Superior Capsular Reconstruction: A Salvage Option for Massive Irreparable Rotator Cuff Tears with Pseudoparalysis or Subscapularis Insufficiency

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Purpose: We sought to examine superior capsular reconstruction (SCR) outcomes after minimum 2-year follow-up and determine risk factors that were predictive of outcomes. **Methods:** Forty consecutive patients (mean age 57.3 years, 87.5% male) who underwent SCR for massive irreparable rotator cuff tears (RCT) met the inclusion criteria. Minimum 2-year follow-up was obtained for 32 patients (80% follow-up). Patient demographics and preoperative clinical findings were collected. Postoperative data, including complications, patient satisfaction, strength and range-of-motion (ROM), and patient-reported outcomes were collected. **Results:** The Hamada score was $\leq$2 in 88% with average acromiohumeral interval distance of 6.8 mm. Preoperatively, 6 patients had external rotation lag (19%) and 6 had pseudoparalysis (19%). Intraoperative assessment of the subscapularis demonstrated true insufficiency in 38%. There was significant improvement in forward elevation (FE) (31° increase; $P = .007$) and strength in all planes (all $P < .05$). Patient-reported outcomes significantly improved (American Shoulder and Elbow Surgeon [ASES] 34-point increase; visual analog scale [VAS] 2.9-point decrease; single alpha-numeric evaluation [SANE] 48-point increase; all $P < .05$). Twenty-six patients (81%) were completely or somewhat satisfied with surgery. At time of final follow-up, 3/32 patients (9%) failed SCR and converted to reverse total shoulder arthroplasty. There were 4 (13%) reported complications (2 patients had postoperative falls; 1 patient had persistent severe pain; 1 had persistent stiffness). One patient was deceased. Patients with pseudoparalysis ($n = 6$) had significant improvement in post-operative FE (28 vs 154°; $P < .0001$) and SANE score ($P = .016$) with 66% patient satisfaction. However, outcome scores overall remained lower than SCR without pseudoparalysis. Regarding subscapularis insufficiency ($n = 12$), significant improvement was seen in postoperative FE (108 vs 158°; $P = .019$) and patient-reported outcome scores ($P < .005$). In patients converted from SCR to reverse total shoulder arthroplasty ($n = 3$), there were no distinguishing characteristics present. **Conclusion:** Superior capsular reconstruction is an effective salvage operation for massive irreparable RCT. Patients with pseudoparalysis or subscapularis insufficiency demonstrate significant postoperative improvement in FE and patient-reported outcomes. **Level of Evidence:** IV, retrospective cohort.

Introduction

Massive, irreparable rotator cuff tears (RCTs) present unique challenges for the orthopaedic surgeon.[1-3] Massive tears represent 10-40% of rotator cuff pathology and are most commonly defined as involving at least two tendons of the rotator cuff, containing a defect greater than 5 cm in size, and/or retraction to the glenoid rim.[4-9] These tears are evaluated intraoperatively, and oftentimes, they cannot be sufficiently repaired. This presents a unique challenge for the treating surgeon, as the pathology can be difficult to address. Multiple surgical options exist for a massive

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irreparable RCT,[10-18] including tendon transfer, partial repair with or without interval slide,[19,20] graft interposition,[21] cuff debridement with or without biceps tenotomy,[22] tuberoplasty,[23] suprascapular nerve ablation,[24] subacromial biodegradable spacer,[25,26] superior capsular reconstruction (SCR),[27,28] and reverse total shoulder arthroplasty (rTSA).[10,12,29-34] The broad range of surgical options suggest controversy in deciding optimal treatment, with no one surgical procedure having been proven superior in the literature.

