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Impact of previous non-arthroplasty surgery on clinical outcomes after primary anatomic shoulder arthroplasty

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Background: The objectives of this study were to address the following questions regarding previous non-arthroplasty surgery prior to primary anatomic shoulder arthroplasty (either total shoulder arthroplasty [TSA] or ream-and-run arthroplasty): (1) To what degree is primary anatomic shoulder arthroplasty after prior non-arthroplasty surgery associated with inferior clinical outcomes and higher revision rates compared with arthroplasty without previous surgery? (2) Does type, approach, or timing of previous surgery affect outcomes after anatomic arthroplasty?
Methods: A retrospective review of a primary shoulder arthroplasty database was performed and identified 640 patients undergoing anatomic shoulder arthroplasty (345 TSAs and 295 ream-and-run arthroplasties). Of these patients, 183 (29%) underwent previous non-arthroplasty surgery. Baseline and demographic information, 2-year postoperative outcome scores, and revision surgical procedures with associated culture results were collected.
Results: In patients undergoing TSA, previous non-arthroplasty surgery was associated with a significantly lower 2-year Simple Shoulder Test (SST) score ($P = .010$), percentage maximum possible improvement (MPI) ($P = .024$), and Single Assessment Numeric Evaluation (SANE) score ($P < .001$) and a higher rate of reoperation ($P < .001$). In patients undergoing ream-and-run arthroplasty, previous non-arthroplasty surgery was associated with a nonsignificantly lower 2-year SST score, percentage MPI, and SANE score and higher reoperation rate. Prior fracture surgery carried a higher risk of reoperation than other types of surgery including rotator cuff repair and instability surgery. Among TSA and ream-and-run arthroplasty cases with prior non-arthroplasty surgery, prior open surgery and the time interval from most recent surgery were associated with nonsignificant differences in the 2-year SST score, percentage MPI, SANE score, and revision risk.
Conclusion: Previous surgery is associated with inferior clinical outcomes and higher revision rates in patients undergoing index TSA but not in those undergoing the ream-and-run procedure. Patients with previous fracture surgery carry the highest risk of reoperation.
Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Total shoulder arthroplasty; ream-and-run arthroplasty; previous surgery; revision risk; proximal humeral fracture; anatomic shoulder arthroplasty

This study was approved by the University of Washington Institutional Review Board (no. 38897).

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Although anatomic shoulder arthroplasty is a generally effective management for patients with loss of comfort and function caused by glenohumeral arthritis, certain risk factors for suboptimal results have been identified, such as increased medical comorbidities, work-related shoulder problems, severe glenoid pathology, and humeral head decentering.[8,10,12] Recent investigations have revealed that previous non-arthroplasty surgery may lead to suboptimal outcomes regarding pain, function, and complication rates.[2,6,12,17,22] However, the associations of anatomic arthroplasty outcomes with the specific type of prior surgery, the characteristics of the patient and shoulder, the time from non-arthroplasty surgery to index shoulder arthroplasty, and the type of anatomic arthroplasty have not been studied in detail.

The objectives of this study were to address 2 questions: (1) To what degree are total shoulder arthroplasty (TSA) and ream-and-run arthroplasty performed after prior non-arthroplasty surgery associated with inferior clinical outcomes and higher revision rates compared with these procedures performed in patients without previous surgery, and what patient and shoulder characteristics influence these associations? (2) In patients undergoing surgery prior to index arthroplasty, does the type, approach, or timing of surgery affect outcomes?

Methods

A longitudinally maintained institutional database of primary shoulder arthroplasty patients was retrospectively reviewed for patients undergoing primary anatomic shoulder arthroplasty between August 2010 and August 2016. At the time of enrollment in the database, patients were asked if they had undergone previous surgery on the ipsilateral shoulder and, if so, the characteristics and dates of the previous surgical procedures.

A total of 807 patients were enrolled in the database during the aforementioned period, of whom 640 (79%) underwent anatomic shoulder arthroplasty, including 345 TSAs and 295 ream-and-run arthroplasties. The surgeons' approach to arthroplasty has been described previously.[11,12] A minimum 2-year follow-up was completed in 551 patients (86%). In 183 of these patients (33%), non-arthroplasty surgery was previously performed on the ipsilateral shoulder. Baseline and demographic information included sex, age, body mass index, diagnosis, type of surgery, type of insurance, American Society of Anesthesiologists (ASA) class, tobacco use, alcohol use, narcotic use, and presence of diabetes. Visual analog scale pain, Simple Shoulder Test (SST), and Single Assessment Numeric Evaluation (SANE) scores were collected preoperatively and at 2 years postoperatively. The percentage maximum possible improvement (MPI) was calculated. Reoperation was recorded in 2 categories: manipulation under anesthesia (MUA) for stiffness and surgical revision.

