Technical Note

Arthroscopic Treatment of Shoulder Stiffness With Rotator Cuff Repair Yields Similar Outcomes to Isolated Rotator Cuff Repair

Parker L. Brush, M.D., Adrian Santana, B.S., Ruchir Nanavati, B.S., Gregory R. Toci, M.D., Tariq Z. Issa, B.A., Daniel J. Fletcher, M.D., and Joshua Hornstein, M.D.

Purpose: To compare patient-reported and surgical outcome measures in patients with and without secondary shoulder stiffness (SSS) undergoing rotator cuff repair (RCR). **Methods:** Patients undergoing rotator cuff repair from 2014 to 2020 with complete patient-reported outcome measures (PROMs) by the short-form 12 survey (SF-12) were retrospectively reviewed to identify if operative intervention for SSS was performed alongside the RCR. Those patients with operative intervention for SSS were propensity matched to a group without prior intervention for stiffness by age, sex, laterality, body mass index, diabetes mellitus status, and the presence of a thyroid disorder. The groups were compared by rotator cuff tear (RCT) size, surgical outcomes, further surgical intervention, rotator cuff retear rate, postoperative range of motion (ROM), and SF-12 results at 1 year after surgery. Delta values were calculated for component scores of the SF-12 and ROM values by subtracting the preoperative result from the postoperative result. **Results:** A total of 89 patients with SSS were compared to 156 patients in the control group at final analysis. The patients in the SSS group experienced a significant improvement in the delta mental health component score (MCS-12) of the SF-12 survey that was not seen in the control group ($P = .005$ to $P = .539$). Both groups experienced significant improvement by the delta physical health component score (PCS-12) of the SF-12 survey (SSS: 7.68; $P < .001$; control: 6.95; $P < .001$). The SSS group also experienced greater improvement of their forward flexion (25.8° vs 12.9°; $P = .005$) and external rotation (7.13° vs 1.65°; $P = .031$) ROM than the control group. **Conclusions:** Operative intervention of SSS at the time of RCR has equivalent postoperative SF-12 survey outcome scores when compared to patients undergoing RCR without preoperative stiffness despite those patients having lower preoperative scores. **Level of Evidence:** Level III retrospective comparative study.

Introduction

Rotator cuff tears (RCT) have an estimated prevalence of 20% in the general population that increases with age as up to 50% of people in their ninth decade life are found to have RCTs.[1,2] Despite up to 34% of RCTs being asymptomatic in the general population,[3] RCRs are one of the most common orthopaedic procedures and have increased in number over the last two decades with a trend toward arthroscopic repair.[4-6] Rotator cuff tears are frequently complicated by secondary shoulder stiffness (SSS), as the pain associated with the tear leads to disuse and secondary muscular and/or capsular contracture.[7,8] Evaluation of preoperative shoulder stiffness before RCR is not well documented and its evaluation is inconsistent, but it is estimated to occur in 9.2 to 23.6% of patients.[7,9]

Controversy exists as to the proper management of the stiffness associated with RCT. Although some studies support restoration of motion prior to surgical RCR, this treatment strategy can result in lengthening of the RCT and increased fatty atrophy.[10-12] Others studies support immediate surgical repair of the RCT with additional operative treatment for stiffness by manipulation under anesthesia (MUA) and/or capsular release, reporting improvement similar to those

From the Rothman Orthopaedic Institute at Thomas Jefferson University Hospital, Philadelphia, Pennsylvania, U.S.A. (P.L.B., G.R.T., T.Z.I., D.J.F., J.H.); Rutgers Robert Wood Johnson Medical School, New Brunswick, New Jersey, U.S.A. (A.S.); and Rowan University School of Osteopathic Medicine, Stratford, New Jersey, U.S.A. (R.N.).

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received January 31, 2023; accepted May 25, 2023.

Address correspondence to Parker L. Brush, M.D., Rothman Orthopaedic Institute at Thomas Jefferson University, 925 Chestnut St, 5th Floor, Philadelphia, PA, 19107, U.S.A. E-mail: brushparker@gmail.com

2666-061X/23152

https://doi.org/10.1016/j.asmr.2023.05.008

without SSS and delayed operative intervention.[13-17] A recent systematic review on this topic suggested that early operative intervention of SSS with RCR provides a similar outcome to RCR in patients without preoperative stiffness. However, this finding is limited to patients with nonmassive RCTs, as data on these patients are limited.[18] The purpose of this study is to compare patient-reported and surgical outcome measures in patients with and without secondary shoulder stiffness undergoing rotator cuff repair. We hypothesize that patients will have similar outcomes regardless of the presence of SSS or size of the RCT.

