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Establishing and comparing reference preoperative Patient-Reported Outcomes Measurement Information System (PROMIS) scores in patients undergoing shoulder surgery

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Background: The Patient-Reported Outcomes Measurement Information System (PROMIS) has become increasingly popular among orthopedic surgeons treating shoulder pathology. Despite this, there have been few studies that have described and compared preoperative reference scores for specific shoulder surgical procedures. The primary purpose of this study was to establish and compare baseline preoperative PROMIS scores for 3 common types of shoulder surgery: rotator cuff repair (RCR), total shoulder arthroplasty (TSA), and labral repair (LR). The secondary goal was to stratify these operative groups by diagnosis and compare preoperative PROMIS scores.
Methods: In this cross-sectional study, adult and pediatric patients who underwent surgery for either RCR, TSA, or LR were included. PROMIS–Upper Extremity (UE), PROMIS–Pain Interference (PI), and PROMIS–Depression (D) scores that were collected at each patient's preoperative visit were reviewed. Continuous and categorical variables were compared between operative groups using analysis of variance and χ^2 or Fisher exact tests, respectively. Multivariable general linear models were used to identify significant independent predictors of PROMIS scores when controlling for age, sex, and body mass index.
Results: A total of 413 patients were included in the study: 272 in the RCR group, 84 in the TSA group, and 57 in the LR group. The average PROMIS-UE score was 39.8 in the LR group vs. 29.9 in the RCR group ($P < .001$) and 29.6 in the TSA group ($P < .001$). There was no difference between the mean RCR and TSA PROMIS-UE scores ($P = .93$). The average PROMIS-PI score was 56.6 in the LR group vs. 62.8 in the RCR group ($P < .001$) and 63.9 in the TSA group ($P < .001$). There was no difference between RCR and TSA PROMIS-PI scores ($P = .09$). The average PROMIS-D score was 43.5 in the LR group vs. 47.7 in the RCR group ($P = .004$) and 50.3 in the TSA group ($P < .001$). The TSA group had a higher mean PROMIS-D score than the RCR group ($P = .03$). For PROMIS-UE scores, age and body mass index were not found to be significant independent predictors ($P = .98$ and $P = .88$, respectively). For PROMIS-PI scores, age, body mass index, and sex were not found to be significant independent predictors ($P = .31$, $P = .81$, and $P = .48$, respectively).
Conclusion: Patients undergoing shoulder LR had higher preoperative function scores and lower pain interference and depression scores than those undergoing TSA and RCR. These baseline PROMIS scores should be taken into consideration when tracking a patient's outcomes after surgery, as a certain score could mean drastically different functional and pain outcomes depending on the underlying pathology.

The Henry Ford Health System Institutional Review Board approved this study (study no. 11361).

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Shoulder-related injuries and diseases continue to be one of the most common indications for surgery in the field of orthopedics.[5,17,21] As the current state of health care continues to emphasize the importance of a patient-centered approach, the Patient-Reported Outcomes Measurement Information System (PROMIS) has become increasingly popular among orthopedic surgeons treating shoulder pathology.[1,7,12,13,15,16]

PROMIS was designed to be comprehensive and generalizable enough to be used to track outcomes across a variety of disease states in all parts of the body.[3] Although this has its benefits, there have been few studies that have described reference scores for specific conditions.[9] Moreover, there is a limited body of literature that reports baseline preoperative scores for patients undergoing different types of shoulder surgery.[2,4,10,13] Furthermore, many of these studies had relatively small sample sizes. If orthopedic surgeons wish to track their patients' outcomes from the preoperative phase to the final postoperative visit, it is vital for these surgeons to know what a typical preoperative PROMIS score is for patients undergoing a specific shoulder operation.

The primary purpose of this study was to establish and compare baseline preoperative PROMIS scores for 3 common types of shoulder surgery: rotator cuff repair (RCR), total shoulder arthroplasty (TSA), and labral repair (LR). The secondary goal was to stratify these operative groups by diagnosis and compare preoperative PROMIS scores. We hypothesized that (1) PROMIS scores would demonstrate differences between the LR and RCR groups and between the LR and TSA groups and (2) there would be no differences between the RCR and TSA groups.

Methods

Patient records were retrospectively reviewed for all patients who underwent either RCR, TSA, or LR from June 19, 2017, to February 28, 2020, performed by 1 of 3 sports medicine or shoulder and elbow orthopedic surgeons at 2 tertiary academic medical centers. In this study, both patients undergoing TSA and those undergoing reverse TSA were included in the TSA group. Patients were identified using Current Procedural Terminology codes 23472, 29827, 29806, and 29807 (Fig. 1).

