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Medium-term outcomes of a cohort of revision rotator cuff repairs

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Background: There are limited medium- and long-term studies investigating clinical outcomes following revision rotator cuff surgery. The aim of the current study was to analyze the medium-term pain and functional outcomes of a cohort of revision rotator cuff repairs.
Methods: This was a multicenter, prospective cohort study of revision rotator cuff repairs undertaken between March 2009 and December 2010. Pain, function (Flex-SF), and postoperative data were collected at baseline; 6, 12, and 24 months; and 5 years.
Results: A total of 125 revision rotator cuff repairs were included in this study. Average improvement in Flex-SF and pain from baseline to 5 years was 8.5 ($P < .001$) and 2.1 points, respectively ($P < .001$). The improvement was not as pronounced as those who underwent primary repair. Significantly lower pain scores were seen in nonsmokers ($P < .001$) and in those who underwent tenotomy rather than tenodesis (2 vs. 3.5, $P < .05$) for a damaged long head of biceps. Significantly higher function scores were seen in those with only 1 tendon involved ($P < .05$). The patient-reported retear rate was 32.6%, and the reoperation rate was 34.7%.
Conclusion: Revision rotator cuff repair provides significant improvement in both pain and function at 5 years postoperation, though not as good as primary repair. Superior clinical outcomes are seen in nonsmokers, those with only 1 tendon affected, and those who undergo tenotomy instead of tenodesis for a damaged long head of biceps tendon.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Orthopedic surgery; shoulder; rotator cuff; revision; outcomes; prognostic factor

Primary rotator cuff repair is a well-established surgical procedure for rotator cuff tears. As surgical techniques and outcomes following primary repair have improved, the rates of rotator cuff repair have increased.[9,20] Despite clinical success with primary repair, retears are a common occurrence, with rates of 11%-94% reported.[8,10,11,13,15,18] Although structural failure is not always correlated with clinical failure, several studies have demonstrated poorer clinical outcomes with rotator cuffs that have lost anatomic

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integrity.[1,2,6,13] Restoring integrity of the rotator cuff with revision surgery is important to achieving a good clinical outcome.

Although a number of studies have demonstrated clinical improvement at 1-2 years following revision surgery,[7,17,21,22] there is limited data regarding longer-term outcomes and even less directly comparing midterm results of revision to primary rotator cuff surgery. Additionally, a paucity of good-quality evidence exists regarding predictive factors for clinical and structural success following revision surgery.

The aim of the current study was to analyze the medium-term pain and functional outcomes of a cohort of revision rotator cuff repairs. We hypothesize that revision rotator cuff repairs will continue to show improvement out to 5 years, though the improvement will not be as great as that seen following primary repair.

Materials and methods

The New Zealand Rotator Cuff cohort is a prospective multicenter study of rotator cuff operations undertaken in New Zealand from March 1, 2009, till December 31, 2010. A total of 92 surgeons from across the country participated. Inclusion in the cohort required a rotator cuff repair to be performed within the study time frame. This included primary and revision repairs; open, mini-open, and arthroscopic repairs; and concurrent shoulder procedures.

The current study analyzes the revision subgroup of the New Zealand Rotator cuff cohort. Inclusion criterion was a revision rotator cuff repair performed during the study time frame. Exclusion criteria included primary repairs (n = 2533), those deceased during the follow-up period (n = 10), and those unable to participate because of cognitive decline (n = 2).

Recruitment of patients to the study was undertaken by the operating surgeon. Once enrolled, follow-up was taken over by the research team. At enrolment, patients completed a baseline demographic questionnaire, which included age, sex, ethnicity, hand dominance, smoking status, recreational and occupational activity (a self-reported score of shoulder demand—nil, light, medium, or heavy), and duration of symptoms.

Pain and function scores were collected at baseline. The pain score was a 1-10 scale quantifying average pain levels over the preceding month, with a higher score representing higher pain levels. The Flex-SF, which is a validated shoulder-specific functional assessment score, was chosen as the functional score.[4,5] Patients are asked a discriminating question that directs them to easy, medium, or hard questionnaires. The set of shoulder-specific questions generates a Flex-SF score out of 50. A higher score represents better function.

