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Clinically significant subscapularis failure after anatomic shoulder arthroplasty: is it worth repairing?

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Background: Symptomatic subscapularis (SC) failure after anatomic total shoulder arthroplasty (TSA) is difficult to treat. The purpose of this study was to determine the outcomes of reoperation for SC failure.
Methods: All patients undergoing reoperation for SC failure after TSA were identified from a single-institution database. Patients underwent either revision SC repair or revision to reverse shoulder arthroplasty. At a minimum of 1 year after reoperation, complications, reoperations, and functional outcomes were collected.
Results: Patients who initially underwent SC repair were significantly younger than patients who underwent revision to reverse shoulder arthroplasty (mean age, 59.3 years vs. 70.3 years; $P = .004$), had a better comorbidity profile (mean Charlson Comorbidity Index, 2.2 vs. 3.6; $P = .04$), and had a more acute presentation (mean time between injury and surgery, 9.1 weeks vs. 28.5 weeks; $P = .03$). Patients who underwent SC repair also had a significantly higher reoperation rate (52.9% vs. 0.0%, $P = .01$). At final follow-up, functional outcomes scores and patient satisfaction rates were not significantly different between treatment groups.
Discussion: Decision making on how to treat patients with SC failure following TSA remains challenging and should be individualized to the patient's age, level of activity, comorbidities, timing and mechanism of SC failure, and functional expectations.
Level of evidence: Level IV

Keywords: Subscapularis; failure; shoulder arthroplasty; reverse shoulder arthroplasty; subscapularis repair; rotator cuff

The subscapularis (SC) muscle is an internal rotator of the glenohumeral joint and generates a strong counterforce to posterior rotator cuff muscles to limit external rotation and maintain the humeral head position in the sagittal plane during motion.[16,26] In anatomic total shoulder arthroplasty (TSA), the traditional open deltopectoral approach involves SC takedown. Mobilizing the SC muscle creates an inherent vulnerability following shoulder arthroplasty and has long been recognized as an important source of post-arthroplasty complications.[5]

Causes of SC dysfunction after arthroplasty include attritional or traumatic failure of the SC repair, attenuation of the tendon without tear, and muscle denervation or fatty infiltration.[6] SC failure can lead to pain, decreased range of motion, lower functional outcomes, implant instability, and the eventual need for revision surgery. The reported rates of SC failure after arthroplasty vary considerably, mainly owing to the silent nature of its clinical presentation in

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many cases.[19] Armstrong et al[2] reported ultrasound evidence of complete SC failure after TSA in 13% of patients at a minimum follow-up of 8 months, but the majority of patients did not show any clinical signs of failure.

Treatment options for symptomatic SC failure include nonoperative treatment, soft-tissue repair, tendon transfer, or revision to reverse total shoulder arthroplasty (RSA). Traditionally, soft-tissue repair has been performed when there is adequate and good-quality tissue to substantiate the potential for healing. Augmentation with a graft or tendon transfer is an option if tissue quality is poor or the native SC is not repairable. It has been shown, however, that pectoralis major tendon transfer for irreparable SC failure after TSA carries a high risk of failure, particularly if there is anterior subluxation of the humeral head.[8] SC repairs without augmentation also carry a significant risk of failure.[20] RSA has shown acceptable survivability and low complication rates in the setting of TSA revision, however not specifically to address SC failure.[12]

Reported outcomes of surgically managed SC failure after shoulder arthroplasty are sparse and do not clearly favor any of the aforementioned treatment options. The purpose of this study was to report the outcomes of surgically managed, clinically significant SC failures after anatomic TSA.

