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Patient-Reported Outcomes Measurements Information System (PROMIS) upper extremity and pain interference do not significantly predict rotator cuff tear dimensions

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Background: Proper diagnosis of rotator cuff tears is typically established with magnetic resonance imaging (MRI); however, studies show that MRI-derived measurements of tear severity may not align with patient-reported pain and shoulder function. The purpose of this study is to investigate the capacity for the Patient-reported Outcomes Measurements Information System (PROMIS) computer adaptive tests to predict rotator cuff tear severity by correlating preoperative tear morphology observed on MRI with PROMIS upper extremity (UE) and pain interference (PI) scores. This is the first study to investigate the relationship between tear characteristics and preoperative patient-reported symptoms using PROMIS. Considering the essential roles MRI and patient-reported outcomes play in the management of rotator cuff tears, the findings of this study have important implications for both treatment planning and outcome reporting.

Methods: Two PROMIS—computer adaptive test forms (PROMIS-UE and PROMIS-PI) were provided to all patients undergoing rotator cuff repair by one of three fellowship-trained surgeons at a single institution. Demographic information including age, sex, race, employment status, body mass index, smoking status, zip code, and preoperative PROMIS-UE and -PI scores was prospectively recorded. A retrospective chart review of small to large full- or partial-thickness rotator cuff tears between May 1, 2017 and February 27, 2019 was used to collect each patient's MRI-derived tear dimensions and determine tendon involvement.

Results: Our cohort consisted of 180 patients (56.7% male, 43.3% female) with an average age of 58.9 years (standard deviation, 9.0). There was no significant difference in PROMIS-UE or -PI scores based on which rotator cuff tendons were involved in the tear ($P > .05$). Neither PROMIS-UE nor PROMIS-PI significantly correlated with tear length or retraction length of the supraspinatus tendon ($P > .05$). The sum of tear lengths in the anterior-posterior and medial-lateral directions was weakly correlated with PROMIS-UE ($P = .042$; $r = -0.152$, $r^2 = 0.031$) and PROMIS-PI ($P = .027$; $r = 0.165$, $r^2 = 0.012$).

Conclusion: Rotator cuff tear severity does not significantly relate to preoperative PROMIS-UE and -PI scores. This finding underscores the importance of obtaining a balanced preoperative assessment of rotator cuff tears that acknowledges the inconsistent relationship between rotator cuff tear characteristics observed on MRI and patient-reported pain and physical function.

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Rotator cuff tears are a common cause of shoulder pain and disability, resulting in millions of clinic visits and hundreds of thousands of surgeries each year.[10] The diagnosis and management of rotator cuff tears is based on both a clinical evaluation of tear severity, which typically includes measures such as in-office functional testing and shoulder imaging, and the patient's self-assessment of their injury. Patient-reported outcome (PRO) measures for the upper extremity (UE) are survey-based tools used to quantify the patient's perspective, allowing clinicians to track subjective shoulder function and pain levels over time.[4] For patients with rotator cuff tears, the relationship between tear severity and patient-reported pain and disability is complex and variable.

Magnetic resonance imaging (MRI) is a commonly used imaging modality for the preoperative evaluation of rotator cuff tears that

Henry Ford Health System Institutional Review Board Committee approved this study (no. 13895).

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measures tear severity based on observable characteristics, such as tear size, number of torn tendons, and length of tendon retraction.[9,13] However, MRI-based measurements of tear severity do not always align with patient-reported pain and function.[2,6,7,16] Dunn et al demonstrated that length of rotator cuff tear did not correlate with pain in patients with chronic, full-thickness rotator cuff tears.[2] Furthermore, many patients with rotator cuff tears are asymptomatic[8,11,14,17] with half of all tears in individuals over the age of 50 years and two-thirds of tears over the age of 60 years being asymptomatic.[8] In addition to pain, tear severity has been shown to inconsistently correlate with patient-reported shoulder function.[6,7,16] This finding has been demonstrated for a number of PROs used to assess UE function, including the American Shoulder and Elbow Surgeons score, the Western Ontario Rotator Cuff (WORC) index, and the Simple Shoulder Test (SST).[6,7,16]

The Patient-reported Outcomes Measurement Information System (PROMIS) computer adaptive test (CAT) is a relatively new addition to the collection of available PROs, but has quickly demonstrated its potential for evaluating shoulder pathology, proving to have increased reliability, precision, and efficiency compared with existing PROs for the UE.[1,3] To our knowledge, no study has investigated the capacity of PROMIS-CAT to predict objective measures of tear severity. Therefore, the purpose of this study is to elucidate the relationship between tear characteristics observed on MRI and PROMIS-UE and pain interference (PI) scores in patients before undergoing rotator cuff repair. Considering the essential role MRI and PROs play in the management of rotator cuff tears, the findings of this study have important implications for both treatment planning and outcome reporting.