A more recently developed salvage option for treating massive irreparable RCT is arthroscopic SCR. This technique was first published by Mihata et al. in 2012 to address superior instability, resulting from irreparable tears, using fascia lata autografting. This has been largely modified in the United States to use an allograft dermal extracellular matrix patch to reconstruct the rotator cuff.[27,35,36] The graft is thought to work by a tenodesis effect, force coupling, and/or serving as a subacromial spacer.[37,38] The procedure has gained popularity and success due to early outcome data and anecdotal evidence of a relatively lower rate of retear, reversal of profound pseudoparalysis, and substantial improvement in functional capacities[28,39-46]

However, there remains a relative lack of literature regarding exact indications for SCR, as well as unbiased clinical outcomes studies.[47-51] The purpose of this study was to examine SCR outcomes after a minimum 2-year follow-up and determine risk factors predictive of outcomes. It was our hypothesis that SCR would provide improved outcomes at two years following surgery.

Methods

Study Design

This Institutional Review Board-approved retrospective study of prospectively collected data was performed at a single tertiary academic medical center. All patients who underwent SCR (ArthroFLEX dermal allograft; Arthrex, Inc., Naples, FL) from January 1, 2016, to December 31, 2017, for the diagnosis of massive irreparable RCT were considered for inclusion. Massive was defined as involving 2 or more tendons or being larger than 5 cm in size. Patients were required to be at least 18 years of age, have intraoperative confirmation of a massive, irreparable RCT, and failed attempts at prior nonoperative management. Of the 41 eligible patients, 1 was deceased within 2 years of surgery due to an unrelated medical illness, resulting in a total of 40 patients included in the study. A total of 32 eligible patients had minimum 2 years follow up (80% follow-up; $n = 32/40$.

Surgical Technique

Superior capsular reconstruction was determined at the discretion of the surgeon but was generally deemed to be appropriate due to the patient being too young and/or active for rTSA and following intraoperative confirmation of an irreparable tear. Surgical reconstruction was performed by one of three fellowship-trained surgeons as an outpatient arthroscopic procedure similar to previously described techniques.[52,53] Specifically, a total of 5 portals were used (posterior, anterior, lateral, anterolateral, posterolateral), as well as small percutaneous incisions for anchor placement. Two anchors were used on the glenoid and four on the humerus (2 in medial row, 2 in lateral row). A 3-mm thick dermal allograft was used in all patients. This was appropriately sized in all dimensions by using the suture exiting the anchor and an arthroscopic measuring device. After tying and securing the graft to the anchors, 2 or 3 side-to-side repair sutures were passed from the remaining posterior rotator cuff to the graft. If there were robust tissue remaining anteriorly in the rotator interval, the graft was secured to this with a side-to-side suture; otherwise, it was left alone. If the subscapularis was determined to be insufficient, it was repaired arthroscopically using suture anchor fixation.

Postoperative Rehabilitation

Patients all underwent postoperative physical therapy using a standardized rotator cuff repair protocol.[54] For the first 6 weeks, all patients remained in the sling, did not participate in physical therapy, and worked on elbow, wrist, and hand exercises, as well as shoulder pendulums. Physical therapy was initiated at 6 weeks with passive range of motion (ROM) exercises, gradually transitioning to active assist, followed by active alone. This was followed by active ROM exercises and strengthening, with a goal of return to full-active ROM and pain-free activities of daily living by 12 weeks post-op, and return of full strength by 16 weeks post-op. The timing of return to work was variable depending on the nature of each patient's job. Participants all provided informed consent with institutional review board-approved forms and procedures.

Data Collection

The operating surgeons collected patient demographic and preoperative data that included age, gender, diabetes, tobacco use, workers compensation status (B.W.C.), prior shoulder surgery, Hamada score, AH distance, subscapularis status, tear size on MRI, symptom duration, strength, and ROM in all planes, presence of external rotation (ER) lag, presence of pseudoparalysis, and patient-reported functional outcome measures,[55-57] including American Shoulder and Elbow Surgeon (ASES) score,[58] simple shoulder test (SST),[59] visual analog scale (VAS),[60,61] and single alpha-numeric evaluation (SANE)[62] scores. Subscapularis functionality was determined during the surgery, and the subscapularis was noted to be insufficient/nonfunctional if there were a full-thickness retracted tear. All of the full-thickness