Operative data were collected by the primary operating surgeon. Intraoperative findings were recorded, including tear size, tear retraction, tendon quality, tendon reducibility, and tendons involved. Tear size and retraction were measured by the surgeon in centimeter increments. Tendon quality was classified into thin or poor vs. good by the operating surgeon. Tendon reducibility was judged on the ability to reduce the tendon back to the anatomic footprint, and subjectively classified as easy, requiring releases, unable to fully reduce, or unable to reduce at all. Concurrent shoulder pathology including biceps tendinopathy or instability, and labral pathology were recorded, as was surgical approach, repair technique (single- vs. double-row), acromioplasty, distal clavicle resection, and long head of biceps (LHB) intervention.

Outcome data were then gathered at 6, 12, and 24 months and then after 5 years. Pain, the Flex-SF, and a postoperative questionnaire were collected. The postoperative questionnaire captured patient-reported complication data such as whether the participant had experienced a retear or undergone further surgery on the shoulder. Functional data concerning return to work and recreational activity was also obtained. Forms were mailed to patients for the 6-, 12-, and 24-month scores. For the 5-year follow-up, this was changed to an online method, and this was extended for a total collection period of 18 months.

Pain and Flex-SF trends were analyzed over time. Cumulative complication data were collected over the 5 years. Certain demographic and intraoperative findings were analyzed. These results were also compared with outcomes following primary repairs.

Univariate analysis was carried out using the SOFA statistics program (version 1.4.3). Independent *t*-testing and χ^2 testing was used to examine statistical relationships, with P values $<.05$ considered statistically significant. Pearson correlation was used to examine linear correlations, with P values $<.05$ considered statistically significant.

Results

A total of 125 revision repairs were included in the study. This represents 5% of the overall rotator cuff cohort. Follow-up at 5 years was achieved in 105 (84%) of these patients. Table I describes the demographic features of both the revision and primary repair groups. The average age of the revision cohort was 56 years, 70% were male, 94% were European, and 14% were smokers.

Table II describes the tear characteristics of both revision and primary repair groups. Tendon quality in the revision group was inferior to that of primary, described as being poor in 52.4% of revisions compared with 18.1% of primaries ($P < .0001$). A greater proportion of revision cuffs were retracted more than 2 cm compared with primary (47.2% vs. 34.8%, $P < .005$). Additionally, revision cuffs were less likely to involve only 1 tendon compared with primary (49.6% vs. 58.6%, $P < .05$).

Table III describes the surgical data of both revision and repair groups. An open approach was used more commonly in revision surgery (55.2% vs. 43.5%, $P = .01$). Rupture of the biceps tendon was encountered more commonly in revision surgery (26.4% vs. 6.4%, $P < .0001$). Acromioplasty was performed more frequently in primary surgery (91.9% vs. 59.2%, $P < .0001$), whereas single-row repair was used more commonly in revision surgery (60% vs. 43.9%, $P < .0005$).

At 6-12 months postoperation, Flex-SF and pain scores in both the revision and primary groups improved significantly from preoperative values, and this improvement was

Table I Demographics of revision and primary

	Revision (n = 125)	Primary (n = 2533)	*P* value
Average age, yr	56.1	56.3	
Sex			
Male	88 (70.4)	1788 (70.6)	.96
Female	37 (29.6)	745 (29.4)	
Ethnicity			
European	118 (94.4)	1154 (89.6)	.08
Maori	3 (2.4)	72 (5.6)	.12
Asian	0 (0.0)	20 (1.6)	.15
Pacific Island	0 (0.0)	21 (1.6)	.15
Other	2 (1.6)	21 (1.6)	>.99
Smoking status			
Yes	18 (14.4)	144 (11.2)	.27
No	107 (85.6)	1144 (88.9)	
Occupation demand			
High	64 (51.2)	1217 (53.4)	.63
Low	61 (48.8)	1064 (46.6)	
Recreation demand			
High	49 (39.2)	612 (47.5)	.07
Low	76 (60.8)	675 (52.5)	

Unless otherwise noted, values are n (%).