For the secondary goal of the study, we compared the following diagnostic groups: rotator cuff tear (RCT), cuff tear arthropathy (CTA), osteoarthritis (OA), and LR. The patients in the RCR and TSA operative groups were stratified by primary diagnoses; these diagnoses were RCT, CTA, OA, and proximal humeral fracture. The LR cohort was the same group used for analysis in the comparison of operative-group PROMIS scores. This group was not stratified by diagnosis because the majority of patients had overlapping labral pathologies, making discrete segregations challenging. The proximal humeral fracture group was excluded from statistical comparison as this cohort had only 6 patients and the sample size was not sufficient to make a meaningful contribution to the analysis.

Both adult and pediatric patients were included in this study if they underwent one of the aforementioned surgical procedures and completed at least 1 set of PROMIS computer adaptive test (CAT) forms preoperatively. If a patient had multiple preoperative visits and associated PROMIS scores, the visit closest to the date of surgery was selected. One completed set of PROMIS CAT forms included PROMIS–Upper Extremity (UE), PROMIS–Pain Interference (PI), and PROMIS–Depression (D). PROMIS surveys are calibrated against a healthy reference population in which the average score is 50, with a standard deviation of 10. A higher score correlates with more of the indicated health domain in question. That is, a higher PROMIS-UE score indicates higher functional capabilities, whereas a higher PROMIS-PI or PROMIS-D score indicates more pain interference or more depressive symptoms in the patient.[3]

Both PROMIS surveys and demographic information were completed on a portable computer tablet (iPad tablet; Apple, Cupertino, CA, USA) using a Web-based application (REDCap; Vanderbilt University, Nashville, TN, USA).[14] Patient demographic information was obtained at the initial clinic visit and included age, sex, race, and body mass index (BMI). Patients were excluded if they could not communicate in written and spoken English and/or if they could not use the electronic tablet. Revision procedures were also excluded from analysis.

For statistical analyses, continuous variables were compared between operative or diagnostic groups using analysis of variance whereas categorical variables were compared between groups using the χ^2 test or, if expected cell counts were <5, using the Fisher exact test. Pair-wise comparisons were carried out on variables that were significant overall between the 3 operative groups, and a Benjamini-Hochberg correction was applied to the P value to control the false discovery rate inherent to multiple comparisons. Multivariable general linear models were used to determine which independent variables were significant predictors of PROMIS-UE, -PI, and -D scores. Furthermore, these models were used to determine the effect of each independent variable on the dependent variables. This was reported as a β-adjusted estimate. Independent variables examined included operative group (ie, LR vs. TSA, LR vs. RCR, and TSA vs. RCR), age, sex, and BMI. Statistical significance was set at $P < .05$. All analyses were performed using SAS software (version 9.4; SAS Institute, Cary, NC, USA).