Methods

After receiving approval by our Institutional Review Board with an exempt status, we retrospectively identified all patients who underwent arthroscopic RCR with or without arthroscopic lysis of adhesions from 2014 to 2020 using current procedural terminology codes (arthroscopic RCR: 29827; arthroscopic lysis of adhesions: 29825).Adult patients (≥18 years) who underwent arthroscopic RCR with preoperative and one-year postoperative mental health component score (MCS-12) and physical health component score (PCS-12) from the 12-item short form survey (SF-12) were included. Patients with missing SF-12 items preoperatively or at 1 year postoperatively were excluded. All surgeons performed RCR by either single- or double-row technique based on intraoperative characteristics of the tear. Patients who underwent RCR without lysis of adhesions ("control"), and no prior treatment for SSS were matched to those undergoing arthroscopic lysis of adhesions and capsulotomy ("SSS") in a 2:1 manner controlling for age, sex, laterality, body mass index, diabetes mellitus, and thyroid disorder.

We collected patient characteristics, demographics, surgical data, and postoperative outcomes from the electronic medical record. Patient characteristics included age, sex, body mass index (BMI), RCT thickness and length, hand dominance, diabetes, smoking status (nonsmoker, current smoker, former smoker), thyroid disease, and arthritis (inflammatory and non-inflammatory) history. We classified RCTs as either partial or full-thickness tears and full RCT size was described as either small (<1 cm), medium (1-3 cm), large (3-5 cm), or massive (>5 cm) as previously defined in the literature.[19,20] These data were obtained through review of preoperative magnetic resonance imaging (MRI) and confirmed by operative report review. If differences were observed between imaging reports and operative reports, operative report findings were used for their increased accuracy and to account for tear progression between the two dates.[21]

Preoperative ROM data were obtained from the preoperative note closest to the day of surgery, and postoperative ROM data were obtained from either the final follow-up note from the surgeon or the final physical therapy progress note, depending on which note occurred at a later date, but was not restricted to at least 1-year follow-up. Forward flexion (FF) and abduction data are reported in degrees. External rotation (ER) data are reported in degrees of ER with the shoulder at 0° of abduction. Internal rotation (IR) data are reported by Apley's scratch test with numerical values applied to the spinal level starting with "0" starting at the sacrum and increasing by one for every additional vertebral level above the sacrum (i.e., 5 for L1, 10 for T8). This method for quantifying our data is adopted from the study by Kim et al.[14] A delta ROM measurement was obtained by subtracting the preoperative value from the postoperative value.

Patient-reported outcome measures (PROMs) were collected through the institution's prospectively managed outcomes database (OBERD, Columbia, MO). A delta value was calculated for PCS-12 and MCS-12, which was the 1-year postoperative value subtracted by the preoperative value. Descriptive statistics were reported as mean and standard deviation for continuous variables. Bivariate analyses were conducted between the SSS and control groups using independent *t*-tests for parametric continuous variables and Mann-Whitney *U*-tests for nonparametric continuous variables. The Pearson's chi-squared test or Fisher's exact test was used for categorical variables, as appropriate, with Fisher's exact test only used in cases of small cell counts. Subgroup analysis was performed on full RCTs with large or greater tear size. Multivariate regression analysis was performed with dependent variables of delta PCS-12 and delta MCS-12. All statistical analyses were performed using R Studio Version 4.0.2 (Boston, MA) with P values <.05 considered statistically significant.

Results

Of 249 patients undergoing arthroscopic RCR with concomitant shoulder stiffness, 83 (33.3%) had complete patient-reported outcome measures. They were propensity-matched to a cohort of 991 patients without shoulder stiffness and complete patient-reported outcome measures in a 2:1 fashion. Upon further chart review, 6 patients in the control group were found to meet criteria for the SSS group and were moved accordingly, and 4 patients in the control group were removed due to errors in their SF-12 reports. The final statistics were performed with 89 patients in the SSS group and 156 patients in the control group. There were no differences in age (SSS: 61.9 years vs control: 60.4 years; $P = .164$), sex (SSS: 51.7% female vs control: 56.4% female; $P = .561$), laterality (SSS: 55.1% right vs control: 62.8% right; $P = .290$), body mass index (SSS: 29.2 vs control: 29.3; $P = .935$), or smoking status (SSS: 10.1% current smokers vs control: 9.6%

