



The functional internal rotation scale: a novel shoulder arthroplasty outcome measure

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Background: Shoulder arthroplasty, especially reverse shoulder arthroplasty (RSA), continues to increase in volume. Limitations in internal rotation can be challenging following RSA. Current patient-reported outcome measures are limited in assessing a patient's functional internal rotation following shoulder arthroplasty. To address this limitation, a questionnaire was developed.

Methods: A single-center prospective comparative cohort study was performed to determine the reliability of the questionnaire. A pilot group of patients who had at least 1 year of follow-up following shoulder arthroplasty was asked to complete the questionnaire. Reliability testing was performed using Cronbach's alpha test. Additionally, individual questions and total questionnaire scores were compared between patients who underwent anatomic total shoulder arthroplasty (TSA) and RSA.

Results: The questionnaire showed high reliability with all questions. A group of 23 anatomic TSA and 20 RSA patients were compared. RSA patients scored significantly lower on the questionnaire (35.2 out of 50 vs. 43.9, $P = .001$).

Conclusion: The questionnaire can be used in conjunction with other patient-reported outcome measures to help surgeons better assess patients' results following shoulder arthroplasty. The initial findings from our internal reliability study found that RSA patients had significantly lower scores and higher variability in internal rotation function vs. patients with TSA. Further studies are needed to determine the clinical importance of this questionnaire.

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Shoulder arthroplasty continues to increase in volume globally, especially reverse shoulder arthroplasty (RSA).^{1,3,7,12,13,21} RSA provides patients of various indications with reliable pain relief and improvement in function. Several studies show significant increase in both objective and subjective patient-reported outcomes.^{1,2,7,12,21} However, limitations in motion, especially internal rotation, is still a challenge following RSA.^{11,12,19,22}

Internal rotation is required for several activities of daily living tasks, notably bathing, toileting, and getting dressed.^{9,17} Most patient-reported outcome measures (PROMs) for the shoulder focus on activities that require flexion, abduction, and external rotation.¹⁷ This bias toward these activities can lead to PROM scores that are considered “good” or “excellent” despite limitations in internal rotation. Currently, there is no PROM that can adequately assess a patient's internal rotation function.

Institutional review board approval was received from Washington University in St Louis, School of Medicine (approval no. 201708041).

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The purpose of this study was to evaluate the reliability of a specially formed questionnaire assessing a patient's internal rotation function following shoulder arthroplasty. We also sought to compare the outcomes of patients who underwent anatomic total shoulder arthroplasty (aTSA) vs. those who underwent RSA. Our hypothesis was that this questionnaire would reliably describe patients' internal rotation function and that RSA patients would have significantly worse internal rotational function than those with TSA.

Methods

The study was a prospective comparative cohort study evaluating the responses of our specially formed questionnaire. Institutional review board approval was obtained. Patients who were returning for 1-year postoperative follow-up for aTSA or RSA were eligible for inclusion. To ensure a subscapularis-deficient shoulder, RSA patients in whom the subscapularis was repaired were excluded from analysis. All RSA patients had the Zimmer TM implant with a neck-shaft angle of 155° and 2–4 mm of lateral offset from the glenoid (Zimmer-Biomet, Warsaw, IN, USA). All aTSA patients had the Zimmer Bigliani-Flatow implant (Zimmer-Biomet).

Please circle where you agree with the following statements with respect to the shoulder in question:

1. I have difficulty reaching my arm behind my back
 strongly agree agree neutral disagree strongly disagree

2. I have difficulty using my arm for toileting
 strongly agree agree neutral disagree strongly disagree

3. I have difficulty reaching my arm across my body
 strongly agree agree neutral disagree strongly disagree

4. I have difficulty tucking in a shirt behind my back
 strongly agree agree neutral disagree strongly disagree

5. I have difficulty putting my arm in a jacket
 strongly agree agree neutral disagree strongly disagree

6. I have difficulty buckling my seat belt with my arm
 strongly agree agree neutral disagree strongly disagree

7. I have difficulty looping a belt through my pants with my arm
 strongly agree agree neutral disagree strongly disagree

8. I have difficulty reaching under my opposite arm to shower/put on deodorant
 strongly agree agree neutral disagree strongly disagree

9. I have difficulty closing doors with my arm
 strongly agree agree neutral disagree strongly disagree

10. I have difficulty cutting food (e.g. meat) with my arm
 strongly agree agree neutral disagree strongly disagree

Figure 1 Likert-type scale questionnaire to assess internal rotation function.

