J Shoulder Elbow Surg (2023) ■, 1–6

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Long-term results of revision rotator cuff repair for failed cuff repair: a minimum 10-year follow-up study

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Hypothesis: Rotator cuff repair remains associated with high retear rates, which range from 13% to 79%. The objective of this study was to evaluate the long-term clinical and structural results after revision rotator cuff repair at a minimum 10-year follow-up.

Methods: We retrospectively studied the records of all patients who underwent revision rotator cuff repair in 3 different institutions between July 2001 and December 2007 with a minimum 10-year follow-up. A total of 54 patients (61% males, mean age 52 ± 6 years old) met the inclusion criteria. Outcome measures included pain (visual analog scale [VAS]), range of motion (ROM), Subjective Shoulder Value (SSV), and the Constant score. Superior migration, osteoarthritis, and acromiohumeral interval (AHI) were assessed on standard radiographs. Fatty infiltration and structural integrity of the repaired tendon were evaluated on magnetic resonance imaging or computed tomographic arthrogram.

Results: At a mean 14.1 years (10.4-20.5), range of motion did not progress significantly in elevation and internal rotation between pre- and postoperation (158° [range, 100°-180°] to 164° [range, 60°-180°], $P = .33$, and L3 [range, sacrum-T12] to T12 [range, buttocks-T7], $P = .34$, respectively) and decreased in active external rotation from 45° (range, 10°-80°) to 39° (range, 10°-80°) ($P = .02$). However, VAS, SSV, and Constant score were all significantly improved at last follow-up ($P < .001$). AHI decreased significantly ($P = .002$) from 10 mm (7-14 mm) to 8 mm (0-12 mm). Two percent of the supraspinatus/infraspinatus tendons were Sugaya 1, 24% were Sugaya 2, 35% were Sugaya 3, 12% were Sugaya 4, and 27% were Sugaya 5. Goutallier score progressed for all muscles, but this did not reach significance and mean Goutallier remained <2 for all 4 muscles at last follow-up. Hamada score progressed from 0% >grade 2 preoperatively to 6% >grade 2 at last follow-up.

Conclusion: Revision rotator cuff repair provides significant pain relief and improvement in functional scores at long-term follow-up. The mild progression of fatty infiltration, AHI, and Hamada score suggests that despite high retear rates

This study was approved by the Institutional Review Board of the Ethical Committee of CNIRIPH (approval no. 20.07.04.62624). Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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https://doi.org/10.1016/j.jse.2023.06.009

(39% of stage 4 and 5 in the Sugaya classification), revision repair could possibly have a protective role on the evolution toward cuff tear arthropathy.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Retear; failed cuff repair; tendon healing; cuff revision repair; arthroscopy; prognostic factor

Rotator cuff repair remains associated with high retear rates, which range from 13% to 79%.[1] These retears may not necessarily be symptomatic.[8] However, several studies have reported better clinical results when the repair has healed.[6,16,22,33] Therefore, in case of symptomatic failed rotator cuff repair, surgeons may hesitate to consider revision repair as little information is known regarding the results of revision rotator cuff repair. Nevertheless, several studies seem to demonstrate that in selected patients with reparable retears (no osteoarthritis, no superior migration of the humeral head, tendon retraction <3 in the Patte classification,[28] and fatty infiltration ≤2 in the Goutallier classification[19]), revision cuff repair can provide significant functional improvement.[1,7] In 2020, Brochin et al[3] showed satisfactory functional results after revision rotator cuff repair at a mean 42 ± 20–month follow-up in a large systematic review. Several studies have reported satisfactory long-term results after primary rotator cuff repair despite relatively high rates of repair failure.[4,9,12,29] However, it is not known yet whether similar long-term results can be expected after revision rotator cuff repair.

The objective of this study was to evaluate the long-term clinical and structural results after revision rotator cuff repair at a minimum 10-year follow-up. We hypothesized that revision rotator cuff repair would provide improved clinical functional outcomes but high rates of structural failures long-term in patients with reparable rotator cuff retear.