Table 1. Patient Demographics and Disease Characteristics

	Complete Cohort			Large and Massive Tears		
	SSS n = 89	Control n = 156	P Value	SSS n = 34	Control n = 67	P Value
Age (years)	61.9 (7.7)	60.4 (8.4)	.164	61.6 (8.0)	63.5 (7.0)	.228
Sex (female)	46 (51.7%)	88 (56.4%)	.561	17 (50.0%)	36 (53.7%)	.885
Laterality:			.290			.775
Left	40 (44.9%)	58 (37.2%)		17 (50.0%)	30 (44.8%)	
Right	49 (55.1%)	98 (62.8%)		17 (50.0%)	37 (55.2%)	
Body mass index	29.2 (5.4)	29.3 (4.4)	.935	29.6 (5.65)	29.9 (5.53)	.773
Hand dominance:			.532			1.000
Ambidextrous	2 (3.8%)	3 (2.3%)				
Left	6 (11.3%)	8 (7.1%)		2 (10.5%)	5 (9.8%)	
Right	45 (84.9%)	101 (90.2%)		17 (89.5%)	46 (90.2%)	
Smoking status:			.972			.552
Current smoker	9 (10.1%)	15 (9.6%)		5 (14.7%)	6 (9.0%)	
Former smoker	20 (22.5%)	37 (23.7%)		8 (23.5%)	21 (31.3%)	
Nonsmoker	60 (67.4%)	104 (66.7%)		21 (61.8%)	40 (59.7%)	
Diabetes:	19 (21.3%)	36 (23.1%)	.879	7 (20.6%)	16 (23.9%)	.805
Type I	7 (7.9%)	4 (2.6%)		2 (5.9%)	1 (1.5%)	
Type II	12 (13.5%)	32 (20.5%)		5 (14.7%)	15 (22.4%)	
Thyroid disorder:	10 (11.2%)	18 (11.5%)	1.000	3 (8.82%)	7 (10.4%)	1.000
Inflammatory arthritis	11 (12.4%)	20 (12.8%)	1.000	4 (11.8%)	6 (9.0%)	.729
Previous shoulder surgery:	21 (23.6%)	31 (19.9%)	.601	7 (20.6%)	17 (25.4%)	.774
RCR	15 (16.9%)	15 (9.6%)	.144	7 (20.6%)	10 (14.9%)	.662
Ipsilateral RCR	12 (13.5%)	9 (5.8%)	.066	6 (17.6%)	6 (9.0%)	.212
GHJ arthritis	12 (13.5%)	24 (15.4%)	.828	8 (23.5%)	13 (19.4%)	.823
Tear thickness:			.572			1.000
Partial	20 (22.5%)	29 (18.6%)				
Full	69 (77.5%)	127 (81.4%)		34 (100%)	67 (100%)	
Full tear length:			.912			.895
Small	10 (14.5%)	15 (12.0%)				
Medium	25 (36.2%)	43 (34.4%)				
Large	20 (29.0%)	37 (29.6%)		20 (58.8%)	37 (55.2%)	
Massive	14 (20.3%)	30 (24.0%)		14 (41.2%)	30 (44.8%)	

GHJ, glenohumeral joint; RCR, rotator cuff repair; SSS, secondary stiff shoulder.

current smokers; P = .972) between groups. Further, there were no differences in the presence of diabetes mellitus (SSS: 21.3% vs control: 23.1%; P = .879), thyroid disorder (SSS: 11.2% vs control: 11.5%; P = 1.000), or inflammatory arthritis (SSS: 12.4% vs control: 12.8%; P = 1.000) between groups. The groups were similar with regard to prior shoulder surgery with 21 (23.6%) patients in the SSS group and 31 (19.9%) patients in the control group. These surgeries included RCR, acromioplasty, or arthroscopic debridement. We identified no significant differences with regard to prior RCR on the ipsilateral shoulder between the SSS (13.5%) and control (5.8%) groups. The groups had a similar composition with regard to tear thickness (partial vs full thickness) (P = .572) and full-thickness tear length (P = .912). Subgroup analysis of the large or massive RCTs showed no differences between groups with regard to demographics and past medical history (Table 1).

Regarding surgical outcomes, we identified no patients with complications outside of reoperation and rotator cuff retear, as diagnosed by MRI in the postoperative period. The two groups experienced a similar rotator cuff retear rate (stiff group: 6.7% vs control: 8.3%, P = .654). There were no differences in the proportion of patients who underwent reoperation (SSS: 9.0% vs control: 10.3%; P = .922) or patients who had subsequent surgery for postoperative rotator cuff retear (SSS: 4.5% vs control: 4.5%; P = 1.000). Operations outside of RCR include debridement/capsular release (6), shoulder arthroplasty (4), super capsular reconstruction (1), labrum repair (1), and trapezius transfer for irreparable cuff tear (1). The large or massive tear subgroups also had similar surgical outcomes (Table 2).