Table 1. Patient Demographics

	SCR ($n = 32$)
Male	28 (87.5%)
Female	4 (12.5%)
Age	57.3
History of diabetes (yes)	6 (19%)
Current tobacco use	7 (22%)
Former tobacco use	11 (34%)
Never tobacco use	14(44%)
BWC status	0 (0%)
Prior shoulder surgery	14 (44%)
Hamada Grade	
Grade 1	22 (69%)
Grade 2	6 (19%)
Grade 3	2 (6%)
Grade 4	2 (6%)
Acromial-humeral interval distance (mm)	6.8
MRI tendon involvement:	
Supraspinatus	32 (100%)
Infraspinatus	28 (88%)
Subscapularis	21 (66%)
MRI tear size (cm)	4.23
Symptom duration (months)	21.7
Preoperative outcome measures:	
ASES	44
VAS	5.3
SANE	26

ASES, American Shoulder and Elbow Surgeon (scale); VAS, visual analog scale; SANE, single alpha-numeric evaluation (scale); SCR, superior capsular reconstruction.

retracted tears were repaired, while smaller tears (i.e., isolated to the upper rolled border) were fixed at the discretion of the surgeon. Postoperative data were collected both from chart review, as well as phone call follow-up and included any complication or reoperation, strength, and ROM in all planes (from recorded clinic data only), patient satisfaction, and the aforementioned patient-reported outcome scores. Patients were all placed into a sling for the first 6 weeks and underwent postoperative physical therapy using massive rotator cuff repair protocol. Strength was assessed by the operating surgeon using a standard five-point muscle testing scale; no specific device was used for strength or ROM, as there is known fair-to-good reliability between visual estimation and use of a goniotometer.[63,64] ER lag was defined as an inability to maintain ER in the same position as the contralateral arm, while pseudoparalysis was defined as having active FE less than 90°.

Statistical Analysis

Analyses were performed with a standard statistical software package (STATA 15.0, Statacorp, College Station, TX). Descriptive statistics were generated for the entire sample. Differences in preoperative and postoperative continuous outcome (patient-reported outcome measures, ROM, and strength) were assessed by two-tailed Student's *t*-tests. To determine independent predictors of outcomes, a series of multivariate regression models were created. Multivariate logistic regression models were created for risk of revision surgery and likelihood to report satisfaction with the surgical outcome. Multivariate linear regression models were created to predict the postoperative ASES score, post-operative ROM, and post-operative strength. All models were created with a forward selection method with an entry criterion of alpha $<.05$. Potential covariates considered for inclusion in each model were age, sex, tobacco use status, diabetes status, workers compensation (BWC) status, prior shoulder surgery history, tendon involvement (supraspinatus, infraspinatus, and/or subscapularis), tear size on MRI, functionality of the subscapularis tendon, radiographic Hamada grade and acromial-humeral interval distance, duration of symptoms, preoperative active range of motion, preoperative strength (including findings of preoperative pseudoparalysis, ER lag, and positive belly press, or lift-off tests), preoperative patient-reported outcome measures (ASES, SANE, and VAS scores), and length of follow-up.

The average reported minimal clinically important difference (MCID) for ASES is 15.5 points based on a recent meta-analysis,[65] and the average standard deviation of postoperative ASES scores following SCR was 12.9 points in another recent review.[66] The sample ($n = 32$) was adequately powered to estimate the mean ASES score at final follow-up with a margin of error (95% confidence interval) equal to one-half of the MCID for ASES (7.75 points) at 80% power and an

Table 2. Preoperative, Intraoperative, and Postoperative Clinical Findings

	SCR ($n = 32$)
Preoperative assessment	
Range of motion (active) (deg)	
Forward elevation	116
Internal rotation	32
External rotation	40
Strength (5-point scale)	
Forward elevation	4.1
Internal rotation	4.4
External rotation	4.2
External rotation lag	6 (19%)
Positive lift off test	5 (16%)
Positive belly press	2 (6%)
Pseudoparalysis	6 (19%)
Intraoperative assessment	
Subscapularis insufficiency (nonfunctional)	12 (38%)
Subscapularis repair	19 (59%)
Postoperative assessment	
Range of motion (active) (deg)	
Forward elevation	147
Internal rotation	34
External rotation	48
Strength (5-point scale)	
Forward elevation	4.6
Internal rotation	4.8
External rotation	4.5

SCR, superior capsular reconstruction.