Previous surgical procedures were classified into 1 of 4 categories: rotator cuff repair, instability surgery (eg, labral repair, open Bankart repair, or Latarjet procedure), surgery for a proximal humeral or glenoid fracture, and non-repair surgery. Non-repair surgery included procedures such as débridement, subacromial decompression, biceps tenodesis, distal clavicle excision, and capsular release. Each surgical procedure was also classified as open or arthroscopic. Patients who underwent multiple previous surgical procedures were classified as having undergone open surgery if they underwent 1 procedure performed through an open approach. Patients could be classified as undergoing non-repair surgery only if they had not undergone previous cuff repair, instability surgery, or surgery for fracture. The time between index arthroplasty and last non-arthroplasty surgery was calculated.

Statistical analysis

Descriptive characteristics are presented as means, standard deviations, and ranges for continuous variables and as counts and percentages for categorical variables. The statistical significance of differences in the characteristics between patients with and patients without previous surgery was calculated using the 2-sample *t* test with unequal variances, χ^2 test, or Fisher exact test (as appropriate). Unadjusted and adjusted effects of the previous surgical procedure and of characteristics of the previous surgical procedure on the mean 2-year outcomes (SST score, percentage MPI, and SANE score) and on the revision rate were estimated using linear regression and Cox proportional hazards regression, respectively. Adjusted effects controlled for the following: sex, age at surgery, body mass index, which shoulder was operated on, primary insurance, ASA class, tobacco use, alcohol use, narcotic use, type 1 diabetes, type 2 diabetes, preoperative pain score, preoperative SST score, and preoperative SANE score. All calculations were carried out in the R package (version 3.5.2; R Foundation for Statistical Computing, Vienna, Austria). $P < .05$ was used to denote statistical significance.

Results

Total shoulder arthroplasty

Of the 345 patients undergoing TSA, 48% were male patients aged 66 ± 11 years (mean ± standard deviation) (Table I). In this cohort, patients with prior non-arthroplasty surgery were more likely to be younger (mean age, 59 years vs. 68 years; $P < .001$), have different diagnoses ($P < .001$), have commercial insurance ($P = .003$), and have lower preoperative SST scores (mean, 2.3 vs. 3.0; $P = .020$) than patients without prior non-arthroplasty surgery. The follow-up time was significantly shorter in patients with previous surgery (mean, 2.7 years vs. 3.3 years; $P = .028$).

The 2-year SST score (mean, 8.4 vs. 9.6; $P = .010$), percentage MPI (mean, 63% vs. 74%; $P = .024$), and SANE score (mean, 74 vs. 86; $P < .001$) were lower in patients who underwent previous surgery. In addition, the rates of MUA (9% vs. 0%, $P < .001$) and open revision (8% vs. 1%, $P < .001$) were significantly higher in the previous surgery group.

Unadjusted effects of prior surgery demonstrated significant differences for the 2-year SST score ($P = .002$), percentage MPI ($P = .012$), and SANE score ($P < .001$) (Table III). The risk of reoperation was significantly higher (hazard ratio [HR], 20.79; 95% confidence interval [CI],

Table I Descriptive statistics for preoperative and outcome data among total shoulder arthroplasties overall and by presence of previous surgery

