pm standard deviation (range). Continuous variable mean values were compared using the Student *t* test, whereas categorical variable analysis was performed with the χ^2 test or Fisher exact test. To identify independent factors associated with revision RCR outcomes,

significant univariate parameters were entered into a multivariate logistical regression, with results reported as odds ratios (ORs) with 95% confidence intervals (CIs) and *P* values. The level of statistical significance was set at *P* < .05. Statistical analyses were performed with EasyMedStat software (Levallois-Perret, France; www.easymedstat.com).

Results

Patient demographic characteristics

The characteristics of the 69 patients (mean age, 55 years) who underwent AR-RCR for failed RCR are summarized in [Table I](#). The main clinical presentation was a painful and weak shoulder in 93% of the cases; however, 3 patients (4%) had persistent shoulder pain and stiffness, defined by passive and active forward elevation < 120°, and 5 (7%) presented with pain and pseudoparalysis, defined by active forward elevation < 90° and a positive landing test result with complete active forward elevation.⁴ The average interval between the primary RCR and revision was 45 months (range, 2-264 months).

Most of the tears were posterosuperior, involving the supraspinatus and infraspinatus, and 13 patients had a large tear with tendon retraction to the glenoid rim (stage 3). Most of the patients had no or little preoperative FI of the cuff muscles ([Table II](#)).

Complications and reoperations

In 3 patients (4%), complex regional pain syndrome was noted, which symptomatically improved with time and physiotherapy. Five patients (7%) had persistent stiffness postoperatively (passive and active forward elevation < 120°): Glenohumeral osteoarthritis developed in 1, infection occurred at the time of revision in 2, and stiffness was present before revision and continued postoperatively in 2. Of the 5 shoulders that were pseudoparalytic before revision, 1 remained so postoperatively.

Four patients with persistent shoulder impairment and absence of tendon healing on imaging studies underwent subsequent reoperation (5.5%). One patient underwent repeated AR-RCR with a good result, whereas 3 patients underwent reverse shoulder arthroplasty: 1 for persistent shoulder pseudoparalysis at 7 months after AR-RCR, 1 for development of cuff tear arthropathy at 2 years postoperatively, and 1 for persistent stiffness without osteoarthritis at 6 years postoperatively.

Tendon healing

Tendon integrity was evaluated on MRI (57 cases) or, alternatively, on CT arthrogram (12 cases), performed at a minimum interval of 1 year following surgery ([Fig. 1](#)). On imaging studies, absence of tendon healing occurred in 25

Table I Characteristics of patients

	Data
Prior failed cuff repair, n (%)	69 (100)
Mean time between primary cuff repair and revision (range), mo	45 (2-264)
Mean age at revision surgery (range), yr	55 (34-78)
Sex: male/female, n (%)	38 (55)/31 (45)
Dominant arm, n (%)	53 of 69 (77)
Smoking consumption at surgery, n (%)	15 of 69 (22)
Workers' compensation, n (%)	22 (33)
Clinical presentation, n (%)	
Pain and weakness	60 (86)
Pain and stiffness	4 (6)
Pain and pseudoparalysis	5 (7)
Mean acromiohumeral distance (range), mm	8.5 (6-12)
Cuff tear retraction (coronal), n (%)	
Small (stage 1, tendon retracted to cartilage margin)	29 (42)
Medium (stage 2, tendon retracted to humeral head)	27 (39)
Large (stage 3, tendon retracted to glenoid rim)	13 (19)
Massive (stage 4, retraction medial beyond glenoid rim)	0 (0)
Cuff tear size (sagittal), n (%)	
1-Tendon tear: supraspinatus	35 (51)
2-Tendon tear: supraspinatus and infraspinatus	31 (45)
3-Tendon tear: supraspinatus, infraspinatus, and subscapularis	3 (4)
Primary cuff repair, n (%)	
Arthroscopic single-row repair	33 (48)
Arthroscopic double-row repair	9 (13)
Side-to-side repair	1 (1)
Open repair	26 (38)
Arthroscopic revision cuff repair, n (%)	
Single-row repair	49 (70)
Double-row repair	13 (19)
Side-to-side repair	7 (11)
Additional concomitant procedures, n (%)	
Hardware removal	30 (43)
Arthrolysis	34 (49)
Acromioplasty	47 (68)
Acromioclavicular joint resection	18 (26)
Biceps tenodesis	32 (46)
Biceps tenotomy	15 (22)
Mean follow-up after revision cuff surgery (range), mo	43 (12-136)

Table II Preoperative fatty infiltration of rotator cuff muscles (according to Goutallier classification²²)

	Stage 0, %	Stage 1, %	Stage 2, %	Stage 3, %	Stage 4, %
Supraspinatus	22	40	34	3	2
Infraspinatus	47	44	9	0	0
Subscapularis	84	16	0	0	0

shoulders (36%) following AR-RCR (Fig. 2) and was associated with an increased tear size in 8 of these cases (32%) compared with the initial tear size.