We expect PROMIS-CAT, like other PROs for the UE, to be a poor predictor of MRI-derived rotator cuff tear characteristics. More specifically, we hypothesize that tear size, length of tendon retraction, and which specific tendons were involved in the tear will not significantly correlate with PROMIS-UE and -PI scores.

Materials and methods

Study design

This study was approved by the Henry Ford Health System institutional review board (#11361) and was compliant with the Health Insurance Portability and Accountability Act. Patients indicated for rotator cuff repair were prospectively and consecutively enrolled into a medical registry. All patients were assessed at a single institution by one of three board-certified, fellowship-trained orthopedic surgeons (two sports medicine surgeons and one shoulder and elbow surgeon). A retrospective chart review of small to large full- or partial-thickness rotator cuff tears between May 1, 2017 and February 27, 2019 was used to collect each patient's MRI-derived tear characteristics. Patients were included if they were indicated for surgical repair of their rotator cuff tear (Common Procedural Terminology [CPT] 29827), their tear involved the supraspinatus tendon, they completed at least 1 PROMIS CAT domain (within 1 year before surgery for preoperative patients), and they had a preoperative MRI of the affected shoulder. Patients less than 18 years of age, those with a previous shoulder surgery on the same side, and those without a tear of the supraspinatus tendon were excluded. Of the 399 patients who were indicated for surgical repair of the rotator cuff between May 1, 2017 and February 27, 2019, 180 met inclusion criteria.

Patient evaluation

Demographic information and preoperative PROMIS-UE and -PI scores were prospectively recorded using an iPad (iPad tablet; Apple Inc., Cupertino, CA, USA). All patient demographic information and PROMIS scores were collected using Research Electronic Data Capture (REDCap, Vanderbilt University, Nashville, TN, USA), an Health Insurance Portability and Accountability Act (HIPAA)-compliant data collection application. Demographics collected included the following: age, sex, race, employment status, body mass index, smoking status, and zip code. Following previously published methods,[4,5] the zip code was used to determine median household income with data from the 2019 United States Census Bureau: (https://data.census.gov/cedsci/map?q=michigan%20median%20income&t=Income%20%28Households,%20Families,%20Individuals%29&tid=ACSST1Y2019.S1901&hidePreview=false&vintage=2019&layer=VT_2019_860_00_PY_D1&cid=S1901_C01_001E&palette=Teal&break=5&classification=Natural%20Breaks&mode=thematic).

PROMIS is scored using a reference population as the standard T-score of 50, with a standard deviation (SD) of 10.[12] Each patient completed the PROMIS Upper Extremity Physical Function–CAT, version 2.0, (PROMIS-UE) and Pain Interference–CAT, version 1.1, (PROMIS-PI). A higher PROMIS-UE score denotes higher physical function of the UE, whereas higher PROMIS-PI signifies greater pain burden.

MRI was interpreted at the same institution as the surgeons by board-certified radiologists or radiology residents whose interpretations were attested by board-certified radiologists. Tear dimensions were evaluated for anterior-posterior (AP) and medial-lateral (ML) tear length, retraction length (RE), and number of tendons involved in the tear. Tear size and RE were recorded in millimeters. Number of rotator cuff tendons involved in the tear was determined at the discretion of the radiologist and was defined as any tendon with a tear in it, regardless of whether it was the primary tear. This definition resulted in four tendon tear combinations: supraspinatus alone, supraspinatus and infraspinatus, supraspinatus and subscapularis, and involvement of all three. The tear sum was calculated by adding the AP and ML tear length: AP + ML.