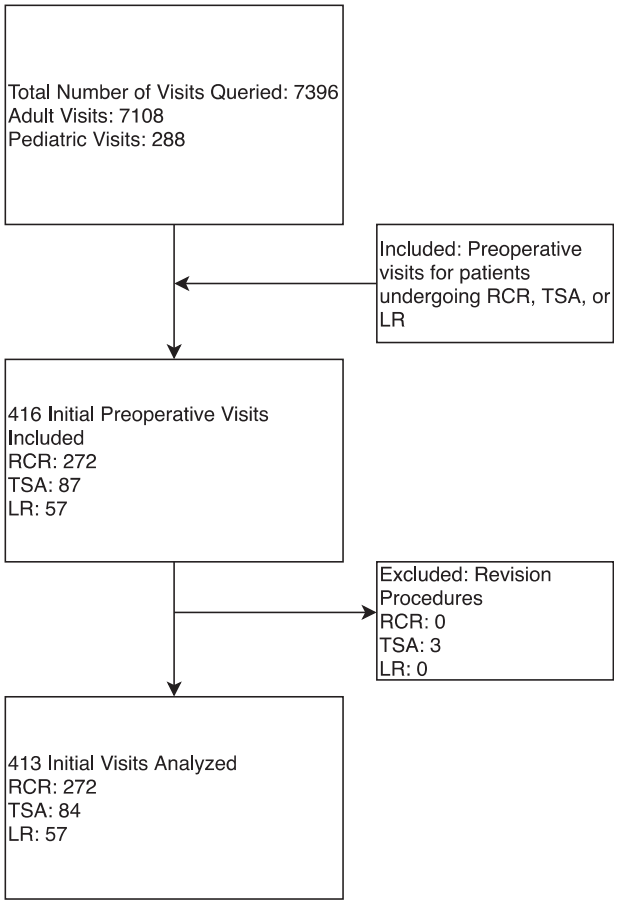

Figure 1 Inclusion criteria. All preoperative visits for patients undergoing rotator cuff repair *(RCR)*, total shoulder arthroplasty *(TSA)*, or labral repair *(LR)* were included. Revision procedures were excluded.

Results

A total of 413 patients were included in the study: 272 in the RCR group (age range, 19.5-90.0 years), 84 in the TSA group (age range, 43.7-96.9 years), and 57 in the LR group (age range, 17.2-68.7 years) (Table I). The average age of the entire cohort was 58.4 years (range, 16.8-95.6 years), and the average BMI was 29.4 (range, 16.8-50.8). The LR group had the youngest average age, at 26.6 years, compared with 60.0 years for the RCR group ($P < .001$) and 71.1 years for the TSA group ($P < .001$). The average time between preoperative PROMIS score collection and the date of surgery was 30.8 days (range, 1.2-98.5 days), 30.0 days (range, 1.1-84.6 days), and 25.1 days (range, 1.1-91.6 days) for RCR, TSA, and LR, respectively.

The LR group had the highest mean PROMIS-UE score preoperatively compared with the TSA and RCR cohorts (Table II, Fig. 2). The average PROMIS-UE score was 39.8 in the LR group vs. 29.9 in the RCR group ($P < .001$) and 29.6 in the TSA group ($P < .001$). There was no difference between the mean RCR and TSA PROMIS-UE scores ($P = .93$).

The LR group had the lowest mean PROMIS-PI score compared with the TSA and RCR cohorts. The average PROMIS-PI score was 56.6 in the LR group vs. 62.8 in the RCR group ($P < .001$) and 63.9 in the TSA group ($P < .001$). Comparison between the RCR and TSA PROMIS-PI scores yielded $P = .09$.

The LR group had the lowest average PROMIS-D score compared with the TSA and RCR cohorts. The average PROMIS-D score was 43.5 in the LR group vs. 47.7 in the RCR group ($P = .004$) and 50.3 in the TSA group ($P < .001$). The TSA group had a higher mean PROMIS-D score than the RCR group ($P = .03$).

When we compared diagnostic groups, the LR group had the highest mean PROMIS-UE score ($P < .001$ for each comparison) and the lowest PROMIS-PI score ($P < .001$ for each comparison) compared with the other diagnostic groups (Table III). The mean PROMIS-UE score was 39.8 for the LR group vs. 29.9 for the RCT group ($P < .001$), 29.3 for the CTA group ($P < .001$), and 32.2 for the OA group ($P < .001$). No difference was found between RCT and OA ($P = .50$), RCT and CTA ($P = .94$), or OA and CTA ($P = .34$).

The average PROMIS-PI score was 56.6 in the LR group vs. 62.8 in the RCT group ($P < .001$), 63.4 in the CTA group ($P < .001$), and 63.6 in the OA group ($P < .001$) (Table III). There was no difference between RCT and OA ($P = .96$), RCT and CTA ($P = .93$), or OA and CTA ($P = .99$).

The LR, RCT, CTA, and OA diagnostic groups had average PROMIS-D scores of 43.5, 47.7, 50.7, and 49.4, respectively (Table III). The PROMIS-D score was lower in the LR group than in the RCT ($P = .004$), CTA ($P < .001$), and OA ($P = .04$) groups. There was no difference between RCR and OA ($P = .92$) or between RCR and CTA ($P = .16$). There was also no difference between OA and CTA ($P = .98$).