Functional and subjective results

Shoulder range of motion, functional results, and subjective results are summarized in Table III. The Constant score improved from an average of 49 ± 4 points preoperatively

to 64 ± 5 points at the time of the last follow-up evaluation ($P = .0001$), and the SSV improved from 41% to 66% ($P = .0001$).

According to the ACS, the postoperative outcomes were excellent (ACS > 80%) in 57% of patients, good (ACS of 65%-79%) in 18%, fair (ACS of 50%-64%) in 9%, and poor (ACS < 50%) in 16%. At final follow-up, 54 patients (78%) were either satisfied or very satisfied whereas 15 (22%) were disappointed (8%) or dissatisfied (14%).

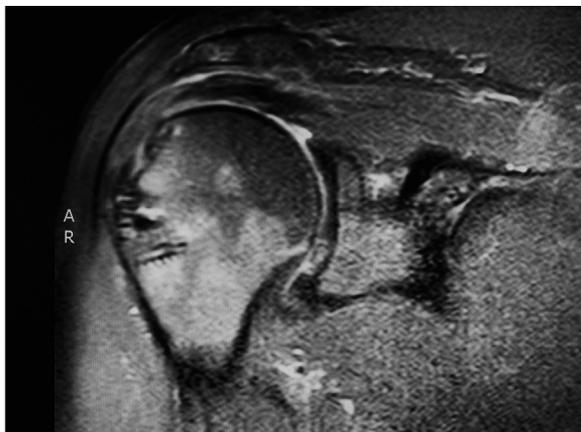


Figure 1 Magnetic resonance imaging performed 18 months after revision cuff repair demonstrating complete healing of re-repaired cuff tendon.

Correlations between cuff repair integrity and functional outcomes

As shown in Table IV, absence of tendon healing was associated with poorer clinical outcomes (average Constant score, 69 ± 20 vs. 54 ± 18 ; $P = .003$) and decreased subjective outcomes (average SSV, 72% vs. 54%; $P = .002$). Pain, mobility, strength, and passive and active external rotation were worse when the tendons did not heal to the footprint.

Prognostic factors associated with failure of tendon healing

Three factors were found to negatively affect tendon healing after an attempt at re-repair: age ≥ 55 years (OR, 4.5 [95% CI, 1.6-12.5]; $P = .02$), tendon retraction of stage 2 or higher (OR, 4.4 [95% CI, 1.4-14.3]; $P = .01$), and severe cuff muscle FI (ie, FI index > 2) (OR, 10.2; $P < .0001$). Cuff tendon healing was observed in 80% of patients aged < 55 years vs. only 50% of those aged ≥ 55 years (Fig. 3).

The retear rate increased with tendon size and retraction (Fig. 4): from 20% in small tears (stage 1) to 45% in medium tears (stage 2) to 65% in large tears (stage 3). With the numbers available, no association was found between tendon healing and sex, dominant arm, workers' compensation status, tobacco use, preoperative forward flexion, delay between primary cuff repair and revision, type of repair (single or double row), and associated procedures. No differences in retear rates were found between single- and double-row cuff repairs.

Associated low-grade infection

With respect to bacteriologic samples, 13 of 36 samples (36%) taken at the time of arthroscopic revision showed

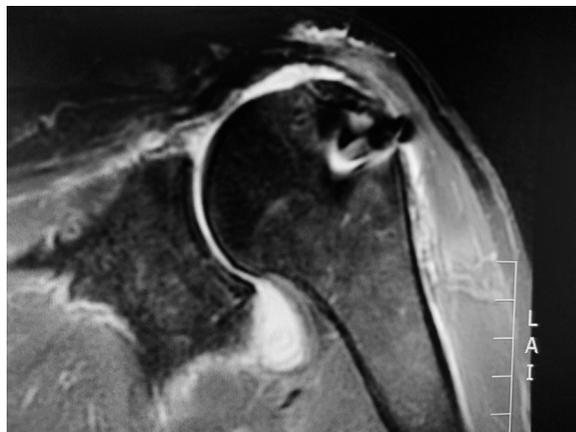


Figure 2 Magnetic resonance imaging performed 14 months after revision cuff repair demonstrating absence of rotator cuff tendon healing.