Table II Tear characteristics: revision vs. primary

	Revision, n (%) (n = 125)	Primary, n (%) (n = 2533)	*P* value
Tendon quality			
Good	60 (48)	2077 (82)	<.0001
Poor	65 (52)	456 (18)	
Number of tendons affected			
1	62 (49.6)	1484 (58.6)	.046
2	50 (40)	770 (30.4)	.023
3	13 (10.4)	278 (11)	.83
Size of tear			
Large (>3 cm)	32 (25.6)	603 (23.8)	.64
Small (<3 cm)	93 (74.4)	1930 (76.2)	
Tear retraction			
<2 cm	66 (52.8)	1652 (65.2)	.0047
>2 cm	59 (47.2)	881 (34.8)	
Tendons affected			
SS	59 (47.2)	1347 (53.5)	.16
Sub	3 (2.4)	130 (5.2)	.16
SS/IS	26 (20.8)	384 (15.2)	.09
SS/Sub	23 (18.4)	380 (15.1)	.31
SS/IS/Sub	14 (11.2)	278 (11)	.94

SS, supraspinatus; *IS*, infraspinatus; *Sub*, subscapularis.

maintained to 5 years. The improvement in the revision group was not as pronounced as those who underwent primary repair (Figs. 1 and 2). The average improvement in Flex-SF from baseline to 5-year follow-up was 8.5 points ($P < .001$) for the revision group and 15.5 points ($P < .001$) for the primary group. In contrast, the average improvement in pain from baseline to the 5-year follow-up was 2.1 ($P < .001$) in the revision group and 3.2 ($P < .001$) in the primary group.

Table IV displays specific factors related to pain and Flex-SF scores for the revision group at 5 years postoperation. Significantly lower pain scores were seen in nonsmokers compared with smokers (2.5 vs. 5.8, $P < .001$), as well in those who underwent tenotomy rather than tenodesis (2 vs. 3.5, $P < .05$) for a damaged LHB. Significantly higher Flex-SF scores were seen in those who only had 1 tendon involved compared with those who had 3 involved (32 vs. 24, $P < .05$). There was a trend toward higher Flex-SF scores in nonsmokers ($P = .07$) and those of male sex ($P = .08$) but neither reached statistical significance.

No difference in pain or Flex-SF scores was seen with regard to surgical approach, tear size, condition of LHB tendon, repair pattern (single- vs. double-row), or postoperative physiotherapy.

Preoperative Flex-SF and pain scores were also not predictive of 5-year Flex-SF and pain scores. Those who rated their pain <5 on the visual analog scale preoperatively had the same average pain score at 5 years (2.9, $P = .96$) as those who rated it >5. Those who scored >23 on the Flex-SF preoperatively had an average Flex-SF score at 5 years of 33.8, whereas those who score <23 preoperatively had an average of 28.9 at 5 years ($P = .13$).

The patient-reported retear rate was 32.6% (n = 31) in the revision group, which was significantly higher than the rate in the primary group of 7.1% (OR 7.4, $P = .0001$; Table IV). Other patient-reported complications included stiffness (34.7%) and infection (2.6%). The patient-reported reoperation rate in the revision group was 34.7%, significantly higher than the 5.5% seen following primary surgery. Reasons for reoperation in the revision group included retear (48%), stiffness (42%), and infection (10%).

Discussion

This study clearly demonstrates that patients who undergo revision rotator cuff repair achieve improvements in both pain and function, and this benefit is maintained at 5 years. The average improvement in Flex-SF score was 8 points, exceeding the minimal clinically important difference of 3 points reported for this score.[5] Most clinical improvement occurred in the first 6 months; however, patients continued to improve in both pain and function up to 2 years postsurgery. These benefits are largely maintained out to 5 years, although there is a slight worsening in pain and function between 2 and 5 years postoperation. These improvements are not as large as that seen following primary rotator cuff repair.