For PROMIS-UE, when controlling for age, sex, and BMI, the β-adjusted estimates for LR vs. TSA and LR vs. RCR were 9.8 ($P < .001$) and 9.3 ($P < .001$), respectively (Table IV). For RCR vs. TSA, the β-adjusted estimate was 0.5 ($P = .567$). For PROMIS-PI, the β-adjusted estimates for LR vs. TSA and LR vs. RCR were –8.5 ($P < .001$) and –7.0 ($P < .001$), respectively. For RCR vs. TSA, the β-adjusted estimate was –1.5 ($P = .05$). For PROMIS-D, there were no significant β-adjusted estimate responses for the operative groups. For PROMIS-UE, sex was found to be a significant predictor of the score ($P < .001$); age ($P = .98$) and BMI ($P = .88$) were not found to be significant predictors. For PROMIS-PI, sex ($P = .48$), age ($P = .31$), and BMI ($P = .81$) were not found to be significant predictors of the score. Likewise, for PROMIS-D, sex ($P = .63$), age ($P = .19$), and BMI ($P = .15$) were not found to be significant predictors of the score.

Table I Demographic factors by operative group

	LR (n = 57)	RCR (n = 272)	TSA (n = 84)
Age, mean (range), yr	26.6 (16.8-68.3)	60.0 (19.2-89.6)	71.1 (43.3-96.5)
Sex, n (%)			
Male	48 (84)	156 (57)	43 (51)
Female	9 (15)	116 (43)	41 (49)
BMI, mean (range)	27.8 (20.1-48.6)	29.9 (19.8-50.8)	28.9 (16.8-42.8)
Race, n (%)			
White	34 (60)	172 (66)	59 (72)
African American	12 (21)	71 (27)	21 (26)
Other	11 (19)	18 (7)	2 (2)

LR, labral repair; *RCR*, rotator cuff repair; *TSA*, total shoulder arthroplasty; *BMI*, body mass index.

Table II Preoperative PROMIS domains by operative group

	LR (n = 57)	RCR (n = 272)	TSA (n = 84)
PROMIS-UE	39.8 (8.4)	29.9 (6.1)	29.5 (6.6)
PROMIS-PI	56.6 (6.9)	62.8 (5.3)	63.8 (5.4)
PROMIS-D	43.5 (7.5)	47.7 (9.2)	50.3 (9.2)

PROMIS, Patient-Reported Outcomes Measurement Information System; *LR*, labral repair; *RCR*, rotator cuff repair; *TSA*, total shoulder arthroplasty; *UE*, Upper Extremity; *PI*, Pain Interference; *D*, Depression.
Data are presented as mean (standard deviation). The LR group had higher PROMIS-UE and lower PROMIS-PI scores than the RCR group ($P < .001$ and $P < .001$, respectively) and TSA group ($P < .001$ and $P < .001$, respectively).