positive findings for infection. *Cutibacterium acnes* was cultured in 12 cases, with associated *Proteus mirabilis* in 1 case and *Staphylococcus capitis* in another. In the final case of infection, a low-grade infection occurred due to *Staphylococcus epidermidis*. All patients with positive findings for infection were treated initially with oral administration of clindamycin. Later, more specific antibiotic treatment was administered if applicable when the culture results were obtained. The total duration of antibiotic administration was 3 months.

Discussion

The main finding of this study is that, despite careful patient selection and intraoperative complete footprint coverage, revision arthroscopic RCR failed to obtain tendon healing in 36% of patients on imaging studies (MRI or CT arthrogram) performed at a minimum of 1-year follow-up. Predictive factors for non-healing were patient age (≥ 55 years), tendon retraction (stage 2 or higher), and cuff muscle FI (FI index > 2). Furthermore, structurally failed cuff repair may be associated with low-grade infection, and surgeons should be encouraged to perform biopsy procedures to eliminate hidden low-grade infection. Although revision arthroscopic RCR may result in reliable pain relief and improvement in shoulder function in selected cases, absence of tendon healing after revision cuff surgery is associated with inferior functional and subjective outcomes. Overall, 25% of patients (1 in 4) have unsatisfactory clinical outcomes according to the ACS and 22% (1 in 5) are dissatisfied or disappointed with the results of arthroscopic revision cuff surgery.

Anatomic outcomes

The retear rate of 36% after revision cuff surgery is disappointing but in line with prior published results.^{19,32,37}

Table III Range of motion and functional and subjective results

	Preoperative	Postoperative	Change	P value
Range of motion				
Active forward elevation, °	134 ± 8	152 ± 8	+18	<.001
Passive forward elevation, °	157 ± 5	166 ± 5	+9	.001
Active external rotation at side, °	35 ± 4	37 ± 5	+2	.68
Passive external rotation at side, °	44 ± 4	45 ± 4	+1	.87
Active internal rotation (of 10)	6 ± 1	7 ± 1	+1	<.001
Constant score				
Pain (of 15)	6 ± 1	10 ± 1	+4	<.001
Activity (of 20)	10 ± 1	14 ± 1	+4	<.001
Mobility (of 40)	25 ± 2	30 ± 2	+5	<.001
Strength (of 25)	7 ± 1	9 ± 2	+2	.027
Total (of 100)	49 ± 4	64 ± 5	+15	<.001
Adjusted Constant score, %	60 ± 5	82 ± 7	+22	<.001
Subjective Shoulder Value, %	41 ± 4	66 ± 5	+25	<.001

Keener et al,²⁹ using ultrasound to assess tendon healing in 21 revision RCRs, reported a healing rate of 48%, whereas Willinger et al,⁵⁶ using postoperative MRI, showed a retear rate > 50% at minimum 2-year follow-up in 31 patients who underwent reoperation for failed cuff repair. The healing rate is somewhat disappointing as the patient population was strictly selected: We indicated cuff revision surgery mainly in younger patients (mean age of 55 years in our series) with small- and medium-sized cuff tears; only 18% of the patients in this series had large rotator cuff tears, retracted to the glenoid rim (stage 3). Patients with severe FI of the cuff muscles (Goutallier stage 3 or 4) and those with static upward migration of the humeral head and/or osteoarthritis (Hamada stage 2, 3, 4, or 5) were excluded. We acknowledge that the failure rate may increase with time: Shamsudin et al⁵⁰ found retear rate progression from 28% at 6 months to 42% at 2 years.

The causes of tendon healing failure and retear after cuff repair are multifactorial.^{5,7,21,29,45,48,52,57} In this series, we identified 3 factors that negatively affected tendon healing: patient age (≥ 55 years), tendon retraction (stage 2 or higher), and FI (FI index > 2). Whereas 80% of the cuff tendons healed in patients aged < 55 years, only 50% healed in patients aged ≥ 55 years ($P < .001$). Older age and tear size and retraction are well-known risk factors for failed tendon healing after both primary⁵ and revision cuff surgery.²⁹ Other poor prognostic factors frequently described in the literature (eg, smoking, workers' compensation, female sex, and multiple previous surgical procedures)^{45,48} were not found to be significant in our series. Although the surgical technique is important, we found no differences in retear rates between single- and double-row cuff repairs. Our interpretation is that we performed a single-row technique in cases of small cuff tears (stage 1) whereas we selected a double-row technique in cases of medium and large cuff tears (stages 2 and 3). Other important factors in achieving a successful reoperation for

failed cuff repair include adequate acromial decompression and associated biceps tenotomy or tenodesis.