Materials and methods

Study cohort

We retrospectively studied the records of all patients who underwent revision rotator cuff repair in 3 different institutions between July 2001 and December 2007 with a minimum 10-year follow-up. The inclusion criteria were the following: (1) patients with a diagnosis of a reparable full-thickness rotator cuff retear after prior open or arthroscopic rotator cuff repair, (2) full passive range of motion (ROM), (3) a symptomatic retear (with pain and/or weakness) despite nonoperative treatment, and (4) complete clinical and radiologic follow-up ≥10 years. Patients were excluded if they had osteoarthritis >Hamada 3, and if one of the rotator cuff tendons was considered irreparable: superior migration of the humeral head (acromiohumeral index [AHI] ≤6 mm, fatty infiltration >2 in the Goutallier classification). A total of 54 patients fulfilled these criteria.

Surgical technique

The primary repair had been performed open in 58% of cases and arthroscopic in the remaining 42%. Sixty-two percent of the patients had had either a tenotomy or a tenodesis of the long head of the biceps, 98% had had an acromioplasty performed, and 5% had had a concomitant acromioclavicular resection. The initial repair was a single-row repair in 38% of cases, a transosseous repair in 41%, and a double-row repair in 21% of cases.

All revision surgeries were performed by 3 shoulder fellowship–trained senior shoulder surgeons. They were performed open in 35% of cases and arthroscopically in 65% of cases based on surgeon preference. A tenotomy or tenodesis of the long head of the biceps was performed in 37% of cases, which means that after revision surgery none of the patients had a biceps left. A concomitant acromioplasty was performed in 67% of cases and a resection of the acromioclavicular joint was performed in 16% of cases. The revision repair was a single-row repair in 51% of cases, a transosseous repair in 28%, and a double-row repair in 21% of cases.

Postoperatively, the repaired cuff was protected in a standard internal rotation sling in 23% of cases and on abduction pillow in 77% of cases.

Clinical evaluation

Pain, ROM, and outcome scores were evaluated at preoperative and last postoperative visits. ROM measures assessed included active abduction, active forward elevation (FE), active external rotation (ER) measured in degrees. Active internal rotation (IR) was assessed as the most cephalad vertebral level reached by the thumb behind the patient's back and scored as described in the Constant score.[15] Clinical outcome scores evaluated included the visual analog scale (VAS), the Subjective Shoulder Value (SSV),[18] and the Constant score.

Radiographic evaluation

True anteroposterior standard radiographs and either computed tomographic arthrogram or a magnetic resonance imaging scan were obtained preoperatively and at last follow-up. Superior migration and osteoarthritis were evaluated according to the Hamada classification,[20] and the AHI was measured. The critical shoulder angle was also measured as described by Moor et al.[24] Tendon retraction was evaluated preoperatively according to the Patte classification.[28]

Fatty infiltration was graded for each muscle according to Goutallier et al,[19] and the structural integrity of the tendon was evaluated at last follow-up using the Sugaya classification.[30] The teres minor was graded as being either absent, normal, or hypetrophic.[23]

To assess the influence of tendon healing on functional outcomes, Sugaya grade 1, 2, and 3 tendons were considered healed whereas Sugaya grade 4 and 5 tendons were considered reruptured.

Statistical analysis

Descriptive statistics were calculated, including means, standard deviation, and minimum and maximum values of continuous variables Normal distribution of data was tested according to the Shapiro-Wilk and Levene tests. Dependent samples were compared by use of a paired *t* test and by the Wilcoxon signed-rank test according to data distribution. Independent samples were compared with the Student *t* (unpaired) if data were normally distributed. Comparison of categorical data was performed using the Fisher exact test (as $n < 5$). The level of statistical significance was set at $P < .05$. Statistical analyses were performed with EasyMedStat software (Levallois-Perret, France; www.easymedstat.com).