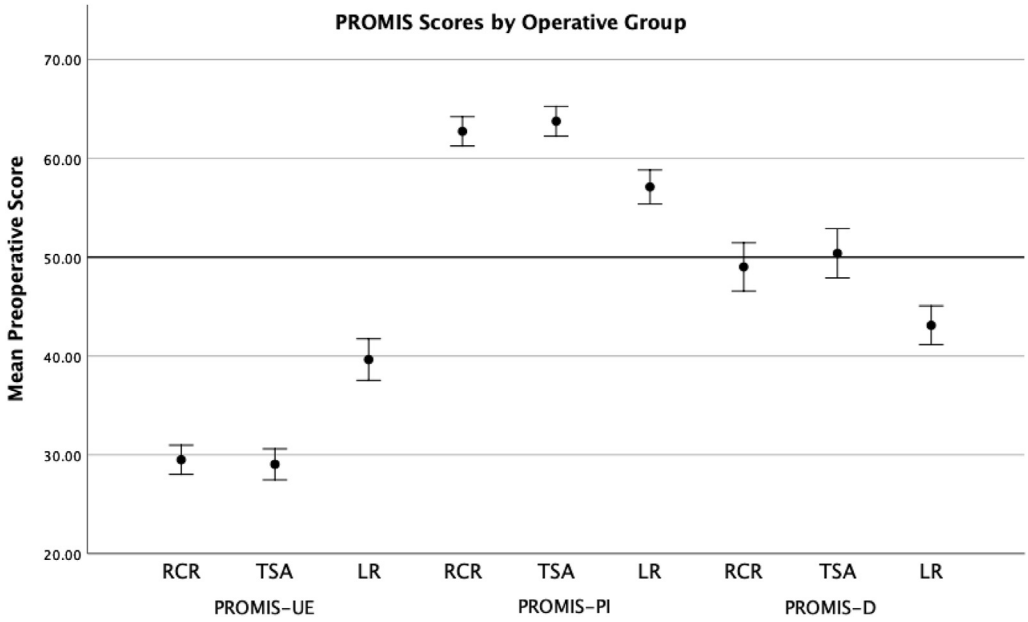

Figure 2 Patient-Reported Outcomes Measurement Information System *(PROMIS)* scores by operative group. Results are presented as means with standard deviations *(error bars)*. A score of 50 is the average score for each domain as calibrated against a healthy reference population. For PROMIS–Upper Extremity *(UE)*, $P < .001$ for labral repair *(LR)* vs. rotator cuff repair *(RCR)*, $P < .001$ for LR vs. total shoulder arthroplasty *(TSA)*, and $P = .93$ for RCR vs. TSA. For PROMIS–Pain Interference *(PI)*, $P < .001$ for LR vs. RCR, $P < .001$ for LR vs. TSA, and $P = .09$ for RCR vs. TSA. For PROMIS–Depression *(D)*, $P < .004$ for LR vs. RCR, $P < .001$ for LR vs. TSA, and $P = .03$ for RCR vs. TSA.

Table III Preoperative PROMIS domains by diagnostic group

	LR (n = 57)	RCT (n = 272)	CTA (n = 56)	OA (n = 22)
PROMIS-UE	39.8 (8.4)	29.9 (6.1)	29.3 (6.1)	32.2 (5.9)
PROMIS-PI	56.6 (6.9)	62.8 (5.3)	63.4 (5.5)	63.6 (4.8)
PROMIS-D	43.5 (7.5)	47.7 (9.2)	50.7 (9.4)	49.4 (7.4)

PROMIS, Patient-Reported Outcomes Measurement Information System; *LR*, labral repair; *RCT*, rotator cuff tear; *CTA*, cuff tear arthropathy; *OA*, osteoarthritis; *UE*, Upper Extremity; *PI*, Pain Interference; *D*, Depression.
Data are presented as mean (standard deviation).

Table IV Effect of operative group, age, sex, and BMI on PROMIS scores

Dependent variable	Independent variable	Response	β-adjusted estimate (SE)	*P* value
PROMIS-UE T-score	Group	LR vs. TSA*	9.8 (1.8)	<.001†
		RCR vs. TSA*	0.5 (0.9)	.567
		LR vs. RCR*	9.3 (1.4)	<.001†
	Age	1-yr increase	−0.0008 (0.03)	.979
	Sex	Female	−2.6 (0.7)	<.001†
		Male	Reference	
	BMI	1-point increase	0.01 (0.07)	.882
PROMIS-PI T-score	Group	LR vs. TSA*	−8.5 (1.5)	<.001†
		RCR vs. TSA*	−1.5 (0.8)	.050
		LR vs. RCR*	−7.0 (1.2)	<.001†
	Age	1-yr increase	−0.03 (0.03)	.306
	Sex	Female	0.4 (0.6)	.475
		Male	Reference	
	BMI	1-point increase	0.01 (0.06)	.811
PROMIS-D T-score	Group	LR vs. TSA*	−4.0 (2.5)	.111
		RCR vs. TSA*	−1.7 (1.2)	.175
		LR vs. RCR*	−2.3 (2.0)	.253
	Age	1-yr increase	0.06 (0.04)	.187
	Sex	Female	0.5 (0.9)	.633
		Male	Reference	
	BMI	1-point increase	−0.1 (0.1)	.154

BMI, body mass index; *PROMIS*, Patient-Reported Outcomes Measurement Information System; *SE*, standard error; *UE*, Upper Extremity; *LR*, labral repair; *TSA*, total shoulder arthroplasty; *RCR*, rotator cuff repair; *PI*, Pain Interference; *D*, Depression.
* Results are presented with TSA as the reference group for LR vs. TSA and RCR vs. TSA and with RCR as the reference group for LR vs. RCR.
† Statistically significant ($P < .05$).

Discussion

Although PROMIS CAT domains continue to grow in popularity in orthopedic surgery practices, there has been a paucity of studies determining true reference PROMIS scores for orthopedic surgery patients. Our study used the largest sample size to date to establish reference PROMIS scores for 3 common shoulder surgical procedures. We found that patients undergoing shoulder LR had higher preoperative function scores and lower pain interference and depression scores than those undergoing TSA and RCR. There was no difference in PROMIS scores between the TSA and RCR groups with the exception of the PROMIS-D score. After controlling for multiple demographic factors, the LR operative group had different PROMIS-UE and PI scores, suggesting that the shoulder pathologies requiring LR truly have differences in scores that are not solely due to differences in demographic traits.