Methods

Electronic medical records were retrospectively reviewed to identify all patients with anatomic TSA who underwent reoperation at our institution between 2008 and 2017 (n = 281). Operative reports of the secondary operations and subsequent clinical progress notes were reviewed to identify cases in which reoperation was performed for SC failure and patients with a minimum of 1-year follow-up. Demographic variables—including age at index surgery, body mass index, dominant arm and medical comorbidities were collected through chart review and confirmed during telephone survey. Perioperative variables were also collected from patients' electronic medical records and included the date of surgery, primary indication for surgery (including traumatic or atraumatic status), and the method of SC management during the index TSA. The date of surgery, indication, and type of procedure were also collected for all subsequent surgical procedures. Administered postoperative surveys included visual analog scale (VAS) pain, Single Assessment Numeric Evaluation (SANE), and American Shoulder and Elbow Surgeons (ASES) scores. Patient satisfaction was assessed using a single Likert scale question ranging from 1 (''very unsatisfied'') to 5 (''very satisfied''). Positive satisfaction was considered a score of 3 or greater.

After we excluded 3 patients who had an infection at the time of SC failure and 1 patient with a massive rotator cuff tear, 32 patients were included. Complete data were obtained for 25 patients (75.8%), excluding patients who could not be reached (n = 3), refused to be interviewed (n = 2), or died (n = 2).

Statistical analysis was performed using SPSS software (version 20.0; IBM, Armonk, NY, USA). Mean outcome scores were first tested for normality and appropriately analyzed using parametric or nonparametric analyses. Multivariate regression modeling was used to determine predictors of patient reoperations, VAS pain scores, and ASES scores at the final follow-up.

Results

The average age at the time of revision surgery was 62.8 years (range, 46-88 years), with a female-male ratio of 11:14. The average Charlson Comorbidity Index was 2.7 (range, 0.0-7.0). In the majority of patients (80.0%), SC failure occurred after primary TSA, whereas it occurred after revision surgery in 20%. The SC was managed during the index operation with lesser tuberosity osteotomy (LTO) in 68.2% of cases, peel in 22.7%, and tenotomy in 9.1%. Thirty-six percent of patients reported an injury prior to presentation, with a mechanical fall being the most common mechanism of injury, occurring in 56% of injured patients. The majority of the study population (64%) had an insidious onset of symptoms. The median time from index surgery to reoperation for SC failure was 8 months (range, 1-32 months), and the median time to final follow-up was 59 months (range, 15-129 months).

Patients with SC failure underwent SC repair (n = 17) or underwent revision to RSA (n = 8). Patients who initially underwent SC repair were significantly younger than patients who underwent revision to RSA (mean age, 59.3 years vs. 70.3 years; P = .004), had a better comorbidity profile (mean Charlson Comorbidity Index, 2.2 vs. 3.6; P = .04), and had a more acute presentation (mean time between injury and surgery, 9.1 weeks vs. 28.5 weeks; P = .03) (Table I). Patients who underwent SC repair had a significantly higher reoperation rate than those who initially underwent revision to RSA (52.9% vs. 0.0%, P = .01), and they underwent a significantly higher number of reoperations (median, 1 vs. 0; P = .04). The 9 cases of reoperation included 5 revisions to RSA (55.6%), 2 pectoralis major transfers (22.2%), 1 hematoma evacuation, and 1 antibiotic spacer placement for infection. In addition, 2 suspected infections occurred and were treated with antibiotics; they did not undergo spacer placement or further reoperation. All 3 cases of suspected or confirmed infection occurred in the SC repair group.

At final follow-up, mean VAS pain, SANE, and ASES scores and patient satisfaction rates were not significantly different between patients who initially underwent repair and those who underwent revision to RSA (Table II). A multivariate regression model did not identify any significant predictors of SANE and VAS pain scores following treatment of SC failure. Time since injury was a significant predictor of the final ASES score after treatment of traumatic SC failure (standardized coefficient, 0.7; P = .04), with a shorter duration between injury and surgery predicting higher final ASES scores in both the repair group and the revision-to-RSA group.