Results

Cohort

A total of 125 patients were identified. Five patients had died, 30 patients refused to come for a new magnetic resonance imaging and clinical evaluation, 35 patients were lost to follow-up, and 1 patient was revised to a reverse shoulder arthroplasty leaving 54 patients for the analysis. Fifty-four shoulders were therefore evaluated at a mean total follow-up of 14.1 years (range, 10.4-20.5 years). The mean age of the patients (61% males) at the time of the first rotator cuff repair was 49 ± 7 years and 52 ± 6 years at the time of the revision repair. The mean time between the 2 repairs was 35 months (range, 2-158 months). Seventy-five percent of the patients were manual workers, and 43% of them were worker's compensation patients.

No traumatic cause for the retear was found in 77% of cases.

Clinical evaluation

Active ROM did not progress significantly in elevation and internal rotation between pre- and postoperatively (158° [range, 100°-180°] to 164° [range, 60°-180°], $P = .33$, and L3 [range, sacrum-T12] to T12 [range, buttocks-T7], $P = .34$ respectively) and decreased in active external rotation from 45° (range, 10°-80°) to 39° (10°-80°) ($P = .02$). However, VAS, SSV, and Constant scores were all significantly improved at last follow-up ($P < .001$). These results are detailed in Table I.

Radiographic evaluation

Preoperatively the mean critical shoulder angle (CSA)[24] was 33° (26°-40°) in our population of revision rotator cuff repair. Sixty-six percent of the patients had an isolated full-thickness tear of the supraspinatus, 20% had a posterosuperior tear (supraspinatus and infraspinatus); 9% had a tear involving the supraspinatus, the infraspinatus, and the upper subscapularis; 4% had an anterosuperior tear (supraspinatus and upper subscapularis); and 2% had an isolated tear of the subscapularis.

Healing of the tendons according to the Sugaya classification is detailed in Table II. Sixty-one percent of supraspinatus and infraspinatus were considered healed at last follow-up (Sugaya 1, 2, and 3).

Mean AHI decreased significantly from 10 mm (7-14 mm) preoperatively to 8 mm (0-12 mm) at last follow-up ($P = .002$). The Hamada score progressed significantly between pre- and postoperatively but mostly from stage 1 to stage 2 (Table III). The mean Goutallier score of all rotator cuff muscles also progressed significantly (Table III), but the mean Goutallier score for all muscles remained <2 at last follow-up.

Value of a healed tendon

At last follow-up, no difference in VAS could be found between patients with or without a healed tendon (4.4 ± 1.8 vs. 4.6 ± 1.7; $P = .703$). Patients with a healed tendon had a higher Constant score (74 vs. 68) but this did not reach statistical significance ($P = .091$). However, SSV was significantly improved in patients with healed tendons (80% vs. 70%, $P = .005$). In addition, AHI was significantly greater is this population (8.94 mm vs. 6.5 mm, $P = .001$), and so was the rate of Goutallier 0-1-2 supraspinatus (87.5% vs. 38.9%, $P = .002$) and infraspinatus (91.7% vs. 41.2%, $P = .001$) and the rate of Hamada 1 shoulders (92.3% vs. 55.6%, $P = .008$). This has been detailed Table IV.

Worker's compensation

At last follow-up, no clinical or structural differences could be found between patients with worker's compensation and those without. Mean Constant scores (70 vs. 74, $P = .352$), mean SSV scores (73% vs. 79%, $P = .305$), and healing rates (50% vs. 42%, $P = .728$) were not significantly different between these 2 groups.

Discussion

This study shows that revision rotator cuff repair can provide durable pain relief and subjective functional results despite a poor rate of tendon healing (61%) in a carefully selected population of patients presenting with a reparable rotator cuff retear. Indeed, although active ROM did not improve significantly, patients can expect a significant improvement in pain and in functional scores such as the

Table I Functional outcome comparisons

	Preoperation	Postoperation	*P* value
Forward elevation, degrees	158 (100-180)	164 (60-180)	.325
External rotation, degrees	45 (10-80)	39 (10-80)	**.022**
Internal rotation	L3 (sacrum-T12)	T12 (fesse-T7)	.341
VAS	5.8 (0-10)	2.9 (0-10)	**<.001**
SSV, %	43 (15-70)	77 (30-100)	**<.001**
Constant score	58 (40-75)	64 (5-98)	**.001**

VAS, visual analog scale; *SSV*, subjective shoulder value.
P values in bold indicate significance.