Preoperatively, the SSS group had a significantly decreased ROM in terms of FF, abduction, IR, and ER when compared to the control group (all; P < .05). There was no difference in the number of days before surgery that these measures were obtained (SSS: 38.9 days vs control: 34.5 days; P =.157). Postoperatively, the control group maintained a significantly greater ROM, except for IR, which did not result in a significant difference (P = .064). There was a significant difference in days to postoperative ROM measurement (SSS: 178 days vs control: 215 days; P = .001), with

Table 2. Surgical Procedures and Outcomes

	Complete Cohort			Large and Massive Tears		
	SSS $n = 89$	Control $n = 156$	*P* Value	SSS $n = 34$	Control $n = 67$	*P* Value
Capsular release	89 (100%)	0 (0%)		34 (100%)	0 (0%)	
Manipulation under anesthesia	6 (6.7%)	0 (0.0%)	**.002**	1 (2.9%)	0 (0%)	.337
Postoperative complications	0 (0.0%)	0 (0.0%)	1.000	0 (0.0%)	0 (0.0%)	
Rotator cuff retear	6 (6.7%)	13 (8.3%)	.654	4 (11.8%)	7 (10.4%)	1.000
Reoperation	8 (9.0%)	16 (10.3%)	.922	3 (8.8%)	8 (11.9%)	.746
RCR	4 (4.5 %)	7 (4.5 %)	1.000	3 (8.8%)	3 (4.5%)	.601

RCR, rotator cuff repair; SSS, secondary stiff shoulder.

both groups averaging less than 1 year for ROM outcomes. Despite having decreased ROM compared to control, the SSS group demonstrated a significantly greater delta FF (25.8° to 12.9°; $P = .005$) and delta ER (7.1° to 1.7°; $P = .031$). However, these differences were not seen in the large or massive RCT subgroups. Instead, the control group was found to have greater delta abduction (13.6° to 40.3°; $P = .032$) (Table 3).

Both groups improved in PCS-12 following surgery (7.7 to 7.0; $P < .001$), but only the SSS group improved in MCS-12 following surgery (SSS: 3.4; $P = .005$; control: 0.5; $P = .539$). Patients in the stiff group had significantly lower preoperative MCS-12 (50.8 to 53.9; $P = .013$) but had similar postoperative MCS-12 scores (54.2 to 52.5; $P = .620$) (Fig 1). No other significant differences in preoperative, postoperative, or delta patient-reported outcome scores for PCS-12 (Fig 2) or MCS-12. No differences were found between the large or massive RCT subgroups by SF-12 component scores (Table 4).

On multivariate regression analysis, the SSS cohort was associated with more improvement by MCS-12 (estimate: 3.03; $P = .028$) and no difference in improvement by PCS-12 (estimate: 1.19; $P = .411$). Prior ipsilateral rotator cuff repair (PCS-12; $P = .420$; MCS-12; $P = .299$) and RCT thickness (PCS-12; $P = .854$; MCS-12; P value $= .522$) were not associated with a difference in outcomes. Male sex was also associated with a greater improvement by MCS-12 after surgery (estimate: 2.77; $P = .036$) (Table 5).

Discussion

The most important finding of this study is that patients with SSS undergoing RCR achieved similar SF-12 scores postoperatively as patients without SSS who underwent RCR despite having lower baseline scores.

The patients in our SSS group were found to have a significantly lower MCS-12 score preoperatively than the control group. However, the SSS group ultimately demonstrated an improvement in their mental health by MCS-12 after surgery that was not seen in the

Table 3. Shoulder Range of Motion

	Complete Cohort			Large and Massive Tears		
	SSS $n = 89$	Control $n = 156$	*P* Value	SSS $n = 34$	Control $n = 67$	*P* Value
Days before surgery	38.9 (26.3)	34.5 (24.4)	.157	35.8 (22.6)	32.0 (24.3)	.317
Days after surgery	215 (133)	178 (123)	**<.001**	218 (137)	199 (139)	.139
Preoperative FF	122 (39.7)	145 (39.7)	**<.001**	116 (43.2)	135 (44.6)	.061
Postoperative FF	145 (21.7)	155 (22.4)	**<.001**	145 (22.0)	154 (25.1)	**.006**
Intragroup *P* value	**<.001**	**.001**		**<.001**	**<.001**	
Preoperative abduction	89.9 (32.0)	111 (42.0)	**<.001**	87.0 (38.0)	90.7 (47.5)	.849
Postoperative abduction	101 (27.1)	135 (25.5)	**<.001**	102 (28.2)	132 (26.9)	**<.001**
Intragroup *P* value	**.004**	**<.001**		.089	**.001**	
Preoperative ER	37.0 (24.3)	56.5 (23.6)	**<.001**	31.3 (23.8)	50.6 (22.4)	**<.001**
Postoperative ER	43.6 (16.7)	57.6 (24.4)	**<.001**	42.2 (15.3)	57.8 (22.7)	**.002**
Intragroup *P* value	**.031**	.485		**.016**	.101	
Preoperative IR	4.9 (4.3)	6.8 (3.8)	**<.001**	4.2 (4.1)	5.5 (3.3)	**.002**
Postoperative IR	6.2 (3.3)	7.3 (4.0)	.064	5.8 (3.6)	8.0 (3.7)	**.027**
Intragroup *P* value	.072	**.046**		.151	**.004**	
Delta FF	25.8 (36.3)	12.9 (42.0)	**.005**	29.0 (35.3)	25.6 (44.8)	.625
Delta abduction	13.7 (29.1)	27.4 (37.4)	.128	13.6 (30.9)	40.3 (35.6)	**.032**
Delta ER	7.1 (25.0)	1.7 (23.9)	**.031**	11.2 (21.0)	6.16 (24.1)	.237
Delta IR	1.5 (4.7)	1.0 (4.0)	.406	2.8 (6.0)	2.8 (6.0)	.867

All values for range of motion are in degrees with exception to internal rotation, which is calculated by each vertebral level above the sacrum during Apley's scratch test.