Statistical methods

An in-house statistician using SAS 9.4 (SAS Institute Inc., Cary, NC, USA) conducted all statistical analyses. Significance was set at $P < .05$. Categorical variables were reported as frequency and percentages. Descriptive statistics were used to analyze continuous variables (median with range when not normally distributed and mean ± SD when normally distributed). Normality was assessed using the Shapiro-Wilk test. Spearman's rank correlation coefficient was used to describe the relationship between two continuous variables when normality was violated. Coefficients and significance are reported. When comparing more than two groups, analysis of variance was used with a post hoc Tukey test for significance between groups.

Results

Between May 1, 2017 and February 27, 2019, 399 consecutive patients indicated for surgical repair of the rotator cuff were entered into the medical registry REDCap. After applying inclusion and exclusion criteria, our cohort consisted of 180 patients with supraspinatus tears. All patients participating in this study were indicated for and underwent surgical repair of the rotator cuff. Patient information is presented in Table I. The cohort consisted of 102 (56.7%) men and 78 (43.3%) women. Of these, 117 (65%) were right-sided tears and 63 (35%) were left-sided tears; 100 (55.6%) were right-sided complete tears, 61 (33.9%) were left-sided complete tears, 17 (9.4%) were right-sided partial tears, and 2 (1.1%)

Table I
Cohort information reported as means, medians, ranges, standard deviations, and percentages where applicable.

Variable	Males	Females
Number of patients (%)	102 (56.7%)	78 (43.3%)
Mean age in years (SD)	59.1 (8.9)	58.7 (9.1)
Affected side (right:left)	63:39	54:24
Race (%)		
Caucasian	72 (70.6)	43 (55.1)
African-American	17 (16.7)	31 (39.8)
Other	13 (12.7)	4 (5.1)
Thickness (full:partial)	90:13	72:6
Tear location (%)		
Supraspinatus alone	46 (45.1)	41 (52.6)
Supraspinatus + infraspinatus	21 (20.6)	18 (23.1)
Supraspinatus + subscapularis	20 (19.6)	9 (11.5)
Supraspinatus + infraspinatus + subscapularis	15 (14.7)	10 (12.8)
Additional diagnoses (%)		
Impingement	90 (88.2)	62 (79.5)
Bicipital tendinitis	10 (9.8)	13 (16.7)
Acromioclavicular arthritis	6 (5.9)	9 (11.5)
BMI (SD)	30.5 (5.8)	31.6 (6.6)
Smoking (%)		
Never	66 (64.7)	52 (66.7)
Former	29 (28.4)	24 (30.8)
Current	7 (6.9)	2 (2.5)
Employment (%)		
Employed	62 (60.8)	46 (59.0)
Unemployed	3 (2.9)	6 (7.7)
Retired	17 (16.7)	16 (20.5)
Other	17 (16.7)	10 (12.8)
Unknown	3 (2.9)	0 (0)
Median household income (range)	$797,411 (27,337-147,180)	$58,161.0 (23,169-147,180)
Surgeon (%)		
SM	14 (13.7)	7 (9.0)
EM	35 (34.3)	30 (38.5)
VM	53 (52.0)	41 (52.6)

SD, standard deviation; *BMI*, body mass index.

were left-sided partial tears. Eighty-seven (48.3%) of the tears involved the supraspinatus alone, 39 (21.7%) involved the supraspinatus and infraspinatus, 29 (21.7%) involved the supraspinatus and subscapularis, and 25 (13.9%) involved all three tendons. Many patients in our cohort had other shoulder pathologies in addition to rotator cuff tear. These included 152 (84.4%) cases of impingement, 23 (12.8%) cases of bicipital tendinitis, and 15 (8.3%) cases of acromioclavicular joint arthritis. The average body mass index was calculated to be 31.0 kg/m^2 (SD 6.2). Regarding smoking status, 118 (65.6%) patients never smoked, 53 (29.4%) were former smokers, and 9 (5.0%) were current smokers. One hundred eight (60.0%) patients were employed, 9 (5.0%) were unemployed, 33 (18.3%) were retired, 27 (15.0%) belonged to other category, and 3 (1.7%) had an unknown employment status. The average median household income for our cohort was $73,530 (SD $29,401). Of the three surgeons who participated in this study, SM assessed 21 (11.7%) cases, EM assessed 65 (36.1%) cases, and VM assessed 94 (52.2%) cases.