	All		Without prior surgery		With prior surgery		*P* value (without vs. with prior surgery)
	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	
Total	345		221		72		
Male sex		166 (48)		106 (48)		42 (58)	.126
Age at surgery, yr		66 ± 11 (24-90)		68 ± 9 (36-90)		59 ± 13 (24-80)	<.001
Body mass index		31 ± 7 (15-58)		31 ± 7 (19-58)		30 ± 7 (15-57)	.312
Primary diagnosis							<.001*
Avascular necrosis		5 (1)		5 (2)		0 (0)	
Capsulorrhaphy arthropathy		16 (5)		0 (0)		16 (22)	
Chondrolysis		5 (1)		0 (0)		5 (7)	
Degenerative osteoarthritis		286 (83)		202 (91)		36 (50)	
Other		2 (1)		2 (1)		0 (0)	
Post-traumatic arthritis		12 (3)		6 (3)		6 (8)	
Rheumatoid arthritis		3 (1)		1 (0)		1 (1)	
Secondary degenerative joint disease		16 (5)		5 (2)		8 (11)	
No. of prior surgical procedures					72	1.7 ± 1.2	
Type of prior surgery							
Cuff repair					72	13 (18)	
Instability surgery					72	29 (40)	
Fracture surgery					72	6 (8)	
Non-repair surgery					72	25 (35)	
Open surgery					65	32 (48)	
Time interval from most recent surgery, yr						14 ± 13	
Insurance							.003*
Commercial		75 (24)		43 (20)		23 (34)	
Workers' compensation		20 (6)		11 (5)		8 (12)	
Medicaid		14 (5)		9 (4)		5 (7)	
Medicare		188 (60)		143 (66)		28 (42)	
Medicare and Medicaid		6 (2)		6 (3)		0 (0)	
Other		7 (2)		3 (1)		3 (4)	
Self-pay		1 (0)		1 (0)		0 (0)	
ASA class	310	2.4 ± 0.6 (1.0-4.0)	216	2.4 ± 0.6 (1.0-4.0)	66	2.3 ± 0.7 (1.0-4.0)	.220
Tobacco use	343		220		72		.070*
Never		144 (42)		97 (44)		23 (32)	
Passive		3 (1)		1 (0)		2 (3)	
Quit		168 (49)		106 (48)		38 (53)	
Yes		28 (8)		16 (7)		9 (12)	
Alcohol use	344	196 (57)	220	118 (54)	72	43 (60)	.367
Narcotic use	336	112 (33)	214	65 (30)	70	29 (41)	.088
Type 1 diabetes	345	9 (3)	221	5 (2)	72	1 (1)	>.999*
Type 2 diabetes	345	33 (10)	221	24 (11)	72	8 (11)	.953
Preoperative pain score	338	7.1 ± 1.9 (1.0-10.0)	218	7.0 ± 1.9 (1.0-10.0)	69	7.1 ± 1.7 (2.0-10.0)	.808
Preoperative SST score	345	2.8 ± 2.3 (0.0-10.0)	221	3.0 ± 2.4 (0.0-10.0)	72	2.3 ± 2.0 (0.0-7.0)	.020
Preoperative SANE score	338	35 ± 21 (0-100)	215	37 ± 21 (0-100)	71	31 ± 21 (0-100)	.058
2-yr SST score	284	9.4 ± 2.7 (0.0-12.0)	180	9.6 ± 2.4 (1.0-12.0)	61	8.4 ± 3.5 (0.0-12.0)	.010
% MPI	284	72 ± 29 (−25 to 100)	180	74 ± 27 (−25 to 100)	61	63 ± 33 (−10 to 100)	.024

(*continued on next page*)

Table I Descriptive statistics for preoperative and outcome data among total shoulder arthroplasties overall and by presence of previous surgery (*continued*)

	All		Without prior surgery		With prior surgery		*P* value (without vs. with prior surgery)
	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	
2-yr SANE score	279	84 ± 17 (20-100)	178	86 ± 13 (25-100)	59	74 ± 23 (20-100)	<.001
Open revision surgery	344	9 (3)	221	2 (1)	71	6 (8)	<.001
Manipulation	343	6 (2)	221	0 (0)	70	6 (9)	<.001*
Follow-up time for revision, yr	344	3.0 ± 2.0 (0.0-7.3)	221	3.3 ± 2.1 (0.1-7.3)	71	2.7 ± 1.9 (0.0-7.1)	.028

SD, standard deviation; *ASA*, American Society of Anesthesiologists; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *MPI*, maximum possible improvement.
The *P* value was determined with the 2-sample *t* test for continuous variables and χ^2 test for categorical variables, unless specified otherwise.
* Fisher exact test.

4.65-93.00; *P* < .001) in the previous surgery group. Adjusted analysis demonstrated significantly lower 2-year SANE scores (*P* = .045) in patients undergoing prior surgery.

In the group with prior surgery, 2 patients underwent revision surgery for stiffness with downsizing of the humeral head component and 5 underwent revision for soft-tissue failure (rotator cuff or biceps). In the group without prior surgery, 1 patient underwent single-stage component exchange for suspected infection and 1 underwent revision because of rotator cuff failure.