ER, external rotation; FF, forward flexion; IR, internal rotation; SSS, secondary stiff shoulder.

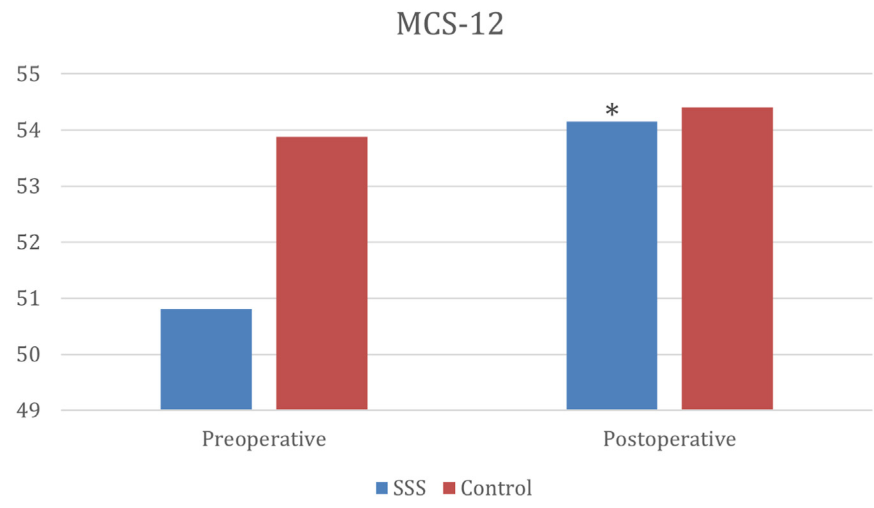

Fig 1. Graphical representation of mental health component score (MCS-12) scores before and after surgery. MCS-12, mental health component score; SSS, secondary shoulder stiffness. *Significantly different postoperative score compared to the preoperative score.

control patients. Thus, resulting in a similar postoperative score despite their worse baseline status. Further, these patients were found to have a significant increase in their physical function by PCS-12. Both groups in our study, on average, experienced PCS-12 improvement above the previously reported minimal clinically important differences for shoulder pathology (6.5) and RCTs (5.4).[22,23] The improvement by delta-PCS-12 and postoperative PCS-12 were also similar between groups, signifying preoperative stiffness, if surgically treated, does not impede a patient's physical function recovery. Overall, these findings support operative intervention of SSS in the setting of a RCT, as patients with SSS are able to achieve similar outcomes by the SF-12, as patients without preoperative SSS despite higher preoperative disability. Our findings are supported by other authors who have demonstrated equivalent functional outcomes by American Shoulder and Elbow Surgeon score, Constant score, and Simple Shoulder Test for patients who have their SSS treated at the time of the RCR.[14,16,17] However, the regression analysis in this study suggests a potentially greater improvement by MCS-12 in those with SSS. Patient-reported outcomes by the 36-Item Short Form survey have been used in orthopaedic surgery for years.[24] The mental health component score of this survey has previously demonstrated a stronger correlation with shoulder pain and function than RCT severity.[25] In addition, a prior systematic review has also suggested a correlation between psychological distress and worse preoperative pain and function in RCTs.[26] Our study uses the SF-12, which has strong inter-class correlation with both the physical and mental health components of the 36-Item Short Form with the added benefit of a lower respondent burden.[27,28]

In this study, we include 101 (41%) full-thickness RCTs classified as large or massive by length.[19] These large-sized tears are more prevalent in older