For all groups, the median AP and ML tear length was 16.0 mm (range in mm, 0.0 to 50.0) and 13.0 mm (range in mm, 2.0 to 50.0), respectively. The median RE was 24.0 mm (range in mm, 5.5 to 55.0), whereas the median tear length sum was 21.20 mm (range in mm, 3.0 to 100.0). The median PRO measure values are represented in Table II. The median PROMIS-UE and -PI for all groups were 29.20 mm (range in mm, 14.7 to 50.7) and 62.80 mm (range in mm, 50.1 to 77.8), respectively.

Figures 1 and 2 display preoperative PROMIS-UE and -PI scores categorized by which rotator cuff tendons were involved. There was no significant difference detected between any of the groups regarding PROMIS-UE and -PI (P > .05). The four groups of supraspinatus alone, supraspinatus and infraspinatus, supraspinatus and subscapularis, and involvement of all three tendons are further expanded on with median and range values for AP and ML tear length, RE, and tear sum in Table II.

Table III describes the relationship between preoperative PROMIS-UE or -PI scores and supraspinatus tendon tear dimensions. PROMIS-UE and -PI did not significantly correlate with AP and ML tear length or RE of the supraspinatus tendon (P > .05). However, the sum of tear lengths (AP + ML) was weakly correlated with PROMIS-UE (P = .042; r = -0.152, r^2 = 0.031) and -PI (P = .027; r = 0.165, r^2 = 0.012).

Discussion

The objective of this study was to investigate the capacity for PROMIS-CAT to predict rotator cuff tear severity by correlating preoperative tear characteristics observed on MRI with PROMIS-UE and -PI scores. This study found that PROMIS-UE and -PI were not associated with supraspinatus tear length or degree of tendon retraction. Furthermore, there was no significant difference in PROMIS-UE and -PI scores based on which rotator cuff tendons were torn. Although the sum of tear lengths in the AP and ML directions was significantly correlated with PROMIS-UE and -PI, this association was weak. To our knowledge, this is the first study to demonstrate the limitations of PROMIS with regard to predicting rotator cuff tear characteristics measured on preoperative MRI.

The lack of association between tear size and PROMIS-PI is consistent with prior studies investigating how rotator cuff tears relate to shoulder pain. These studies have shown that many rotator cuff tears are asymptomatic[8,11,14,17] and that larger tears are

Table II
Tear dimensions and preoperative PROMIS-UE and PROMIS-PI by tendon involvement reported as medians and ranges.

Measure	All groups	Supraspinatus alone	Supraspinatus + infraspinatus	Supraspinatus + subscapularis	Supraspinatus + infraspinatus + subscapularis
Tear characteristics					
Anterior-posterior tear length (mm)	16.0 (0.0 to 50.0)	14 (0 to 27.0)	25 (0 to 50.0)	12 (2.0 to 25.0)	26 (0 to 50.0)
Medial-lateral tear length (mm)	13.0 (2.0 to 50.0)	12 (2.0 to 30.0)	24 (8.0 to 50.0)	7.5 (2.0 to 21.0)	28 (10.0 to 43.0)
Retraction length (mm)	24.0 (5.50 to 55.0)	14.5 (7.0 to 40.0)	27 (15.0 to 54.0)	19 (15.0 to 35.0)	27.5 (14.0 to 40.0)
Tear length sum (mm)	21.20 (3.0 to 100.0)	19 (3.0 to 55.0)	26 (14.0 to 100.0)	19 (4.0 to 46.0)	30 (12 to 84.0)
PROMIS					
PROMIS-UE	29.20 (14.70 to 50.70)	30.2 (6.1)	30.9 (6.2)	31.5 (6.3)	28.1 (6.4)
PROMIS-PI	62.80 (50.10 to 77.80)	62.3 (5.6)	61.7 (5.4)	62.0 (4.2)	64.1 (4.6)

PROMIS, Patient-reported Outcomes Measurement Information System; *UE*, upper extremity; *PI*, pain interference.