Table I Patient baseline characteristics

	Overall (N = 25)	SC repair (n = 17)	Revision to RSA (n = 8)	*P* value
Age, mean (SD), yr	62.8 (9.4)	59.3 (7.5)	70.3 (8.9)	.004
% Female sex	44.0	35.3	62.5	.20
BMI, mean (SD)	32.2 (7.4)	32.6 (8.8)	31.3 (3.7)	.71
Dominant side, n (%)	14 (56.0)	10 (58.8)	4 (50.0)	.69
Primary arthroplasty, n (%)	20 (80.0)	13 (76.5)	7 (87.5)	.52
CCI, mean (SD)	2.7 (1.7)	2.2 (1.4)	3.6 (1.8)	.04
SC repair, n (%)				
LTO	15 (68.2)	12 (75.0)	3 (50.0)	.51
Peel	5 (22.7)	3 (18.8)	2 (33.7)	
Tenotomy	2 (9.1)	1 (6.2)	1 (16.7)	
Injury	9 (36.0)	7 (41.2)	2 (25.0)	.43
Time to surgery, mo, median (IQR)	7.0 (7.0)	5.0 (6.5)	9.5 (21.5)	.25
Time from injury to surgery, mean (SD), weeks	13.4 (11.7)	9.1 (9.1)	28.5 (4.9)	.03

SC, subscapularis; *RSA*, reverse shoulder arthroplasty; *SD*, standard deviation; *BMI*, body mass index; *CCI*, Charlson Comorbidity Index; *LTO*, lesser tuberosity osteotomy; *IQR*, interquartile range.

Discussion

Clinically significant SC failure after TSA is a rare complication that can have devastating effects on patient comfort and function.[6,8,17] Two commonly used surgical treatment strategies are SC repair and revision to RSA. Long-term functional outcome scores were not found to be significantly different between these 2 treatments, but both groups had substantially lower final outcome scores compared with historical controls after uncomplicated anatomic TSA.[21,25] SC repair was more often attempted in younger, healthier patients and was associated with a greater rate of reoperation compared with revision to RSA.

When one is evaluating the incidence of SC failure after TSA, it is important to appropriately distinguish between clinically significant failures that require intervention and subclinical failures. If including asymptomatic failures and those masked by concomitant complications, failure rates could near 50%.[2,4,14,15,20] However, isolated symptomatic failures requiring targeted treatment are considerably less common, as indicated by this study's small cohort size identified over a 10-year period in which over 3000 TSAs were performed. The rate of SC failure requiring reoperation after TSA is thought to be less than 1%. Supporting this estimate through a systematic review of the literature, Levy et al[17] reported a 1.2% rate of cuff injury and 0.6% rate of SC failure after primary TSA requiring reoperation.

The underlying mechanisms and timing of SC failure after TSA are highly variable.[18] The majority of failures were presently found to result from atraumatic processes, although the literature does not appear to support an increased commonality of either traumatic or atraumatic failures.[18,20] There are clinical nuances associated with each failure mechanism that could impact treatment decisions. Traumatic failures can often occur more acutely, and they require prompt evaluation and intervention. Our findings suggested that limiting the time between traumatic failures and attempted repair or revision to RSA may improve outcomes, which is consistent with results in the literature on primary SC tears.[11] Although timing alone should not exclude the potential for atraumatic failures, these tend to occur more insidiously and can present long after the index TSA. A common contributor to atraumatic SC failure is poor tissue quality, including the presence of fatty infiltration and muscle atrophy.[8,11,27] Armstrong et al[3] reported the presence of electromyography-evidenced chronic denervation and reinnervation changes in 15 of 30 shoulders at least 1 year after TSA. Of these cases, 30% primarily involved the SC, which might be in response to manipulation of the SC tendon during surgery.[3] It is therefore pertinent to consider the neuromuscular status of the SC and rotator cuff in atraumatic failures before repair is attempted, as it could portend a negative prognosis if substantially compromised. In terms of overall timing, the onset of SC failure in our cohort was highly variable and ranged from less than 1 month to nearly 3 years. In a series of 7 patients treated for SC failure after TSA, Miller et al[18] similarly reported a wide range of 2-53 months before initial presentation, with 3 traumatic failures that all occurred within 2.2 months. Overall, the timing and mechanism of SC failure are difficult to predict and highly variable but may effectively guide treatment decisions and impact outcomes.