Table III Surgical data: revision vs. primary

	Revision, n (%) (n = 125)	Primary, n (%) (n = 2533)	*P* value
Surgical approach			
Arthroscopic	17 (13.6)	441 (17.4)	.27
Mini-open	39 (31.2)	990 (39.1)	.07
Open	69 (55.2)	1102 (43.5)	.01
Biceps tendon			
LHB left in situ	57 (45.6)	1274 (50.3)	.31
Tenodesis	36 (28.8)	603 (23.8)	.20
Tenotomy	32 (25.6)	656 (25.9)	.94
Biceps combination			
Normal	47 (37.6)	1300 (51.3)	.003
Damaged but enlocated	25 (20)	609 (24.1)	.29
Damaged and dislocated	17 (13.6)	325 (12.8)	.79
Dislocated	3 (2.4)	138 (5.4)	.14
Ruptured	33 (26.4)	161 (6.4)	<.0001
Acromioplasty			
Yes	74 (59.2)	2328 (91.9)	<.0001
No	51 (40.8)	205 (8.1)	
Distal clavicle excision			
Yes	7 (5.6)	124 (4.9)	.72
No	118 (94.4)	2409 (95.1)	
Repair pattern			
Single row	75 (60)	1112 (43.9)	.0004
Double row	50 (40)	1421 (56.1)	

These results are consistent with previously published studies on outcomes following revision rotator cuff surgery.[3,7,12,14,17,21,22,23,24,25] Keener et al[12] conducted a retrospective case series on 21 patients who underwent revision arthroscopic rotator cuff repair and noted significant improvements in pain and function at a minimum follow-up of 2 years. Ladermann et al[14] also reported on outcomes of a retrospective case series of 72 patients (74 shoulders) that had revision arthroscopic rotator cuff repair. Significant improvements were seen with regard to pain, range of motion, and function in both groups at a minimum follow-up of 2 years. More recently, Willinger et al[25] found significant improvements in pain and function at a minimum follow-up of 30 months in a retrospective case series of 31 patients.

Previous literature in this area consists of retrospective case series without a comparison group. The only study that has directly compared outcomes of revision rotator cuff repair with primary repair is by Shamsudin et al,[23] who conducted a retrospective cohort study on 360 patients, 310 primary and 50 revision, at a minimum follow-up of 2 years. Both groups had significant clinical improvement at 6 months; however, the revision group then plateaued whereas the primary group continued to improve. At the 2-year follow-up, the primary group reported less pain and had better function and strength compared with the revision group. The results of this study are similar to our study, showing that patients can expect significant improvement in pain and function following revision rotator cuff repair, especially in the first 6 months; however, this improvement is not as good as that seen following primary repair.

Limited research exists regarding predictors of clinical outcomes following revision rotator cuff repair. There has been some evidence of poorer outcomes with female sex,[3,14,22] older age,[3] preoperative shoulder flexion below 135°,[3,14] and preoperative pain >5 on visual analog scale.[14] We did not find any statistically significant relationship between any of these factors and clinical outcomes at 5 years. Interestingly, preoperative Flex-SF and pain scores were also not predictive of 5-year Flex-SF and pain scores in our study.

Three factors were associated with improved outcomes at 5 years: being a nonsmoker, undergoing tenotomy instead of tenodesis for a damaged bicep tendon, and having only 1 tendon involved at the time of revision surgery. Smoking has been shown to have numerous negative effects on the musculoskeletal system, including impaired wound and fracture healing as well as increased pain.[16] Our findings of significantly greater pain scores in smokers compared with nonsmokers at 5 years post revision repair further illustrates the hugely detrimental effects of cigarette smoking.