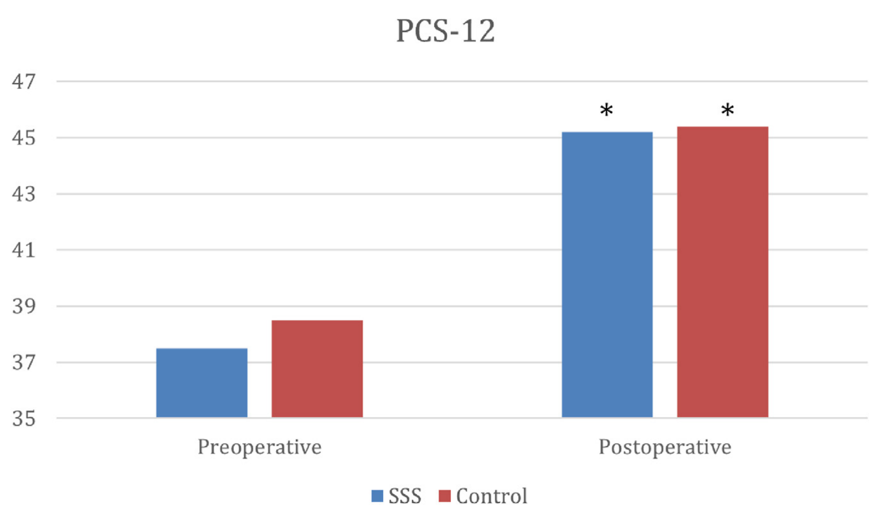

Fig 2. Graphical representation of physical health component score (PCS-12) scores before and after surgery. SSS, secondary shoulder stiffness. *Significantly different postoperative score compared to the preoperative score.

Table 4. Patient-Reported Outcome Measures

		Complete Cohort			Large and Massive Tears		
		SSS $n = 89$	Control $n = 156$	P Value	SSS $n = 34$	Control $n = 67$	P Value
MCS-12	Preoperative	50.8 (10.0)	53.9 (9.17)	**.013**	52.2 (9.94)	54.6 (9.09)	.187
	Postoperative	54.2 (7.82)	54.4 (8.36)	.620	55.1 (6.60)	55.1 (8.53)	.582
	Delta	3.4 (10.9)	0.5 (9.9)	.062	2.9 (10.1)	0.5 (9.9)	.261
	Intragroup P value	**.005**	.539		.102	.675	
PCS-12	Preoperative	37.5 (8.10)	38.5 (8.26)	.371	40.0 (8.48)	38.9 (7.85)	.537
	Postoperative	45.2 (11.0)	45.4 (10.4)	.905	46.2 (10.9)	45.0 (10.9)	.744
	Delta	7.7 (11.3)	7.0 (10.5)	.622	6.2 (12.3)	6.1 (10.8)	.990
	Intragroup P value	**<.001**	**<.001**		**.006**	**<.001**	

MCS-12, mental health component score; PCS-12, physical health component score; SSS, secondary stiff shoulder.

populations and can comprise 40% or more of all RCTs in patients older than 60.[2] Their prevalence emphasizes the importance of understanding how to best manage all facets of their treatment. Previous reports on operative treatment of SSS excluded patients with large and massive tears, or included a nonrepresentative portion of large and massive tears.[14,16,17,29] Our subgroup analysis on these patients with large and massive tears found no significant differences between SSS and control groups with regard to SF-12 component scores. Further, our regression analysis did not suggest a difference in outcomes by SF-12 in those with partial or full-thickness tears. Unlike the full cohort, the subgroup did not show any significant differences between the SSS and control groups with regard to changed MCS-12 scores after surgery (2.9 to 0.5; $P = .261$). Our study may be underpowered to detect a difference at this effect size, but it is important to note that the two groups did have equivalent postoperative results. Both subgroups had significant improvement by PCS-12 above the MCID for RCTs (5.4), suggesting that surgical treatment of preoperative stiffness in large and massive RCTs does not impact 1-year postoperative physical function.[22]

Although the SSS group in our study had reduced ROM, this reduction from normal ROM is less severe than seen in other studies where stiff groups were observed to have FF limited to 100°.[16,17] This suggests that operative treatment of SSS can be beneficial for patients with less severe loss of ROM than previously reported. This finding is supported by authors who report equivalent outcomes by different measures.[14,29] Both groups of patients in our study improved by FF and abduction ROM after surgery, but only the SSS group experienced significant improvement by ER. This difference in ER improvement is most likely due to the capsulotomy that was performed in the SSS group. Patients with SSS associated with a RCT can develop capsular contracture; thus, releasing this contracture by capsulotomy can provide additional ROM improvements beyond that of only an RCR. The control group had higher postoperative ROM in all planes except IR. However, patients can continue to find improvement in ROM beyond our average follow periods of 215 days in SSS group and 178 days in the control group.[30,31] Thus, the patients in our study likely continued to experience modest improvements in ROM after final evaluation recording with potential catch-up in the SSS group given their shorter follow-up.