The subscapularis was taken down with a lesser tuberosity osteotomy and repaired using nonabsorbable heavy sutures after implantation. Subscapularis integrity was assessed on post-operative examination with a normal abdominal compression test

as well as radiographically assessing for healing of the osteotomy and lack of anterior subluxation of the humeral component on axillary radiograph. Finally, a group of patients presenting for evaluation of other shoulder conditions with at least one healthy

Table 1
Demographics

	TSA (n = 20)	RSA (n = 23)	P value
Age at time of surgery, yr, mean \pm SD	64.8 \pm 11.4	68.2 \pm 12.4	.15
Sex, male, n (%)	8 (40)	10 (43)	.82
Operative side, right, n (%)	11 (55)	9 (39)	.3

TSA, total shoulder arthroplasty; RSA, reverse shoulder arthroplasty.

shoulder were asked to fill out the questionnaire for their healthy shoulder to help investigate the questionnaire's reliability. The study period ran over the course of 6 months.

The questionnaire is a 10-question Likert-type scale that attempts to evaluate patient's satisfaction with tasks that require internal rotation (Fig. 1). The questions were developed by 2 fellowship-trained shoulder and elbow surgeons. Patients were asked to fill out the questionnaires at the time of follow-up and were informed of the experimental nature of the questionnaire. The scores are graded in an ordinal manner from 1 to 5, with 5 equating to no difficulties with each task. A score of 50 meant no dissatisfaction with any of the tasks, and a score of 10 equated to complete dissatisfaction with all the tasks.

Our goal was to recruit 20 patients each in the aTSA and RSA groups and 10 control patients. Given that this was a pilot study to determine the reliability of the survey, no power analysis was performed. Basic demographics, including patient age, sex, and operative side, were recorded. Patient responses to the questionnaires were then summed. Individual question and total question scores were compared between the TSA and RSA patients. Differences between scores were assessed for statistical significance using an ordinal logistic model for each individual question and a linear regression model to compare total scores. A *P* value of $<.05$ was considered statistically significant. Finally, to assess the consistency of the questionnaire, Cronbach's alpha was also calculated for each question to determine its reliability.

Results

Overall, 53 patients met inclusion criteria and were included in the study (23 aTSA, 20 RSA, and 10 control). Basic demographics are seen in Table 1. There were no significant differences in age, sex and operative side between the TSA and RSA groups. All 10 control patients scored a perfect 50 on the questionnaire.

RSA patients had a wide range of total score on the question, ranging from 19–50 total score with a mean of 35.2 and a median of

33.0. TSA patients had a much narrower range of scores from 36–50, with a mean of 43.9 and median of 42.0 (Fig. 2, A and B). Comparisons between questionnaire responses for each question individually for TSA and RSA patients were also completed. Table II shows the results of this comparison. In summary, TSA patients had a significantly higher odds for answering a higher score question for all questions except for questions 5 (I have difficulty putting my arm in a jacket) and 8 (I have difficulty reaching under my opposite arm to shower/put deodorant on), respectively. The majority of TSA patients scored a 4 or 5 out of 5 for each question. Comparing total scores between the 2 groups using a linear regression model found TSA patients scoring on average 8.7 points higher than RSA patients (43.9 vs. 35.2, *P* = .001, 95% confidence interval 3.7–13.6).

Finally, to test for internal reliability of the questionnaire, a Cronbach's alpha was calculated for the total questionnaire and for the questionnaire if a certain question was removed. The questionnaire showed very high reliability, with a Cronbach's alpha of 0.94. Table III shows Cronbach's alpha if a question was removed. Removing any single question did not significantly improve the reliability of the questionnaire.

Discussion

The findings of this study validate a method for assessing internal rotation function in patients following shoulder arthroplasty using an easy 10-question scale of common tasks that require internal rotation function. The study also shows, for a small cohort of patients, that internal rotation functionality following RSA is worse and less predictable than similar functionality after aTSA. The questionnaire showed high internal reliability.

RSA continues to increase in popularity given its overall favorable results and longevity.^{1,7,8,12,13,20,21} Indications for RSA have expanded and several surgeons are using RSA in increasingly younger patients.^{5,14,16} Several studies demonstrate favorable patient-reported outcomes at the short- and long-term follow-up. However, several of these patient-reported outcome scales do not account for significant losses in internal rotation function, and patients can still score favorably despite poor function with internal rotation tasks.^{4,11,17,19} The questionnaire used in this study can help reliably identify patients that are having difficulty with internal rotation following shoulder arthroplasty tasks despite overall satisfaction. The questionnaire used in this study did show good internal reliability. Further study is needed to determine if the same