The higher baseline PROMIS-UE score in LR patients than in RCR patients provides valuable information for physicians. A previous study evaluated the responsiveness of PROMIS scores after RCR; the authors found that at 6 months' follow-up, the average PROMIS-UE score was 40.9.[8] This score is very similar to the average preoperative score in our study's LR cohort (39.8). Although these scores are similar, this finding suggests that a score close to 40 in an LR patient indicates the shoulder is symptomatic enough for the patient to seek surgical treatment whereas the same score in an RCR patient is indicative that he or she is recovering well after surgery. These data suggest that

similar PROMIS-UE scores correlate with different levels of impairment depending on what shoulder pathology is involved. These findings highlight the need to establish reference preoperative scores, and these data can aid providers in the interpretation of PROMIS scores as it relates to their patients.

The finding of higher preoperative PROMIS-UE and lower PROMIS-PI and -D scores in the LR group compared with the other 2 operative groups is also notable. After controlling for demographic factors including age, BMI, and sex, the β-adjusted estimates in this study suggested that the preoperative PROMIS-UE scores of patients undergoing LR were 9.8 and 9.3 points higher than those of TSA and RCR patients, respectively. This is a difference of almost 1 standard deviation between baseline scores. The patient population for LR is typically young and active, and the injuries associated with this surgical procedure commonly are more acute in nature.[11,22] Disease courses requiring TSA and RCR, on the other hand, involve chronic, degenerative processes that typically occur in elderly patients over the course of many years.[6,18,19,23] In our study, the average age in the LR group was 26.6 years compared with 60.0 years in the TSA group ($P < .001$) and 71.1 years in the RCR group ($P < .001$). Although age was not found to be a significant independent predictor of PROMIS-UE scores, we hypothesize that the difference in the baseline level of activity associated with younger patients could have played a role in the difference between scores. Furthermore, we hypothesize that the similarly degenerative chronicity associated with both RCR and TSA is responsible for the lack of differences in PROMIS-UE and -PI scores in these 2 groups.

The reference PROMIS scores reported in this study are similar to data in previous studies examining preoperative PROMIS scores in shoulder surgery patients. A prior study examining 62 patients with preoperative and postoperative PROMIS scores following TSA reported similar PROMIS-PI (61.2) and PROMIS-D (49.7) scores to those in our study (63.9 and 50.3, respectively).[4] Patterson et al[20] examined preoperative PROMIS scores in 164 RCR patients and reported a slightly higher average PROMIS-UE score (34) than in our study (29.9). In a study examining the effect of workers' compensation status on preoperative PROMIS-UE scores in RCR patients, average scores of 29.3 and 32.4 were found in workers' compensation and non–workers' compensation patients, respectively.[2] Our study serves to further validate the aforementioned studies and expands on existing literature as our study analyzed larger cohort samples than previously analyzed.

This study has multiple limitations that warrant consideration. The first is due to the retrospective nature of the study. A prospective study would have been ideal, with an appropriate a priori power analysis that would allow more definitive conclusions to be made about statistical differences between comparison groups. However, given the relative paucity of literature on reference PROMIS scores, these data still provide valuable information. The second limitation is that this analysis only compared 4 diagnostic groups (OA, CTA, RCT, and LR). Ideally, there would have been more diagnostic groups for comparison; however, these new data contribute additional insight and provide a solid foundation for future studies to analyze additional shoulder diagnoses. Moreover, the scope of this study was intentionally narrow. The goal was to examine preoperative differences specifically in shoulder surgery patients. Thus, the results of this study apply only to patients with shoulder pathologies that require surgical management. The aforementioned findings may not extend to patients with surgical problems involving other anatomic locations. Similarly, the shoulder is a complex joint with many potential surgical interventions. This study only examined 3 specific shoulder surgical procedures, and the findings may not be applicable to patients with different shoulder pathologies. Data were collected at only 2 different health care practices. This potentially limits the generalizability of our study to the general population. However, each of these practices cares for patients across multiple cities and regional geographies.

Conclusion

This study used the largest sample size to date to establish reference preoperative PROMIS scores for 3 common shoulder surgical procedures. Patients undergoing shoulder LR had higher preoperative function scores and lower pain interference and depression scores than those undergoing TSA and RCR. These baseline PROMIS scores should be taken into consideration when tracking a patient's outcomes after surgery, as a certain score could mean drastically different functional and pain outcomes depending on the underlying pathology.

Disclaimer

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