SC repair was associated with a greater rate and number of reoperations. Similar literature on the outcomes of SC repair after TSA is limited. In a series of 5 patients with failed LTO after TSA, Shi et al[23] reported the results of attempted repair. Additional surgery was required after the attempted repair in 4 of 5 patients, and 3 patients warranted eventual conversion to RSA. The mean SANE and ASES

Table II Outcome of patients with SC repair vs. revision to RSA

	SC repair (n = 17)	Revision to RSA (n = 8)	*P* value
Pain (VAS score), mean (SD)	3.5 (2.4)	3.9 (3.9)	.75
ASES score, mean (SD)	59.4 (21.0)	59.3 (32.5)	.99
SANE score, mean (SD)	64.9 (22.5)	70.6 (33.0)	.61
Satisfaction, n (%)	12 (70.6)	5 (62.5)	.69
Infection, n (%)*	3 (17.6)	0 (0.0)	.21
Total No. of surgical procedures after SC failure, median (IQR)	2.0 (1)	1.0 (0.0)	.04

SC, subscapularis; *RSA*, reverse shoulder arthroplasty; *VAS*, visual analog scale; *SD*, standard deviation; *ASES*, American Shoulder and Elbow Surgeons; *SANE*, Single Assessment Numeric Evaluation.
* Suspected or confirmed infection.

scores at final follow-up were 48 and 63, respectively. In addition, Moeckel et al[20] reported a series of 7 patients with anterior instability after TSA, of whom 4 underwent reoperation with SC repair. In 3 of 4 repairs, reoperation included the use of an Achilles tendon allograft for augmentation. Although no subsequent reoperations were reported, all 3 patients had considerably limited range of motion at final follow-up.[20] In the previously mentioned series of Miller et al,[18] all 7 patients underwent SC repair procedures after TSA. Four repairs were augmented with a pectoralis major tendon transfer. There were no reoperations. The mean ASES score at final follow-up was 63.2, similar to the mean scores of 63 in the study of Shi et al[23] and 59.4 in our SC repair group.

Although revision to RSA was associated with a significantly lower rate of reoperation, final outcome measures, including patient satisfaction, were comparable to those in patients undergoing SC repair. There are inherent functional limitations associated with RSA that likely contributed to the higher number of attempted SC repairs in younger, healthier patients despite the reported efficacy of primary RSA in younger patients.[7,9,10] Regardless of age, revision to RSA after failed TSA has previously been shown to result in acceptable outcomes, including patient satisfaction, although complications are not uncommon.[1,13,22] Reported outcomes, specifically in the setting of post-TSA rotator cuff tears, are less favorable. Shields and Wiater[24] recently examined 35 patients with rotator cuff failures after TSA treated with revision to RSA. Compared with primary RSA, the final ASES scores were similar but the revision group experienced significantly more complications and lower patient satisfaction. The total rate of complications in the revision group was 31%, and 5 patients required reoperation.[24] Overall, revision to RSA is not without substantial risk and functional limitations but is likely the most reliable option for post-TSA SC failure.

This study has several limitations including but not limited to its retrospective design. Patients infrequently undergo reoperation for SC failure, and as a result, the final cohort size is limited. Patients with SC failures are also not always symptomatic, which creates inherent inaccuracy regarding the precise timing of SC failure. Moreover, there is variability among surgeons in their threshold to operate on symptomatic SC failures after TSA, which clouds any true estimation of a clinically significant SC failure incidence. The SC management technique during the index TSA may also impact failure rates, and the high percentage of LTOs in the study group could have confounded statistical analyses. In addition, this cohort may be missing a group of patients who potentially have SC failure and will become symptomatic in the future or were subsequently treated at outside institutions. Finally, outcomes were primarily measured through patient reporting and are thus subject to response bias.

Conclusion

In the setting of a clinically significant SC failure, the decision between SC repair and revision to RSA is challenging, especially when dealing with a younger patient or a patient who is relatively close to the time of primary surgery. Overall, patients who underwent SC repair had a significantly higher reoperation rate than those who underwent revision to RSA. An argument can be made for an attempted repair when performed for traumatic etiology and in a time-sensitive fashion. Decision making on how to treat patients with SC failure following TSA remains challenging and should be individualized to the patient's age, level of activity, comorbidities, timing and mechanism of SC failure, and functional expectations.

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