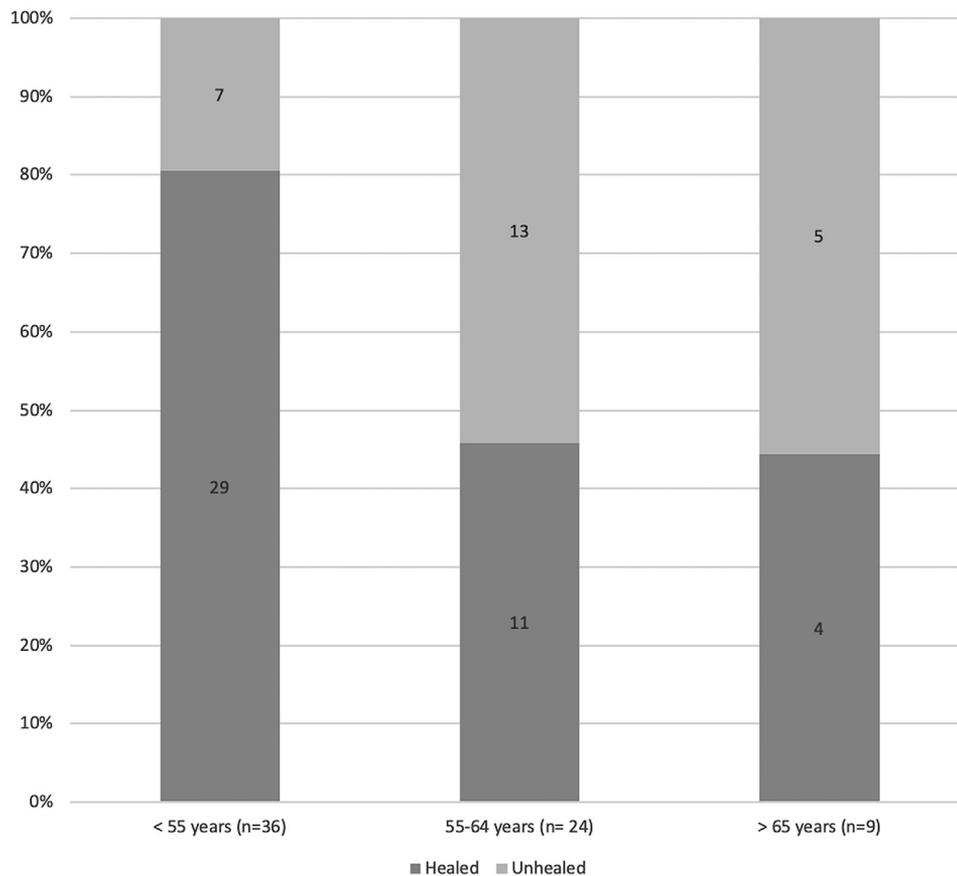
Rotator cuff tendon healing ultimately requires favorable mechanical and biological conditions to heal.⁵² Mechanical conditions can be optimized through muscle and tendon release and other technical considerations. From a biological standpoint, we acknowledge that especially in the revision setting, repairs are often performed in cases of degenerative cuff tears with poor-quality tendons. Return tendons are often more fibrotic, or even necrotic, with reduced vascularity and capacity to heal. Possible solutions to facilitate healing might be augmentation of the repair using a scaffold or the addition of platelet-rich plasma or growth factors. The role of patch augmentation is still controversial.³⁶ Muench et al⁴² published a revision series of massive cuff tears treated using biologically enhanced patch augmentation: Only 41% of patients demonstrated substantial clinical benefit. Hohn et al²⁴ reported a reoperation rate of 13% after AR-RCR with acellular human dermal matrix allograft augmentation. Furthermore, our experience with the addition of an autologous concentrate of growth factors to primary RCR has thus far been disappointing.⁵⁹ Despite these discouraging results, these techniques might provide important future guidance as they undergo further investigation.