Table 3. Preoperative and postoperative outcome comparisons

SCR ($n = 32$)	Pre-op	Post-op	P Value
Range of motion (active)(deg)			
Forward elevation (FE)	116	147	0.007
Internal rotation (IR)	32	34	0.60
External rotation (ER)	40	48	0.10
Strength (5-point scale)			
Forward elevation (FE)	4.1	4.6	0.0003
Internal rotation (IR)	4.4	4.8	0.014
External rotation (ER)	4.2	4.5	0.026
Patient reported outcomes			
ASES	44	78	0.0001
VAS	5.3	2.4	<0.0001
SANE	26	74	0.003

estimated standard deviation of 12.7 points. This analysis was performed following the retrospective review but prior to data analysis. There is no established MCID for range of motion in patients following SCR, but it is our opinion that a difference of 20° or greater or 0.5 grade strength or greater in any plane of motion is clinically important in this population; the current study sample is adequate to estimate range of motion and strength with less than 20° and 0.5 grade margins of error. The number of events ($n = 8$) of patients rating 'no' or 'somewhat' (versus 'yes') for postoperative satisfaction is adequate to include up to 2 predictor variables in the multivariate model for satisfaction; 1 predictor was included in the final model. The number of revision surgeries ($n = 4$) is adequate to include up to 1 predictor in the model for revision surgery; a total of 1 predictor was included in the final model. The sample was adequate to include up to 3 predictors in the multivariate linear regression models for ASES score, range of motion and strength (minimum $n = 10$ observations per predictor); up to 2 predictors were included in each of the final linear regression models.

Results

Demographics and Preoperative Rotator Cuff Status

Patient demographics are reported in Table 1 and were found to be predominantly male (87.5%) with a mean age of 57.3 years at the time of surgery. Patients on average experienced symptoms for more than 21 months prior to pursuing SCR, and 43% had a prior operation on the shoulder. The Hamada score was ≤2 in 88%, with an average AH interval distance of 6.8 mm. Preoperative MRI assessment revealed that the supraspinatus was a component of the massive tear in 100% of cases, followed by the infraspinatus (88%) and the subscapularis (66%). However, intraoperative assessment of the subscapularis demonstrated true insufficiency (as defined as a full-thickness retracted tear) in only 37.5% (Table 2). Preoperatively, 6 patients had an ER lag (19%). There was also pseudoparalysis noted in 6 patients (18.8%). The mean follow-up time was 3.2 years, with a minimum of 2.4 years.

Postoperative Change in Shoulder Function and Complication Rates

Preoperative and postoperative outcome comparisons (Table 3) demonstrated improvement in forward elevation (FE) (31° increase; $P = .007$). Strength improved in all planes (all $P < .05$). Also, patient-reported outcomes all significantly improved (ASES 34-point increase; VAS 2.9-point decrease; SANE 48-point increase; all $P < .05$). All but 2 patients achieved MCID in ASES score following surgery. Twenty-four patients (75%) were completely satisfied with surgery, 2 somewhat satisfied (6%), and 6 unsatisfied (19%) (Table 4). There were 7 reported complications (22%), with 3 patients requiring conversion to reverse shoulder arthroplasty. Other complications included 2 postoperative falls (1 case of humeral avulsion of the glenohumeral ligament lesion, 1 case of distal radius fracture), one case of persistent severe pain, and one case of persistent stiffness.