Table II Tendon healing at last follow-up

	Sugaya 1	Sugaya 2	Sugaya 3	Sugaya 4	Sugaya 5
SSP/ISP	2	24	35	12	27
SSC	64	15	15	3	3

SSP, supraspinatus; *ISP*, infraspinatus; *SSC*, subscapularis.
Values are percentages.

Table III Pre- and postoperative imaging findings

	Preoperatively	Postoperatively	*P* value
AHI, mm, mean (range)	10 (7-14)	8 (0-12)	**.002**
Hamada classification, %			
Stage 1	95	77	—
Stage 2	5	16	—
Stage 3	0	2	—
Stage 4	0	2	—
Stage 5	0	2	—
Goutallier score			
Supraspinatus	1.1	1.8	**<.001**
Infraspinatus	1	1.9	**<.001**
Upper subscapularis	0.6	1.3	**<.001**
Lower subscapularis	0.2	0.6	**.001**
Teres minor	N	N	

AHI, acromiohumeral index; *N*, normal.
P values in bold indicate significance.

SSV and the Constant score. The absence of improvement in ROM can probably be explained by the fact that all patients had full passive ROM preoperatively and that most of them were operated for a painful shoulder rather than for a loss of active ROM. This is comparable with previous studies, as Brochin et al[3] found similar results in a large systematic review including 723 patients who had undergone open or arthroscopic revision rotator cuff repair and followed for a mean 44 months (5-179 months). Indeed, in their study they found that patients slightly improved in forward elevation (+21.3°) and lost some active external rotation (–37.5°), but all functional scores (VAS, ASES) were found to improve significantly. The retear rate in our study of revision cases (39%) compares favorably to what has been reported at similar follow-up in cases of primary repair of massive posterosuperior (34%)[10] and anterosuperior rotator cuff tear (33%),[27] which should theoretically heal better than revision cases. However, it is important to remember that most tears in our study were not massive, with a majority of isolated tears of the supraspinatus in our population. Although the results after revision rotator cuff repair in our series were satisfactory, these were significantly worse in terms of the Constant score (64 vs. 77.7), SSV score (77% vs. 84.9%), and healing rates (61% vs. 81%) than what has been reported previously after primary repair of isolated supraspinatus tears at similar follow-up.[11]

Although patients with healed tendons did not have a significantly greater Constant score or pain relief at last follow-up, tendon healing provided significantly higher SSV scores and possible preservation of the shoulder from an evolution toward fatty infiltration and cuff tear arthropathy.

It remains unclear whether Sugaya 3 tendons should be considered healed or not[26] as the mechanical role of a thin tendon without discontinuity is not clearly known. The healing rate in our population varies greatly depending on whether these are considered healed or not from 26% to 61%. However, the mild progression of superior migration of the humeral head, of Hamada stage, and of fatty infiltration of the muscles at long-term follow-up suggests that even Sugaya 3 tendons may have a role in preventing or slowing down the natural history of a rotator cuff tear that is known to progress to irreparability in 50% of cases at 8.8 years of follow-up.[25]

Numerous options have been proposed to treat failed rotator cuff repairs and these often overlap with options described for the management of irreparable rotator cuff tears. Our study shows that revision rotator cuff repair can be a satisfactory option specially to improve pain and functional scores provided the cuff is perfectly reparable in a carefully selected population with no preoperative osteoarthritis, no proximal migration of the humeral head, and no or little muscle fatty infiltration. In addition, it has been reported that a potential cause of failure after rotator cuff repair was caused by not addressing subscapularis tears.[34] This did not seem to be the case in our population as only 10% of the patients presented with a full-thickness subscapularis tear at the time of the revision repair. Recently, Moor et al[24] described the CSA and demonstrated