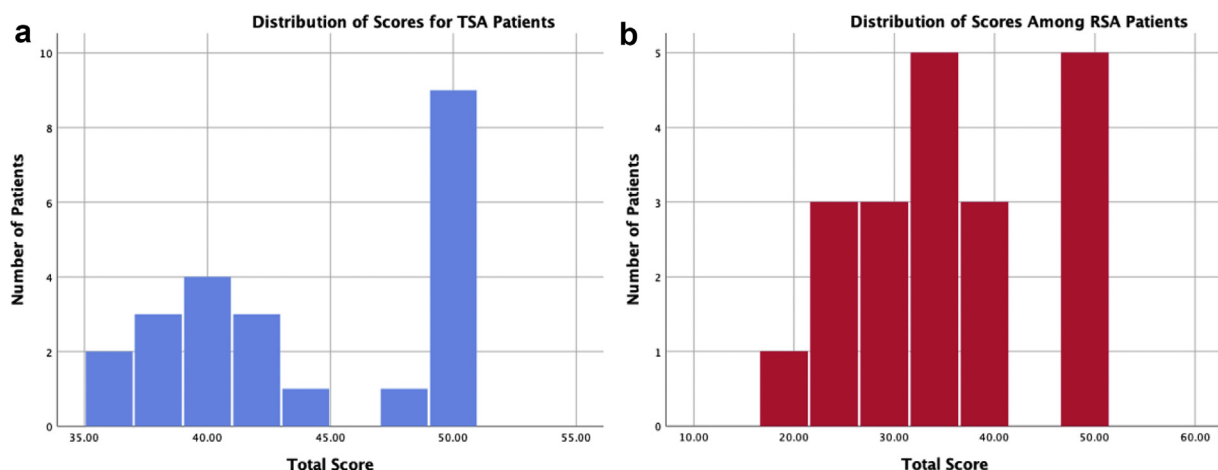


Figure 2 Distribution of scores for anatomic total shoulder arthroplasty (a) and reverse shoulder arthroplasty (b).

Table II
Comparison of scores between anatomic total shoulder and reverse shoulder arthroplasty

Question number	TSA, n (%) (n = 20)	RSA, n (%) (n = 23)	Odds ratio	P value
1	1 0 (0)	5 (25)	4.35	.01
	2 5 (21.7)	7 (35)		
	3 2 (8.7)	1 (5)		
	4 6 (26.1)	2 (10)		
	5 10 (43.5)	5 (25)		
2	1 0 (0)	0 (0)	5.46	.008
	2 1 (4.3)	5 (25)		
	3 2 (8.7)	4 (20)		
	4 3 (13.0)	4 (20)		
	5 17 (73.9)	7 (35)		
3	1 0 (0)	2 (10)	4.66	.01
	2 0 (0)	2 (10)		
	3 2 (8.7)	6 (30)		
	4 7 (30.4)	3 (15)		
	5 14 (60.9)	7 (35)		
4	1 0 (0)	2 (10)	5.05	.006
	2 1 (4.3)	7 (35)		
	3 4 (17.4)	3 (15)		
	4 9 (39.1)	4 (20)		
	5 9 (39.1)	4 (20)		
5	1 0 (0)	1 (5)	2.7	.08
	2 2 (8.7)	6 (30)		
	3 3 (13.0)	2 (10)		
	4 6 (26.1)	4 (20)		
	5 12 (52.2)	7 (35)		
6	1 0 (0)	2 (10)	5.1	.008
	2 0 (0)	5 (25)		
	3 1 (4.3)	1 (5)		
	4 7 (30.4)	5 (25)		
	5 15 (65.2)	7 (35)		
7	1 0 (0)	1 (5)	3.0	.05
	2 3 (13.0)	4 (20)		
	3 2 (8.7)	7 (35)		
	4 7 (30.4)	2 (10)		
	5 11 (47.8)	6 (30)		
8	1 0 (0)	0 (0)	2.01	.21
	2 0 (0)	3 (15)		
	3 3 (13.0)	3 (15)		
	4 8 (34.8)	6 (30)		
	5 12 (52.2)	8 (40)		
9	1 0 (0)	0 (0)	2.12	.03
	2 0 (0)	2 (10)		
	3 0 (0)	3 (15)		
	4 8 (34.8)	7 (35)		
	5 15 (65.2)	8 (40)		
10	1 0 (0)	1 (5)	7.1	.003
	2 0 (0)	2 (10)		
	3 0 (0)	4 (20)		
	4 6 (26.1)	6 (30)		
	5 17 (73.9)	7 (35)		

TSA, total shoulder arthroplasty; RSA, reverse shoulder arthroplasty.

results could be obtained using a smaller number of questions to potentially decrease the burden of the questionnaire on patients.