Ream-and-run arthroplasty

Of the 295 patients undergoing ream-and-run arthroplasty, 92% were male patients aged 58 ± 10 years (mean ± standard deviation) (Table II). In this cohort, patients with prior non-arthroplasty surgery were more likely to be younger (mean, 53 years vs. 61 years; *P* < .001), have different diagnoses (*P* < .001), and have commercial insurance (*P* = .025) than those without prior non-arthroplasty surgery. The preoperative pain score (mean, 7.2 vs. 6.7; *P* = .024) was significantly higher in patients with prior surgery, but the preoperative SST score (mean, 4.6 vs. 5.0; *P* = .135) was similar between the 2 groups. The follow-up time was significantly shorter in patients with previous surgery (mean, 2.7 years vs. 3.2 years; *P* = .047).

The 2-year SST score (mean, 9.7 vs. 10.4; *P* = .065), percentage MPI (mean, 69% vs. 75%; *P* = .285), and SANE score (mean, 77 vs. 81; *P* = .095) were similar between patients with and patients without previous surgery. In addition, the rates of MUA (7% vs. 7%, *P* = .911) and open revision (8% vs. 12%, *P* = .340) were similar between groups.

In the group with prior surgery, 3 patients underwent open release for stiffness, 5 underwent downsizing of the humeral head, 3 underwent single-stage exchange for suspected infection, and 1 underwent revision owing to rotator cuff failure. In the group without previous surgery, 1 patient underwent open release for stiffness, 8 underwent downsizing of the humeral head, 2 underwent single-stage exchange for suspected infection, 1 underwent revision to TSA because of symptomatic glenoid wear, and 1 underwent revision surgery at an outside hospital for an unknown reason.

Unadjusted effects of prior surgery demonstrated no significant differences for the 2-year SST score (*P* = .059), percentage MPI (*P* = .286), and SANE score (*P* = .086) (Table III). A post hoc calculation revealed that an effect size of 0.38 could be detected with an α of .05 and β of .20. Adjusted effects were nonsignificant as well. The risk of reoperation was not significantly higher for patients undergoing prior surgery (HR, 1.34; 95% CI, 0.74-2.44; *P* = .340).

Type, approach, and timing of previous surgery

Among TSA and ream-and-run arthroplasty cases with prior non-arthroplasty surgery, prior fracture surgery carried the highest risk of revision (HR, 5.34; 95% CI, 0.96-29.61; *P* = .055) (Table IV). Unadjusted effects of prior rotator cuff repair demonstrated no significant difference for the 2-year SST score (*P* = .656), percentage MPI (*P* = .799), 2-year SANE score (*P* = .377), and revision risk (*P* = .370) compared with those without a history of cuff repair. Prior open surgery and the time interval from most recent surgery were not associated with a statistically significant difference in the 2-year SST score, percentage MPI, SANE score, or reoperation risk (Table IV).

Discussion

Patients commonly present for consideration of shoulder arthroplasty after having undergone previous surgery on the

Table II Descriptive statistics for preoperative and outcome data among ream-and-run arthroplasties overall and by presence of previous surgery