Outcomes of SCR with Preoperative Pseudoparalysis or Subscapularis Insufficiency

Analysis of patients with preoperative pseudoparalysis revealed comparable demographics and pre-op characteristics (Table 5) with significant improvement in post-op FE (28 vs 154; $P < .0001$) and SANE score ($P = .016$) with 66% patient satisfaction. Five out of 6 patients regained enough FE to complete overhead motion. However, outcome scores overall remained generally lower when compared to all 32 patients. Of note, 3 of the 6 patients with pseudoparalysis also had subscapularis insufficiency. Among those three, no significant outcome differences were appreciated, but one did progress to rTSA.

For those patients with subscapularis insufficiency, a significant improvement was again seen in post-op in FE (108 vs 158; $P = .019$) and all patient-reported

Table 4. Satisfaction, Reoperations, and Complications

	SCR ($n = 32$)
Satisfaction = yes	24 (75%)
Satisfaction = somewhat	2 (6%)
Satisfaction = no	6 (19%)
Reoperations	3 total: 3 conversion rTSA
Other complications	4 total: 2 post-op falls (1 with distal radius fracture, 1 with HAGL lesion) 1 persistent stiffness 1 persistent severe pain
Length of follow-up	mean 3.2 years minimum 2.4 years

HAGL, humeral avulsion of the glenohumeral ligament; rTSA, reverse total shoulder arthroplasty; SCR, superior capsular reconstruction.

Table 5. Analysis of Patients with Subscapularis Insufficiency or Pseudoparalysis

	All SCR Patients	Subscapularis Insufficiency	Pseudo paralysis
Sample size (*n*)	*n* = 32	*n* = 12	*n* = 6
Male	28 (87.5%)	11 (91.7%)	4 (66.7%)
Age	57.3	59.8	56.0
History of diabetes (yes)	6 (19%)	3 (25%)	0 (0%)
Current tobacco use	7 (22%)	3 (25%)	2 (33%)
Former tobacco use	11 (34%)	8 (67%)	2 (33%)
Never tobacco use	14(44%)	1 (8%)	2 (33%)
Prior shoulder surgery	14 (44%)	5 (42%)	1 (17%)
Hamada grade	1.5	1.6	2.2
AH distance (mm)	6.8	6.5	4.9
MRI tear size (cm)	4.2	4.6	4.5
Pseudoparalysis	6 (19%)	3 (25%)	6 (100%)
Subscapularis insufficiency	12 (38%)	12 (100%)	3 (50%)
Range of motion			
Forward elevation			
○ Pre-op	116	108	28
○ Post-op	147	158	154
○ *P* value	.007	.019	<.0001
Internal rotation			
○ Pre-op	32	36	25
○ Post-op	34	38	38
○ *P* value	.60	.96	.12
External rotation			
○ Pre-op	40	45	26
○ Post-op	48	54	48
○ *P* Value	.10	.27	.10
Strength			
Forward elevation			
○ Pre-op	4.1	4.2	4.0
○ Post-op	4.6	4.6	4.5
○ *P* value	.0003	.10	.33
Internal rotation			
○ Pre-op	4.4	4.1	3.9
○ Post-op	4.8	4.6	4.6
○ *P* Value	.014	.21	.16
External rotation			
○ Pre-op	4.2	4.4	3.9
○ Post-op	4.5	4.5	4.1
○ *P* Value	.026	.59	.72
Patient-reported outcomes			
ASES			
○ Pre-op	44	30	30
○ Post-op	78	75	68
○ *P* value	.0001	.023	.21
VAS			
○ Pre-op	5.3	7.0	5.5
○ Post-op	2.4	1.9	3.3
○ *p-value*	<.0001	.023	.21
SANE			
○ Pre-op	26	13	0.00
○ Post-op	74	75	67
○ *p-value*	.003	.005	.016
Satisfied with surgery	24 (75%)	9 (75%)	4 (66%)
	All SCR patients	Subscapularis Insufficiency	Pseudo-paralysis