Table IV Influence of tendon healing at long-term follow-up

	Healed tendon (Sugaya 1/2/3)	Torn tendon (Sugaya 4/5)	*P* value
VAS score	4.4 ± 1.8	4.6 ± 1.7	.703
Constant score	74	68	.091
SSV, %	80	70	**.005**
AHI, mm	8.94	6.5	**.001**
Goutallier 0/1/2 SSP, %	87.5	38.9	**.002**
Goutallier 0/1/2 ISP, %	91.7	41.2	**.001**
Hamada 1, %	92.3	55.6	**.008**

VAS, visual analog scale; *SSV*, subjective shoulder value; *AHI*, acromiohumeral index; *SSP*, supraspinatus; *ISP*, infraspinatus.
P values in bold indicate significance.

that a CSA >35° was associated with a high prevalence of rotator cuff tear. Gerber et al[17] even suggested that a lateral acromioplasty to decrease the CSA to <35° could help reduce the risk of retear. However, the CSA in our population of failed rotator cuff repair was not particularly high (33°), which is in agreement with Como et al[13] who did not find any difference in CSA between patients who had a healed rotator cuff and those who had not.

One additional finding of this study concerns work-related injuries and worker's compensation. Several studies have shown that work-related injuries, occupational diseases, or patients with worker's compensation are negative factors in terms of outcome.[2,21] The present study shows that these negative effects can no longer be observed at long-term follow-up after revision rotator cuff repair when patients get older and probably retired.

Finally, the fact that pain scores at last follow-up were similar in patients with or without tendon healing puts into question the role of acromioplasty and/or biceps tenotomy or tenodesis to obtain pain relief and improved shoulder function during revision cuff surgery. Indeed, 38% of the patients did not have a biceps tenotomy or tenodesis during the primary rotator cuff repair, and 37% of the patients had a tenotomy or tenodesis during the revision repair. Therefore, we can assume that all patients with a biceps still present at the time of the revision repair had a biceps tenotomy or tenodesis, which could explain part of the pain relief. Similarly, an acromioplasty was performed in 67% of the revision procedures, which could also explain part of the pain relief observed in our series. Numerous studies have been performed to evaluate the effect of concomitant acromioplasty during rotator cuff repair, and most of the studies have found no significant effect on pain, function, or the healing rate.[5,14,31] However, Woodmass et al[32] recently reported significantly lower reoperation rates at long-term follow-up in patients who had had concomitant acromioplasty at the time of rotator cuff repair compared to those who had not, suggesting that there might be a benefit to an acromioplasty during rotator cuff repair at long-term follow-up.

Our study has several limitations. It is a retrospective study of a small population of patients with no comparative group and, more specifically, no control group of patients treated nonoperatively. Because of the length of follow-up, a limited percentage of patients returned for evaluation. The low follow-up rate is a significant weakness and has the potential to introduce bias because of incomplete study results.

In addition, the procedures were performed by a small group of surgeons, which limits the generalizability of the results. However, the main strength of the present study is that it is the only study to our knowledge to report functional and structural (with radiographic and magnetic resonance imaging control) outcomes at long-term follow-up after revision rotator cuff repair.

Conclusion

Revision rotator cuff repair can provide significant pain relief and improvement in functional scores at long-term follow-up. The mild progression of fatty infiltration, AHI, and Hamada score suggests that despite high retear rates (39% of stage 4 and 5 in the Sugaya classification), revision repair could possibly have a protective role on the evolution toward cuff tear arthropathy.

Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: Jean-David Werthel, Luc Favard, and Pascal Boileau are paid consultants for Stryker and receive royalties for shoulder arthroplasty. Nicolas Bonnevialle is a paid consultant for MoveUp and receives royalties for shoulder arthroplasty. Laurent Nové-Josserand is a paid consultant for 3S Ortho and receives royalties for shoulder arthroplasty. The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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