	All		Without prior surgery		With prior surgery		*P* value (without vs. with prior surgery)
	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	
Total	295		147		111		
Male sex		272 (92)		138 (94)		102 (92)	.535
Age at surgery, yr		58 ± 10 (31-81)		61 ± 9 (38-80)		53 ± 10 (31-72)	<.001
Body mass index		29 ± 5 (18-47)		29 ± 4 (22-47)		29 ± 5 (20-43)	.888
Primary diagnosis							<.001*
Avascular necrosis		2 (1)		1 (1)		1 (1)	
Capsulorrhaphy arthropathy		32 (11)		0 (0)		32 (29)	
Chondrolysis		6 (2)		0 (0)		6 (5)	
Degenerative osteoarthritis		229 (78)		143 (97)		51 (46)	
Post-traumatic arthritis		8 (3)		3 (2)		5 (5)	
Secondary degenerative joint disease		18 (6)		0 (0)		16 (14)	
No. of prior surgical procedures					111	1.5 ± 0.8	—
Type of previous surgery							
Cuff repair					111	16 (14)	
Instability surgery					111	55 (50)	
Fracture surgery					111	5 (5)	
Non-repair					111	39 (35)	
Open surgery					111	50 (45)	
Time interval from most recent surgery, yr						12 ± 11 (0-53)	
Primary insurance	282		147		108		.025*
Commercial		169 (60)		81 (55)		71 (66)	
Workers' compensation		16 (6)		7 (5)		8 (7)	
Medicaid		9 (3)		4 (3)		4 (4)	
Medicare		63 (22)		43 (29)		13 (12)	
Medicare and Medicaid		0 (0)		0 (0)		0 (0)	
Other		23 (8)		11 (7)		11 (10)	
Self-pay		2 (1)		1 (1)		1 (1)	
ASA class	266	1.9 ± 0.5 (1.0-3.0)	142	1.9 ± 0.5 (1.0-3.0)	101	1.9 ± 0.6 (1.0-3.0)	.760
Tobacco use	295		147		111		.240
Never		180 (61)		93 (63)		64 (58)	
Passive		11 (4)		3 (2)		6 (5)	
Quit		87 (29)		45 (31)		32 (29)	
Yes		17 (6)		6 (4)		9 (8)	
Alcohol use	294	202 (69)	147	100 (68)	110	79 (72)	.513
Narcotic use	289	50 (17)	146	27 (18)	106	19 (18)	.908
Type 1 diabetes	295	3 (1)	147	1 (1)	111	2 (2)	.579*
Type 2 diabetes	295	7 (2)	147	2 (1)	111	4 (4)	.237
Preoperative pain score	288	6.8 ± 1.9 (2.0-10.0)	144	6.7 ± 2.0 (2.0-10.0)	110	7.2 ± 1.7 (2.0-10.0)	.024
Preoperative SST score	295	4.9 ± 2.5 (0.0-11.0)	147	5.0 ± 2.6 (0.0-11.0)	111	4.6 ± 2.3 (0.0-10.0)	.135
Preoperative SANE score	288	41 ± 19 (0-100)	143	41 ± 19 (0-100)	109	38 ± 18 (0-90)	.168
2-yr SST score	255	10.1 ± 2.6 (0.0-12.0)	131	10.4 ± 2.4 (0.0-12.0)	97	9.7 ± 2.7 (0.0-12.0)	.065
% MPI	255	73 ± 38 (−150 to 100)	131	75 ± 39 (−150 to 100)	97	69 ± 39 (−100 to 100)	.285
2-yr SANE score	251	80 ± 19 (0-100)	128	81 ± 17 (0-100)	95	77 ± 20 (10-100)	.095
Open revision surgery	295	26 (9)	147	12 (8)	111	13 (12)	.340

(*continued on next page*)

Table II Descriptive statistics for preoperative and outcome data among ream-and-run arthroplasties overall and by presence of previous surgery (*continued*)

	All		Without prior surgery		With prior surgery		*P* value (without vs. with prior surgery)
	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	n	Mean ± SD (range) or n (%)	
Manipulation	294	21 (7)	146	10 (7)	111	8 (7)	.911
Follow-up time for revision, yr	295	2.9 ± 2.0 (0.0-8.0)	147	3.2 ± 2.3 (0.0-8.0)	111	2.7 ± 1.8 (0.0-7.0)	.047

SD, standard deviation; *ASA*, American Society of Anesthesiologists; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *MPI*, maximum possible improvement.
The *P* value was determined with the 2-sample *t* test for continuous variables and χ^2 test for categorical variables, unless specified otherwise.
* Fisher exact test.

Table III Unadjusted and adjusted effects of prior surgery on outcomes by surgery type: linear regression for 2-year SST score, percentage MPI, and 2-year SANE score and Cox regression for revision

	2-yr SST score		% MPI		2-yr SANE score		Revision	
	Difference (95% CI)	*P* value	Difference (95% CI)	*P* value	Difference (95% CI)	*P* value	Difference (95% CI)	*P* value
Total shoulder arthroplasty								
Unadjusted	−1.3 (−2.1 to −0.5)	.002	−11 (−19 to −2)	.012	−12 (−17 to −7)	<.001	20.79 (4.65-93.00)	<.001
Adjusted*	−0.1 (−1.0 to 0.7)	.778	−2 (−12 to 7)	.662	−5 (−11 to 0)	.045	†	
Ream-and-run arthroplasty								
Unadjusted	−0.6 (−1.3 to 0.0)	.059	−6 (−16 to 5)	.286	−4 (−9 to 1)	.086	1.34 (0.74-2.44)	.340
Adjusted*	−0.5 (−1.2 to 0.3)	.251	−2 (−14 to 9)	.680	0 (−6 to 5)	.894	†	