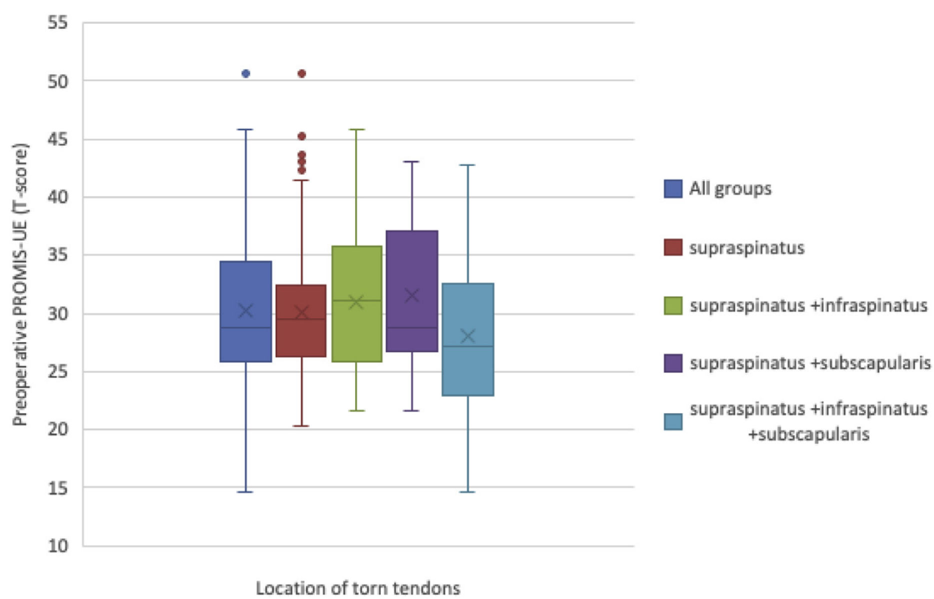

Figure 1 The boxplot of rotator cuff tear tendon involvement and preoperative PROMIS-UE where X denotes the mean and the midline denotes the median. None of the groups were significantly different. *PROMIS*, Patient-reported Outcomes Measurement Information System; *UE*, upper extremity.

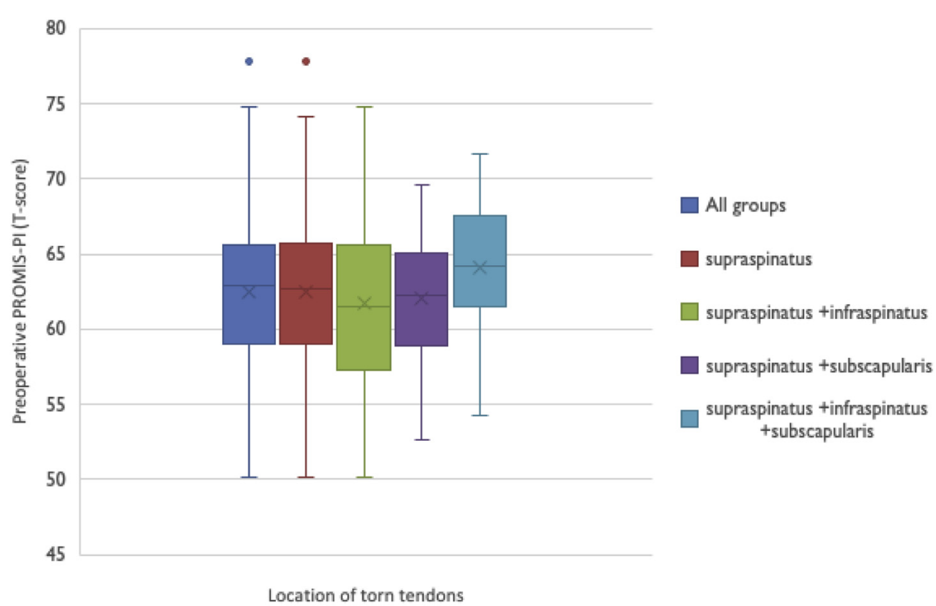

Figure 2 The boxplot of rotator cuff tear tendon involvement and preoperative PROMIS-PI where X denotes the mean and the midline denotes the median. None of the groups were significantly different. *PROMIS*, Patient-reported Outcomes Measurement Information System; *PI*, pain interference.

Table III
Univariate analysis of supraspinatus tendon tear dimensions and preoperative PROMIS.