ASES, American Shoulder and Elbow Surgeon (scale); SANE, single alpha-numeric evaluation (scale); SCR, superior capsular reconstruction; VAS, visual analog scale.

outcome scores (ASES $P = .023$; VAS $P = .023$; SANE $P = .005$). Other strength and ROM measures did not reach statistical significance. In patients converted from SCR to rTSA ($n = 3$), there were no obvious distinguishing patterns or descriptive characteristics present among this small sample size, including presence or absence of pseudoparalysis or subscapularis insufficiency.

Independent Predictors of SCR Outcomes

Multivariate analysis demonstrated that the strongest independent predictor of postoperative patient satisfaction following SCR (Table 6) was the preoperative AH interval distance (per 1-mm increase, adjusted odds ratio 1.67; $P = .01$). A lower Hamada score and increased preoperative IR strength were also found to be significant predictors of patient satisfaction ($P = .04$ for both). However, combinations of these factors were not found to increase the predictive value. There were no independent predictors identified for revision surgery, but there was a trend toward diabetes ($P = .11$). Furthermore, there were no preoperative predictors identified for improved ASES score or revision surgery. However, improved postoperative IR strength was correlated with improved postoperative ASES score ($P = .007$).

An increased AH interval distance was also predictive of improved strength in both FE ($P = .04$) and IR ($P = .001$). No other factors were predictive of postoperative strength in FE, IR, or ER. Regarding ROM, a subscapularis tear seen on a preoperative MRI correlated with improved postoperative ER ROM ($P = .008$). This correlation likely represents type 1 error and not clinically relevant. There were no additional predictors identified for ER ROM; there were also no statistically significant predictive factors identified FE or IR ROM.

Discussion

Our data demonstrated significant improvement in functional outcome scores, including ASES, VAS, and SANE with strength improvement in all planes and ROM improvement in FE. Hirahara examined a series of 9 patients and found a significant improvement in ASES score from 43.54 to 86.46 and a decrease in VAS from 6.25 to 0.38 at mean follow up 32.38 months.[47] Burkhart reported similar results on 33 patients at a minimum of 2-year follow-up, with a significant improvement seen in both ASES and VAS, which did not diminish between year one and two.[48] Furthermore, the study concluded a satisfactory outcome rate of 81%,[48] which is identical to the patient-reported satisfaction rate of 81.2% in our study. Lee and Min showed improved ASES scores on 36 shoulders at mean follow-up of 24.8 months, but 36% graft tear rate, and advised caution in performing SCR in those with inadequate AH distance or poor posterior remnant

Table 6. Multivariate Analysis for Independent Predictors of Patient Satisfaction ('yes' versus 'no' or 'somewhat')

	Adjusted Odds Ratio	95% Confidence Interval	*P* Value
Preoperative internal rotation strength	Per 1-point increase in strength on 5-point scale: 9.64	1.13, 82.5	.04
ROC AUC: .74 Whole model Likelihood-Ratio χ^2 $P = .01$			
	Adjusted Odds ratio	95% confidence interval	*P* Value
Hamada	Per 1 grade increase: .36	0.14, .95	.04
ROC AUC: .78 Whole model Likelihood-Ratio χ^2 $P = .03$			
	Adjusted Odds ratio	95% confidence interval	*P* Value
AH Interval	Per 1.0 mm increase: 1.67	1.12, 2.47	.01
ROC AUC: .84 Whole model Likelihood-Ratio χ^2 $P = .004$			

tissue.[67] Mihata has also now reported 5-year outcomes on 30 patients undergoing SCR for massive irreparable cuff tear.[51] Again, patient-reported outcomes scores, including ASES, were significantly improved from preoperative values, with the ASES score being higher at 5 years post-op than it was at 1 year. Active FE improved by 53° at 1 year and 66° at 5 years.[51] This is similar to our data, which also demonstrated statistically significant improvement in FE at 2 years, albeit only 31° in our data cohort. Mihata also reported a 10% (3/30) graft tear rate, with all 3 patients having significant rotator cuff arthropathy at 5-year follow up.[51] While not having quite the same magnitude of change in postoperative outcome metrics, our data do support the prior findings from Mihata and Burkhart of significant improvement in FE and functional outcomes following SCR at a minimum of 2-year follow-up. While there is consideration given to the use of acellular dermal allograft versus tensor fascia lata autograft, a recent systematic review did not demonstrate significant outcome differences between the two at early clinical follow-up.[68]