SST, Simple Shoulder Test; *MPI*, maximum possible improvement; *SANE*, Single Assessment Numeric Evaluation; *CI*, confidence interval.
For total surgery cases, the numbers equaled 237-292 for the unadjusted analysis and 212-257 for the adjusted analysis. For ream-and-run cases, the numbers equaled 223-258 for the unadjusted analysis and 201-227 for the adjusted analysis.
* Adjusted for sex, age at surgery, body mass index, which shoulder was operated on, primary insurance, ASA class, tobacco use, alcohol use, narcotic use, type 1 diabetes, type 2 diabetes, preoperative pain score, preoperative SST score, and preoperative SANE score.
† Not attempted because of a small sample size (or revision events) relative to the number of independent variables.

ipsilateral shoulder. The impact of previous surgery and the characteristics associated with previous surgery may affect a surgeon's preoperative discussion with a patient regarding the ultimate outcome. This study demonstrates that patients who have undergone non-arthroplasty surgery prior to index TSA or ream-and-run arthroplasty can still have clinically significant levels of improvement, but in patients undergoing TSA, 2-year outcomes are significantly inferior in those who have not undergone prior surgery.

The association between prior surgery and inferior outcomes is likely multifactorial. Prior surgery can alter the normal anatomy of the shoulder and can make an arthroplasty more technically complex given the importance of proper soft-tissue balancing. Previous fracture surgery and instability surgery were associated with a higher risk of revision surgery. The underlying disease (eg, proximal humeral fracture or glenohumeral instability) may be more complex and difficult to address. Medical comorbidities are often associated with worse outcomes,[12] but no significant differences in ASA classification were found between patients with and patients without previous non-arthroplasty surgery and would not account for the inferior results.

Psychosocial factors such as motivation and pain tolerance may be important factors, and psychological diagnoses such as depression and anxiety have been shown to be associated with inferior outcomes.[21] This may explain why 2-year outcomes were significantly different between patients with and patients without previous surgery in the TSA group but were similar in the ream-and-run arthroplasty group. Patients electing to undergo ream-and-run arthroplasty are likely different from a psychosocial standpoint[13] and may represent a more motivated and resilient group of patients who may maximize their

Table IV Unadjusted effect of previous surgery characteristics on outcomes: all anatomic shoulder arthroplasties (total shoulder and ream-and-run procedures): linear regression for 2-year SST score, percentage MPI, and 2-year SANE score and Cox regression for revision

	2-yr SST score (n = 158)		% MPI (n = 158)		2-yr SANE score (n = 154)		Revision (n = 182)	
	Difference (95% CI)	*P* value	Difference (95% CI)	*P* value	Difference (95% CI)	*P* value	Difference (95% CI)	*P* value
Cuff repair: yes vs. no*	−0.7 (−3.6 to 2.2)	.656	−4 (−38 to 30)	.799	9 (−11 to 29)	.377	2.05 (0.43-9.88)	.370
Instability surgery: yes vs. no*	−0.5 (−3.5 to 2.5)	.749	−0 (−35 to 35)	.986	9 (−12 to 30)	.382	2.41 (0.49-11.77)	.276
Fracture surgery: yes vs. no*	−1.8 (−5.2 to 1.6)	.289	−19 (−58 to 21)	.357	6 (−17 to 30)	.585	5.34 (0.96-29.61)	.055
Non-repair surgery: yes vs. no*	−0.4 (−3.6 to 2.8)	.823	−0 (−38 to 37)	.993	11 (−11 to 33)	.316	2.24 (0.38-13.20)	.374
Open surgery: yes vs. no	−0.4 (−1.4 to 0.6)	.417	−3 (−15 to 8)	.559	−1 (−7 to 6)	.879	0.91 (0.45-1.83)	.789
Time interval from most recent surgery (per 12 mo)	0.3 (−0.2 to 0.8)	.180	5 (−1 to 11)	.087	2 (−1 to 5)	.257	1.00 (0.70-1.42)	.982

SST, Simple Shoulder Test; *MPI*, maximum possible improvement; *SANE*, Single Assessment Numeric Evaluation; *CI*, confidence interval.
* The effects of cuff repair, instability surgery, fracture surgery, and non-repair were estimated jointly from the same multivariate model.

rehabilitation potential. This may minimize any potential differences seen between patients with and patients without previous surgery in this particular cohort.