Pain scores were also found to be significantly lower in those undergoing tenotomy vs. tenodesis. As more than 60% of those undergoing revision surgery had some degree of LHB pathology (intrasubstance damage, dislocated or ruptured), a decision around how to best manage the LHB is an essential element to the overall management of the patient's condition. Tenotomy vs. tenodesis for LHB pathology in the setting of primary rotator cuff repair has garnered significant attention in the literature and remains controversial. A systematic review published in 2017 by Maffulli et al[19] concluded no difference in clinical outcome between the 2 techniques, although a higher rate of Popeye deformity was seen in those who underwent tenotomy. To the authors' knowledge, no published literature currently exists regarding how best to manage the LHB in the setting of revision rotator cuff surgery. Our findings suggest that tenotomy may be superior to tenodesis with regard to long-term pain.

In terms of retear following revision surgery, a number of recently published studies have reported rates of 40%-55% at a 2-year follow-up using ultrasonography or magnetic resonance imaging.[12,23,25] The patient-reported retear rate in our cohort was 32.6%. As the retears were not radiologically confirmed, but rather self-reported in the postoperative questionnaire, this is likely to represent a significant underestimate of the actual retear rate.

This study has several limitations. First, enrolment in the study was at the discretion of the operating surgeon, and therefore selection bias cannot be ruled out. However,

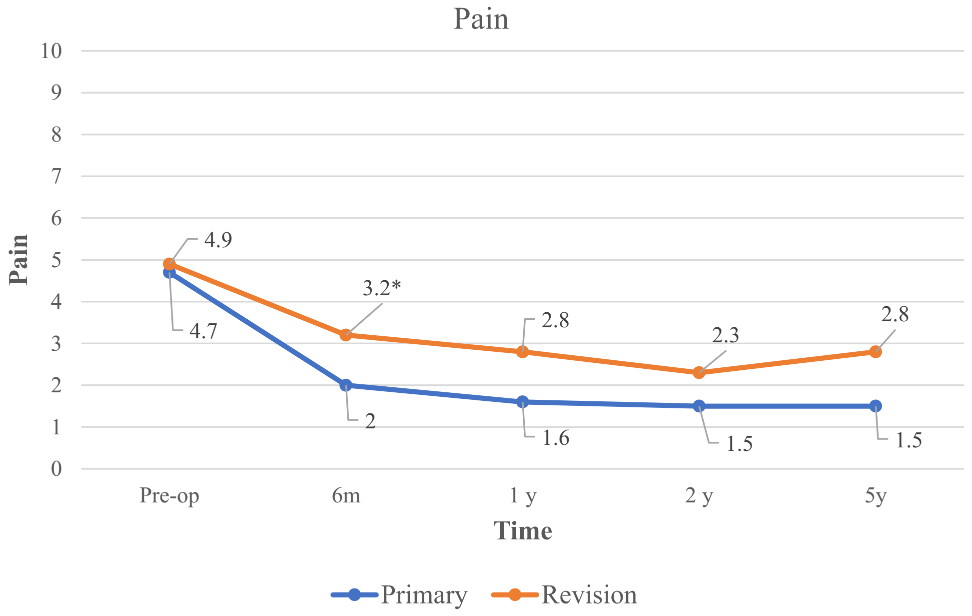

Figure 1 Average pain score at each time point—revision vs. primary. *Significant difference between revision pain baseline and pain 6 months ($P < .001$).