Outcomes	Preoperative PROMIS-UE			Preoperative PROMIS-PI		
	N	r	*P* value	N	r	*P* value
AP tear length	173	−0.114	.134	173	0.122	.110
ML tear length	90	−0.202	.056	90	0.083	.436
Retraction length	94	0.107	.307	94	−0.013	.902
Tear sum	180	−0.152	.042*	180	0.165	.027*

PROMIS, Patient-reported Outcomes Measurement Information System; *UE*, upper extremity; *PI*, pain interference; *AP*, anterior-posterior; *ML*, medial-lateral.
Tear sum was significantly correlated with PROMIS-UE and -PI.
*Indicates statistical significance ($P < .05$).

not necessarily more painful.[2,16] Dunn et al found no association between several measures of rotator cuff tear severity (tendons involved, amount of retraction, presence of humeral head migration, and amount of fatty infiltration of the supraspinatus) and visual analog scale (VAS) pain scores. However, greater pain was associated with several patient factors, such as education level, race, and number of comorbidities.[2] Another study found that VAS for shoulder pain correlated with mental health assessed using the Short Form-36 Mental Component Summary, but not tendon retraction, tear area, or number of tendons torn.[16] In summary, shoulder pain from rotator cuff tears does not appear to follow a clear relationship with tear severity and is likely influenced by many nonanatomical factors, including mental health and patient demographics.

Although this is the first study to investigate the association between tear size and preoperative patient-reported physical function using PROMIS-UE, several studies have previously examined this relationship using other PROs for the UE. In a cohort of 389 patients with atraumatic, symptomatic, full-thickness rotator cuff tears, Harris et al demonstrated that tear size was not associated with the WORC score, except when comparing isolated supraspinatus tears with large tears involving the supraspinatus, infraspinatus, and subscapularis tendons.[7] Similarly, Gibson et al found no significant difference in the WORC score between tear severity categories based on tear thickness and number of tears.[6] Wylie et al found weak correlations between VAS function and tear size and length of tendon retraction and a strong correlation with number of tendons torn. However, the American Shoulder and Elbow Surgeons score and SST were not correlated with tear size or number of tendons torn, and only the SST was correlated with length of tendon retraction.[16] These findings suggest that no individual or combination of tear characteristics can be used to accurately infer how a patient perceives their level of disability.

PROs, including PROMIS, are tools with several inherent features that may make drawing comparisons between tear size and patient-reported function difficult. A single, distilled score from any PRO may not be specific or detailed enough to represent a 3-dimensional tear within a joint as complex as the shoulder. Using the PROMIS as an example, a patient with a full-thickness tear of the subscapularis may report significant disability with internal rotation of the humerus and ultimately score 40 on PROMIS-UE. Another patient may have generalized disability involving several rotator cuff tendons and also have a PROMIS-UE score of 40. Furthermore, certain question and answer combinations—or certain specific patient scenarios—may offer more reliable predictive power in the diagnosis of complex joint pathologies.

Our results suggest that rotator cuff tear dimensions and the extent of rotator cuff tendon involvement should be considered in the context of patient history, preference, and perceived disability when selecting treatment options as these rotator cuff tear characteristics do not significantly relate to patient-reported pain and physical function. MRI can and should be used for diagnosis and the preoperative planning of surgical intervention. However, findings on MRI such as tear size or tendon involvement should not be used as indicators for surgery with the assumption that the patient is more physically debilitated or has more pain. The findings of this study underscore the importance of obtaining a balanced assessment of rotator cuff tears that acknowledges the inconsistent relationship between imaging findings and the subjective patient experience.

This study has limitations. Tear size on MRI was determined by several different radiologists at multiple locations within the same hospital system. This may result in variability within the measured tear sizes and REs. In addition, patients were recruited from a single metropolitan area which may limit the generalizability of these data to other patient populations. Finally, this study did not include patients who had a rotator cuff tear, but were not indicated for surgery. Patients indicated for surgery have typically already failed nonoperative measures, such as physical therapy, nonsteroidal anti-inflammatory medications, and injections.[15] Therefore, our findings cannot be applied to patients who are managed with conservative treatment alone. Currently, we are unaware of any study that has examined the relationship between rotator cuff tear characteristics and PROs and stratified patients based on whether they were managed conservatively or with surgery. This is a potential direction for future research.

Conclusion

PROMIS-UE and -PI scores do not significantly correlate with tear size, supraspinatus tendon retraction, or extent of rotator cuff tendon involvement in patients indicated for rotator cuff repair. MRI is an effective tool for evaluating rotator cuff tears and determining tear severity. However, it is important to recognize that imaging findings may not relate to the subjective experience of our patients regarding pain and shoulder function.

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References

1. Doring AC, Nota SP, Hageman MG, Ring DC. Measurement of upper extremity disability using the patient-reported outcomes measurement information System. J Hand Surg Am 2014;39:1160-5. https://doi.org/10.1016/j.jhsa.2014.03.013.