Functional outcomes

Our mean ACS of 84% after revision cuff surgery compares favorably with the scores reported in the literature.^{24,29,32,33,45,48-50,55,56} Keener et al²⁹ reported a postoperative ACS of 74% after AR-RCR. Our final Constant score of 64 points is close to the scores reported by Piasecki et al⁴⁸ (60 points), Valencia Mora et al⁵⁵ (69 points), and Willinger et al⁵⁶ (65 points). Mean active forward elevation increased from 134° to 152° ($P < .001$), but 5 patients (7%) had persistent stiffness postoperatively

Table IV Influence of cuff tendon healing on range of motion, functional results, and subjective results

	Intact repair (n = 44)	Recurrent tear (n = 25)	P value
Range of motion			
Active forward elevation, °	159 ± 26	142 ± 37	.083
Passive forward elevation, °	170 ± 14	158 ± 29	.107
Active external rotation, °	42 ± 18	28 ± 16	<.001
Passive external rotation, °	48 ± 18	38 ± 16	.034
Active internal rotation (of 10)	7 ± 2	6 ± 3	.081
Constant score			
Pain (of 15)	11 ± 3	8 ± 4	.002
Activity (of 20)	15 ± 5	13 ± 4	.064
Mobility (of 40)	33 ± 8	26 ± 11	.006
Strength (of 25)	11 ± 7	7 ± 4	.043
Total (of 100)	69 ± 20	54 ± 18	.003
Adjusted Constant score, %	89 ± 25	70 ± 25	.006
Subjective Shoulder Value, %	72 ± 20	54 ± 22	.002

**Figure 3** Prevalence of tendon healing according to age.

(passive and active forward elevation < 120°): glenohumeral osteoarthritis developed in 1, infection occurred at the time of revision in 2, and stiffness was present before revision and continued postoperatively in 2. The 25% rate of unsatisfactory results (ACS < 65%) in our study patients is similar to rates reported in the studies of Chuang et al¹²

and Valencia Mora et al.⁵⁵ In a large series of 80 patients who underwent reoperation for failed cuff repair, Djurasovic et al¹⁶ reported that 25 patients (31%) had unsatisfactory (poor) results.

The results of our study confirm that absence of tendon healing is associated with poorer shoulder function

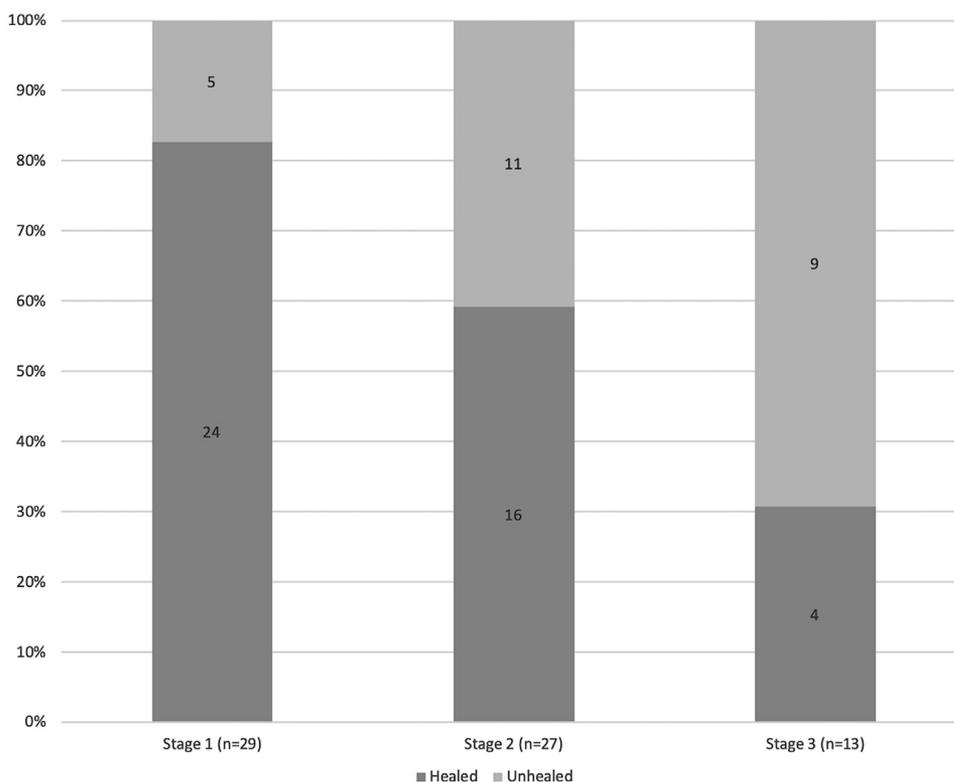


Figure 4 Prevalence of tendon healing according to tendon size and retraction.