Operative treatment for SSS in our study consisted of capsulotomy in all cases, and MUA in only 6 cases. Both MUA and capsulotomy are reported as potential modalities for treating SSS in the case of a RCT.[14,16,17,29] However, review articles on the treatment of adhesive capsulitis and shoulder stiffness describe serious complications that can occur from MUA, including fractures, neurovascular injury, and rotator cuff pathology. These complications are not typical after a capsulotomy.[32,33] Given the potential complications from MUA, we find capsulotomy to be the preferred

Table 5. Multivariate Regression Analysis for Delta PCS-12 and Delta MCS-12

	Delta PCS-12			Delta MCS-12		
Predictors	Estimate	CI	P Value	Estimate	CI	P Value
Stiff shoulder	1.19	−1.65−4.04	.411	3.03	0.32−5.73	**.028**
Prior ipsilateral RCR	−2.01	−6.88−2.86	.420	−2.45	−7.08−2.18	.299
Full-thickness tear	0.33	−3.15−3.81	.854	1.08	−2.23−4.39	.522
Age	−0.15	−0.32−0.03	.095	−0.04	−0.20−0.12	.613
BMI	−0.12	−0.37−0.14	.376	0.00	−0.24−0.25	.980
Sex − Male	−2.12	−4.85−0.61	.128	2.77	0.18−5.36	**.036**

BMI, body mass index; CI, confidence interval; MCS-12, mental health component score; PCS-12, physical health component score.

treatment method. The patients in our study treated by capsulotomy for SSS had a similar rotator cuff retear rate diagnosed by MRI at 6.7% compared to previously cited 10-21%, and we observed no complications outside of retear.[34,35] The control group experienced a similar rotator cuff retear rate as well at 8.3%. Patients in our large to massive RCT groups experienced a higher rotator cuff retear rate (10.9%) than the full cohort, which is supported by the current literature as large to massive RCTs are 2-3 times more likely to have a retear.[34]

Limitations

The limitations of this retrospective study include selection bias and confounding factors that may not have been considered. Rotator cuff tear size may have been misclassified in operative reports and may not be consistent between surgeons. Our distinction of SSS was based on the presence of current procedural terminology codes and operative treatment as opposed to objective ROM assessment. This could lead to potentially misidentifying patients with or without shoulder stiffness. Range-of-motion measurements were not standardized and, thus, susceptible to error and bias. In addition, the follow-up time for ROM measurements was limited by documentation, which resulted in a short duration of follow-up under 1 year. Our follow-up ROM and SF-12 scores are limited to 1 year after surgery. Postoperative MRIs were only performed on symptomatic patients, limiting our ability to identify all potential rotator cuff retears.

Conclusion

Operative intervention of SSS at the time of RCR has equivalent postoperative SF-12 survey outcome scores when compared to patients undergoing RCR without preoperative stiffness despite those patients having lower preoperative scores.

References

1. Yamamoto A, Takagishi K, Osawa T, et al. Prevalence and risk factors of a rotator cuff tear in the general population. *J Shoulder Elbow Surg* 2010;19:116-120.
2. Minagawa H, Yamamoto N, Abe H, et al. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: From mass-screening in one village. *J Orthop* 2013;10:8-12.
3. Sher JS, Uribe JW, Posada A, Murphy BJ, Zlatkin MB. Abnormal findings on magnetic resonance images of asymptomatic shoulders. *J Bone Joint Surg Am* 1995;77:10-15.
4. Molina CS, Thakore RV, Blumer A, Obremskey WT, Sethi MK. Use of the National Surgical Quality Improvement Program in orthopaedic surgery. *Clin Orthop Relat Res* 2015;473:1574-1581.
5. Colvin AC, Egorova N, Harrison AK, Moskowitz A, Flatow EL. National trends in rotator cuff repair. *J Bone Joint Surg Am* 2012;94:227-233.
6. Yanik EL, Chamberlain AM, Keener JD. Trends in rotator cuff repair rates and comorbidity burden among commercially insured patients younger than the age of 65 years, United States 2007-2016. *JSES Rev Rep Tech* 2021;1:309-316.
7. Tauro JC. Stiffness and rotator cuff tears: Incidence, arthroscopic findings, and treatment results. *Arthroscopy* 2006;22:581-586.
8. Cho NS, Rhee YG. Functional outcome of arthroscopic repair with concomitant manipulation in rotator cuff tears with stiff shoulder. *Am J Sports Med* 2008;36:1323-1329.
9. Oh JH, Kim SH, Lee HK, Jo KH, Bin SW, Gong HS. Moderate preoperative shoulder stiffness does not alter the clinical outcome of rotator cuff repair with arthroscopic release and manipulation. *Arthroscopy* 2008;24:983-991.
10. Kang SW. Do we have to perform surgical treatment simultaneously for rotator cuff tear in patients with adhesive capsulitis? *Korean J Sports Med* 2019;37:11.
11. Moosmayer S, Tariq R, Stiris M, Smith HJ. The natural history of asymptomatic rotator cuff tears: a three-year follow-up of fifty cases. *J Bone Joint Surg Am* 2013;95:1249-1255.
12. Goutallier D, Postel JM, Gleyze P, Leguilloux P, Van Driessche S. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. *J Shoulder Elbow Surg* 2003;12:550-554.
13. Weber SC, Abrams JS, Nottage WM. Complications associated with arthroscopic shoulder surgery. *Arthroscopy* 2002;18:88-95 (2 Suppl 1).
14. Kim YS, Lee HJ, Park I, Im JH, Park KS, Lee SB. Are delayed operations effective for patients with rotator cuff tears and concomitant stiffness? An analysis of immediate versus delayed surgery on outcomes. *Arthroscopy* 2015;31:197-204.
15. Kim IB, Jung DW. A rotator cuff tear concomitant with shoulder stiffness is associated with a lower retear rate after 1-stage arthroscopic surgery. *Am J Sports Med* 2018;46:1909-1918.
16. Zhang J, Tan YB, Lie DTT. Outcomes of arthroscopic rotator cuff repair in stiff shoulders are comparable to non-stiff shoulders when combined with manipulation under anesthesia. *Arthroscopy* 2020;36:2954-2961.
17. Mak WK, Lim WSR, Lie DTT. Is single-stage capsular release and rotator cuff repair suitable for rotator tears with concomitant stiffness? *J Orthop* 2020;21:496-499.
18. Sabzevari S, Kachooei AR, Giugale J, Lin A. One-stage surgical treatment for concomitant rotator cuff tears with shoulder stiffness has comparable results with isolated rotator cuff tears: A systematic review. *J Shoulder Elbow Surg* 2017;26:e252-e258.
19. DeOrio JK, Cofield RH. Results of a second attempt at surgical repair of a failed initial rotator-cuff repair. *J Bone Joint Surg Am* 1984;66:563-567.
20. Sambandam SN, Khanna V, Gul A, Mounasamy V. Rotator cuff tears: An evidence-based approach. *World J Orthop* 2015;6:902-918.