Pseudoparalysis is a common finding in patients with a massive cuff tear and was present in 18.8% of patients in our study. Previous literature has suggested that SCR can be an effective treatment option for pseudoparalysis, with Mihata suggesting a 93-96% reversal rate of pseudoparalysis, with the only failures coming in patients who were later found to have graft tears.[50] Burkhart also reported 90% return to active overhead use of the arm following SCR in 10 patients found to have preoperative pseudoparalysis.[41] Our study also demonstrated significant improvement in FE from 28° preoperatively to 154° postoperatively, with 83% (5/6) having their pseudoparalysis reversed. However, only 67% (4/6) patients with preoperative pseudoparalysis were satisfied with the SCR at 2-years post-op. Furthermore, while ASES and SANE scores both improved in this group compared to preoperative values, an ASES score of 68 and SANE score of 67 were noticeably lower than the cohort as a whole (ASES 77.84, SANE 74.09). Although not reporting ≥90% reversal of pseudoparalysis, our small sample of patients would suggest SCR is a reasonable option for this difficult clinical problem.

There has also been recent debate about the status of the subscapularis as it pertains to performing SCR, with some suggesting that subscapularis insufficiency perhaps could be a relative contraindication. After intraoperative assessment, the subscapularis was found to be nonfunctional (as defined by a full-thickness retracted tear) and subsequently repaired in 37.5% (12/32) of patients in our study. Among these patients, results were encouraging overall, with significant improvement seen in FE (from 108 to 158°) and final functional scores (ASES 75, SANE 75, VAS, 1.9) with 75% being satisfied with surgery. Outcomes were not considerably different from the remainder of the cohort with a functional subscapularis. While further study is still needed, this small subset of patients would suggest that an insufficient subscapularis should not be a contraindication to proceeding with SCR.

There were 3 patients in our study who required conversion to rTSA (9%) during the minimum follow-up time of 2 years. There is paucity of the literature, as it pertains to SCR failures, but our data do appear comparable to the little that does exist, including Hirahara's report of 11.1% (1/9) conversion to rTSA at 32 months and Hamada's report of 10% (3/30) graft tear and progressive cuff arthropathy at 5 years post-op. Burkhart reported a SCR revision rate of 5% in 2 years.[48] Revision of SCR was not performed in our data set. A review of the three patients undergoing conversion to rTSA in our study did not reveal any patterns or clear distinguishing characteristics. In addition, we also had 4 other reported complications, including 2 falls, 1 ongoing severe pain, and 1 ongoing severe stiffness. If all reported issues are combined, our study demonstrated an overall complication rate of 22%, similar to the 19% rate reported by Burkhart.[48]

Limitations

This study has multiple limitations. The durability of results beyond the length of follow-up reported in the current study is unclear. The sample size was adequate

for the primary study outcomes (determining postoperative ASES scores, ROM, and strength within an acceptable margin of error) but was relatively underpowered to estimate rates of satisfaction or reoperation. The study subset groups, including those with pseudoparalysis and subscapularis insufficiency, are also underpowered. Our study did also not specifically examine graft tear rates to determine if these correlated with clinical outcomes.

Conclusion

Superior capsular reconstruction is an effective salvage operation for massive irreparable RCT. Patients with pseudoparalysis or subscapularis insufficiency demonstrate significant post-op improvement in FE and patient-reported outcomes.

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