2. Dunn WR, Kuhn JE, Sanders R, An Q, Baumgarten KM, Bishop JY, et al. Symptoms of pain do not correlate with rotator cuff tear severity: a cross-sectional study of 393 patients with a symptomatic atraumatic full-thickness rotator cuff tear. J Bone Joint Surg Am 2014;96:793-800. https://doi.org/10.2106/JBJS.L.01304.
3. Fidai MS, Saltzman BM, Meta F, Lizzio VA, Stephens JP, Bozic KJ, et al. Patient-reported outcomes measurement information System and Legacy patient-reported outcome measures in the Field of Orthopaedics: a Systematic review. Arthroscopy 2018;34:605-14. https://doi.org/10.1016/j.arthro.2017.07.030.
4. Fisk F, Franovic S, Tramer JS, Gulledge C, Kuhlmann NA, Chen C, et al. PROMIS CAT forms demonstrate responsiveness in patients following arthroscopic rotator cuff repair across numerous health domains. J Shoulder Elbow Surg 2019;28:2427-32. https://doi.org/10.1016/j.jse.2019.04.055.
5. Franovic S, Kuhlmann N, Schlosser C, Pietroski A, Buchta AG, Muh SJ. Role of preoperative PROMIS scores in predicting postoperative outcomes and likelihood of achieving MCID following reverse shoulder arthroplasty. Semin Arthroplasty 2020;30:154-61. https://doi.org/10.1053/j.sart.2020.05.008.
6. Gibson E, LeBlanc J, Sabo MT. Intersection of catastrophizing, gender, and disease severity in preoperative rotator cuff surgical patients: a cross-sectional study. J Shoulder Elbow Surg 2019;28:2284-9. https://doi.org/10.1016/j.jse.2019.05.014.
7. Harris JD, Pedroza A, Jones GL, Group MS. Predictors of pain and function in patients with symptomatic, atraumatic full-thickness rotator cuff tears: a time-zero analysis of a prospective patient cohort enrolled in a structured physical therapy program. Am J Sports Med 2012;40:359-66. https://doi.org/10.1177/0363546511426003.
8. Minagawa H, Yamamoto N, Abe H, Fukuda M, Seki N, Kikuchi K, 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. https://doi.org/10.1016/j.jor.2013.01.008.
9. Naqvi GA, Jadaan M, Harrington P. Accuracy of ultrasonography and magnetic resonance imaging for detection of full thickness rotator cuff tears. Int J Shoulder Surg 2009;3:94-7. https://doi.org/10.4103/0973-6042.63218.
10. Rahman H, Currier E, Johnson M, Goding R, Johnson AW, Kersh ME. Primary and Secondary Consequences of rotator cuff injury on joint Stabilizing Tissues in the shoulder. J Biomech Eng 2017;139. https://doi.org/10.1115/1.4037917.
11. Reilly P, Macleod I, Macfarlane R, Windley J, Emery RJ. Dead men and radiologists don't lie: a review of cadaveric and radiological studies of rotator cuff tear prevalence. Ann R Coll Surg Engl 2006;88:116-21. https://doi.org/10.1308/003588406X94968.
12. Rothrock NE, Amtmann D, Cook KF. Development and validation of an interpretive guide for PROMIS scores. J Patient Rep Outcomes 2020;4:16. https://doi.org/10.1186/s41687-020-0181-7.
13. Rutten MJ, Spaargaren GJ, van Loon T, de Waal Malefijt MC, Kiemeney LA, Jager GJ. Detection of rotator cuff tears: the value of MRI following ultrasound. Eur Radiol 2010;20:450-7. https://doi.org/10.1007/s00330-009-1561-9.
14. 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;77:10-5.
15. Wolf BR, Dunn WR, Wright RW. Indications for repair of full-thickness rotator cuff tears. Am J Sports Med 2007;35:1007-16. https://doi.org/10.1177/0363546506295079.
16. 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;98:251-6. https://doi.org/10.2106/JBJS.O.00444.
17. Yamaguchi K, Tetro AM, Blam O, Evanoff BA, Teefey SA, Middleton WD. Natural history of asymptomatic rotator cuff tears: a longitudinal analysis of asymptomatic tears detected sonographically. J Shoulder Elbow Surg 2001;10:199-203.