(Constant score of 54 vs. 69, $P = .003$) and decreased subjective outcomes (SSV of 54% vs. 72%, $P = .002$). Pain, mobility, strength, and passive and active external rotation were worse when the tendons did not heal to the footprint. In the literature, the influence of repair integrity on clinical and subjective results following RCR remains controversial, with some studies showing similar outcomes between shoulders with an intact repair and those with a recurrent tear³¹ but others finding a negative influence of re-reatar on shoulder function and patient satisfaction.^{15,27,29,50,56,58} Although some of our patients maintained reasonably good shoulder function despite structural tendon failure, our data suggest that postoperative cuff tendon integrity should remain the goal to reach when the decision to perform revision cuff surgery is made.^{28,43,47}

Associated low-grade infection

Another interesting finding of this study is that symptomatic failed RCRs with structural tendon failure may be associated with low-grade infection. Our observation of positive culture results in 36% of samples suggests that, besides a purely mechanical origin, a possible associated biological cause of retears should be taken into consideration and anticipated. This rate is probably underestimated because we collected tissue samples from only about half of the patients ($n = 37$), mainly in the more recent cases. After

noting this association anecdotally, with increased experience in revision cuff surgery, we started to systematically look for associated low-grade infection. Ultimately, we found 12 of 13 patients to have positive findings for infection with *C acnes*.

These findings led us to use a more cautious approach in revision cuff surgery, and we now consider every failed cuff repair as infected until proven otherwise. This allows us to systematically collect tissue samples for analysis of bacteriologic cultures and anatomic-pathology. Intraoperatively, we perform débridement of necrotic tissue and removal of foreign bodies (eg, plastic or metallic anchors and remaining sutures). Postoperatively, while awaiting bacteriologic results, we treat patients with antibiotics active on *C acnes*. Even though the reported incidence of infection in primary RCR has been reported to be relatively low (between 0.3% and 1.9%),^{2,46} surgeons should have a high suspicion of infection in the case of a failed RCR with tendon retear. Specifically, we have observed that severe shoulder pain and persistent stiffness after failed RCR should lead to an infectious workup.

Study limitations and strengths

The 2 main limitations of this study are its retrospective nature and the fact that our patients represent a selected cohort, operated on by a single senior shoulder surgeon.

Patients were selected for revision surgery based on their age and activity level, as well as the surgeon's impression of tear reparability. The results of this study, therefore, may not be applicable to all cases of failed RCR, and less experienced surgeons may end up with different results. The heterogeneous population and treatment characteristics, combined with the lack of a control group, limit comparisons and conclusions. Additionally, the minimum of 1-year follow-up should instruct cautious interpretations and conclusions. Nonetheless, the study possesses numerous merits. Particularly, the use of systematic imaging studies (MRI or CT arthrogram) to assess tendon repair integrity is valuable to guide surgeon decision making. Preoperative assessment of tear size and retraction and staging of rotator cuff muscle fatty changes were routinely performed. Both clinical and anatomic outcomes were assessed by examiners not involved in surgery. To our knowledge, this study includes one of the largest cohorts of AR-RCR patients published, and it is the first to start systematically searching for an infectious etiology of RCR failure, as opposed to a purely mechanical origin. We believe that the information gathered from our review of these patients is helpful to inform patients and surgeons about expectations after revision cuff surgery for failed cuff repair.

Conclusion

Despite careful patient selection and intraoperative complete footprint coverage, absence of tendon healing occurred in 36% of cases after arthroscopic revision cuff repair. The absence of tendon healing on postoperative imaging was associated with poorer clinical outcomes, decreased shoulder function, and decreased patient satisfaction. Overall, 25% of patients (1 in 4) had unsatisfactory clinical results according to the ACS and 22% (1 in 5) were disappointed or dissatisfied after revision cuff repair. The factors affecting tendon healing are the patient's age, the extension of the tear in the coronal plane, and the degree of cuff muscle FI. Patients aged ≥ 55 years at the time of revision, patients with larger tears (stage 2 or higher), and patients with more severe muscle FI (FI index > 2) had significantly less chance of tendon healing. Finally, we found that structurally failed cuff repair may be associated with low-grade infection, and we now consider every failed cuff repair as infected until proven otherwise.

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