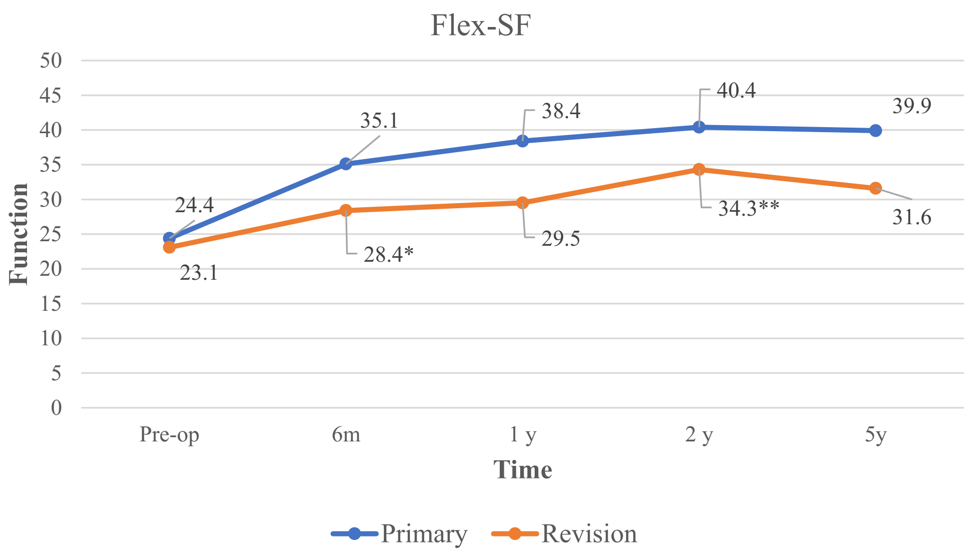

Figure 2 Average Flex-SF at each time point—revision vs. primary. *Significant difference between Revision Flex baseline and Flex 6 months ($P < .001$). **Significant difference between Revision Flex 1 year and 2 years ($P = .05$). *Pre-op*, preoperation.

participating surgeons were asked to enroll all eligible patients consecutively for the duration of the study. Second, intraoperative data were collected by the operating surgeon, and therefore it is likely interobserver variability exists in subjective aspects such as tendon quality and tendon reducibility. Descriptive categories were used on the operative day form in an attempt to control the variability; however, we acknowledge this as a limitation. Finally, the lack of any follow-up imaging is also a limitation. This is particularly important when considering retear rates where data rely on patient-reported retear. The large size of the overall cohort (>2500 participants) made radiologic follow-up impractical.

The strengths of this study include its large size, minimum follow-up time of at least 5 years and high follow-up rate of 84%. As it was a multicenter study involving more than 90 surgeons, the results of this study are also generalizable.

Table IV Factors associated with 5-year pain and Flex-SF scores following revision rotator cuff repair

	Pain	*P* value	Flex-SF	*P* value
Sex				
Male	2.84		33.0	
Female	2.73	.81	28.7	.08
Age				
<65 yr	2.96		31.5	
>65 yr	2.12	.12	31.6	.96
Smoking status				
Smoker	5.8		20.7	
Nonsmoker	2.5	<.001*	32.6	.07
Preoperative VAS score				
<5	2.9		29.2	
>5	2.87	.96	33.2	.23
Preoperative Flex-SF score				
<23	3.4		28.9	
>23	2.4	.11	33.8	.13
Number of tendons affected				
1	2.56		32.4	
2	2.98	.34	32.4	.99
3	3.09	.39	24.1	.038
Tendon quality				
Good	3.3		32.5	
Poor	2.4	.03	32.4	.96
Tear size				
Small (<3 cm)	3.0		31.9	
Large (>3 cm)	2.3	.13	30.8	.67
Tear retraction				
<2 cm	2.97		32.9	
>2 cm	2.88	.82	29.2	.14
Surgical approach				
Arthroscopic	3.23		31.8	
Open	2.86	.55	30.1	.62
Reducibility				
Easily	2.64		32.5	
Unable to reduce fully	3.33	.35	26.7	.15
Repair pattern				
Single row	2.87		32.2	
Double row	2.51	.41	29.6	.29
Condition of LHB				
Normal	2.97		32.9	
Damaged	3.35	.50	31.8	.72
Biceps operation				
Tenodesis	3.47		31.8	
Tenotomy	2.0	.04*	34.1	.57
Acromioplasty				
Yes	2.68		33.3	
No	3.08	.34	28.9	.07
Physiotherapy postoperation				
Yes	2.84		30.8	
No	2.73	.85	35.4	.15

VAS, visual analog scale; *LHB*, long head of biceps.

Conclusion

In conclusion, revision rotator cuff repair provides significant improvement in both pain and function at 5 years postoperation, though with outcomes not as good as for primary repair. Lower pain scores are seen in nonsmokers and those who undergo tenotomy instead of tenodesis for a damaged LHB tendon. Higher functional scores are seen in those with single tendon tears compared with 3 tendon tears.

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