Our results are similar to those found by Frank et al,[2] who studied 263 anatomic TSAs and 243 reverse shoulder arthroplasties and found lower visual analog scale, SST, and American Shoulder and Elbow Surgeons scores and forward elevation in patients who underwent shoulder surgery prior to arthroplasty compared with those who did not. Their multivariate regression analysis revealed prior surgery to be an independent predictor of postoperative complications, and a subgroup analysis of anatomic TSA patients demonstrated inferior mean SST scores (8.5 for previous surgery vs. 10.0 for no previous surgery, $P = .006$), similarly to our study. These differences do not reach the minimal clinically important difference for the SST score described in the literature, which ranges from 1.5 to 2.4.[18,20] Frank et al did not find previous rotator cuff repair to have a significant effect on patient-reported outcomes or reoperation for their anatomic arthroplasties but attributed this to a small sample size. Despite including a larger group of patients with prior cuff repair, we did not find a statistical association of prior cuff repair with inferior patient-reported outcomes or revision risk in these patients.

A substantial number of our patients had a history of stabilization surgery, which has been noted in the literature to be associated with substantial rates of recurrent instability, component loosening, and rotator cuff failure.[1,3,19,23] Bigliani et al[1] noted that distorted anatomy led to more complex technical surgical procedures and a 23% rate of unsatisfactory results according to the criteria used by Neer et al.[14] Similarly, Sperling et al[19] noted high rates of revision surgery and a survival rate of only 61% at 10 years. Willemot et al[23] noted a 30% revision rate for instability after anatomic arthroplasty in patients with a previous Bristow or Latarjet procedure. This could result from altered capsular tension, violation and alteration of the subscapularis muscle, or failure to adequately treat instability, all of which make soft-tissue balancing of the shoulder more difficult. Because of the difficulty in soft-tissue balancing, Raiss et al[15] reported on reverse TSA in the setting of failed instability surgery and found that the results were comparable to reverse arthroplasty performed for other conditions. Our results did not show any clear statistical difference in patient-reported outcomes and revision rates between patients with and patients without prior instability surgery.

Of the 4 categories of previous surgery, previous surgery for fracture was associated with the highest risk of revision. Soft-tissue contractures, both intra- and extra-articular, are common after these fractures, and altered proximal bony anatomy can make humeral component insertion and fixation more challenging. In addition, the status and function of the rotator cuff are often compromised owing to tuberosity nonunion or malunion. A number of studies have described complications stemming from arthroplasty for failed proximal humeral fixation.[7,9] Hussey et al[7] noted a 26% rate of major complications, and Kristensen et al[9] noted a higher risk of revision after arthroplasty performed for failed osteosynthesis compared with primary arthroplasty performed for fracture. Hackett et al[5] found tuberosity malunion or nonunion to be a common characteristic in patients undergoing revision surgery for a failed hemiarthroplasty. In scenarios in which the condition of the rotator cuff or tuberosities is in question, the surgeon may consider reverse TSA a more reliable option, and other groups have confirmed acceptable results with reverse shoulder arthroplasty for failed proximal humeral fixation.[4,16]

There are some limitations to this study. First, radiographic outcomes were not included in our analysis. Second, these procedures were performed at a high-volume tertiary-care referral center. The complexity of pathologies and surgical approaches may not be generalizable. Third, significant differences existed between the 2 groups and limited some comparisons. However, whenever possible, we used adjusted analyses to reduce the effect of confounders. Fourth, even by stratifying previous surgical procedures into 4 groups based on surgery type, there exists a wide spectrum of disease severity and surgery complexity within each category of previous surgery. Fifth, the impact of procedures aimed at the amelioration of arthritis was not studied and would be of interest for future studies.

Conclusion

Previous surgery is associated with inferior clinical outcomes and higher revision rates in patients undergoing index TSA but not in those undergoing the ream-and-run procedure. Previous surgery for fracture was associated with the greatest negative impact on patient-reported outcomes and revision risk. Surgeons can use these data to estimate the risk of poor outcomes after arthroplasty when counseling patients who have undergone previous non-arthroplasty surgery.

Disclaimer

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