21. Sharma G, Bhandary S, Khandige G, Kabra U. MR Imaging of rotator cuff tears: Correlation with arthroscopy. *J Clin Diagn Res* 2017;11:TC24-TC27.
22. Dabija DI, Pennings JS, Archer KR, et al. Which is the best outcome measure for rotator cuff tears? *Clin Orthop Relat Res* 2019;477:1869-1878.
23. Schmitt JS, Di Fabio RP. Reliable change and minimum important difference (MID) proportions facilitated group responsiveness comparisons using individual threshold criteria. *J Clin Epidemiol* 2004;57:1008-1018.
24. Patel AA, Donegan D, Albert T. The 36-item short form. *J Am Acad Orthop Surg* 2007;15:126-134.
25. Wylie JD, Suter T, Potter MQ, Granger EK, Tashjian RZ. Mental health has a stronger association with patient-reported shoulder pain and function than tear size in patients with full-thickness rotator cuff tears. *J Bone Joint Surg Am* 2016;98:251-256.
26. Kennedy P, Joshi R, Dhawan A. The effect of psychosocial factors on outcomes in patients with rotator cuff tears: A systematic review. *Arthroscopy* 2019;35:2698-2706.
27. Wukich DK, Sambenedetto TL, Mota NM, Suder NC, Rosario BL. Correlation of SF-36 and SF-12 component scores in patients with diabetic foot disease. *J Foot Ankle Surg* 2016;55:693-696.
28. Chung SW, Park JS, Kim SH, Shin SH, Oh JH. Quality of life after arthroscopic rotator cuff repair: Evaluation using SF-36 and an analysis of affecting clinical factors. *Am J Sports Med* 2012;40:631-639.
29. Cho CH, Bae KC, Kim DH. Treatment strategy for frozen shoulder. *Clin Orthop Surg* 2019;11:249-257.
30. Keener JD, Galatz LM, Stobbs-Cucchi G, Patton R, Yamaguchi K. Rehabilitation following arthroscopic rotator cuff repair: A prospective randomized trial of immobilization compared with early motion. *J Bone Joint Surg Am* 2014;96:11-19.
31. Harris JD, Ravindra A, Jones GL, Butler RB, Bishop JY. Setting patients' expectations for range of motion after arthroscopic rotator cuff repair. *Orthopedics* 2013;36:e172-e178.
32. Itoi E, Arce G, Bain GI, et al. Shoulder stiffness: Current concepts and concerns. *Arthroscopy* 2016;32:1402-1414.
33. Redler LH, Dennis ER. Treatment of adhesive capsulitis of the shoulder. *J Am Acad Orthop Surg* 2019;27:e544-e554.
34. Longo UG, Carnevale A, Piergentili I, et al. Retear rates after rotator cuff surgery: A systematic review and meta-analysis. *BMC Musculoskelet Disord* 2021;22:749.
35. Zhao J, Luo M, Pan J, et al. Risk factors affecting rotator cuff retear after arthroscopic repair: A meta-analysis and systematic review. *J Shoulder Elbow Surg* 2021;30:2660-2670.