Studies comparing outcomes of RSA to aTSA generally show similar outcomes. Kiet et al⁸ performed a retrospective study of a group of patients undergoing aTSA compared with RSA. They found no significant differences in range of motion, with the exception of better external rotation in aTSA. They found no differences in PROMs in either group. Latif et al¹¹ compared outcomes of patients with bilateral shoulder arthroplasties. They found better range of motion in the side with aTSA compared with RSA, but no differences in functional outcomes. Similarly, Cox et al³ performed a retrospective review of patients with an aTSA and contralateral RSA. Among 19 patients, they found that the RSA side had worse internal rotation compared with the aTSA, but no other differences in range of motion. Similar to other studies, they found no difference in reported patient-rated outcomes at final follow-up.

Table III
Assessment of reliability

	Scale mean if question removed	Cronbach's alpha if question removed
Question 1	37.8	0.93
Question 2	37.1	0.93
Question 3	37.2	0.93
Question 4	37.6	0.93
Question 5	37.3	0.94
Question 6	37.2	0.94
Question 7	37.4	0.93
Question 8	37.1	0.93
Question 9	36.9	0.94
Question 10	37	0.94

Interestingly, 13 of 19 patients reported greater satisfaction with their RSA.

When comparing patients who underwent bilateral RSAs, Mel-lano et al¹² found in a group of 50 patients that all patients had significant improvements in functional outcomes and range of motion. Importantly, they noted all patients were able to independently perform bathing and toileting functions, which require internal rotation. Wirth et al²² attempted to determine the frequency of patients with “insufficient” internal rotation, defined as an inability to reach beyond the lumbosacral junction following bilateral RSA. They found only 5% of patients had bilateral insufficient internal rotation, and there were no differences in the Constant score of these patients.

The prior studies all highlight the difficulty with assessing internal rotation function, especially following RSA. Most report good to excellent outcomes for all patients, with no specific differences in functional outcome scores. Triplet et al¹⁹ performed a more detailed evaluation of internal rotational function following shoulder arthroplasty, comparing range of motion, strength, and specific internal rotation function questions from the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form and Simple Shoulder Test questionnaires among aTSA and RSA patients. They found significantly worse internal rotation range of motion, strength, and functionality as determined by select questions in patients with RSA. They also found significantly lower but clinically irrelevant differences in the overall American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form and Simple Shoulder Test scores comparing RSA to aTSA patients.

As discussed, internal rotation motion is a known clinical finding following RSA.^{19,22} Internal rotation weakness is difficult to assess and is inconsistently reported in outcome studies following RSA.^{4,10,19,22} The findings from our study reveal that difficulty with tasks that require internal rotation for patients with RSA is common and unpredictable despite consistency in implant design used in this patient cohort. Several studies have found that changing implant orientation and design does not always lead to differences in functional outcomes.^{1,6,15,18}

There are several limitations to our study. First, we used a small patient cohort to evaluate the reliability of this questionnaire, and external validation of the questionnaire is needed. However, we found excellent internal reliability in our survey using the Cronbach's alpha test, a validated statistical measure for questionnaire reliability. Additionally, all internal rotation functional questions were created by shoulder and elbow fellowship-trained surgeons based on commonly recognized clinical deficits in subscapularis-deficient shoulders. The questionnaire comprises 10 questions and focuses on only 1 parameter of functionality following shoulder arthroplasty. Further investigation is needed to determine if similar conclusions regarding internal rotation functionality can be drawn out with fewer questions, while maintaining the ability to discern

subtle differences in internal rotation function. Patient responses for RSA were more variable than aTSA responses, and significant differences between responses may become less apparent with a larger number of responses. We were able to find significant differences between outcomes of RSA and aTSA in a small cohort, but a larger cohort may show more similarities and reduce the chance of type I error. RSA patients with repaired subscapularis tendon following surgery were excluded from this pilot study. However, this was done to exclude a confounding variable between our study groups. Finally, the study did not correlate the scores from this questionnaire with other patient-related outcome scores evaluating shoulder function. We felt this was not necessary because the purpose of this study was to evaluate the questionnaire and establish it as a tool to use in addition to other outcome scores rather than be a substitute for these scores. Also, as mentioned earlier, most shoulder assessment scores focus little attention on internal rotation function, and all postoperative patients reported general satisfaction with their outcomes.

Conclusion

We created a, reliable, and easy-to-execute questionnaire to assess internal rotation function following shoulder arthroplasty. The questionnaire can be used in conjunction with other patient-reported outcome measures to help surgeons better assess patients' results following either aTSA or RSA. The initial findings from our internal reliability study found that RSA patients had significantly lower scores and higher variability in internal rotation function vs. patients with aTSA. Further studies are needed to determine the clinical importance of this questionnaire.

Disclaimer

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