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Purpose: To determine the influence of preoperative opioid use on Patient-Reported Outcomes Measurement Information System (PROMIS) scores pre- and postoperatively in patients undergoing arthroscopic rotator cuff repair (RCR). **Methods:** A retrospective review of all RCR patients aged >18 years old was performed. PROMIS pain interference ("PROMIS PI"), upper extremity function ("PROMIS UE"), and depression ("PROMIS D") scores, were reviewed. These measures were collected at preoperative, 6-month, and 1-year postoperative time points. A prescription drug—monitoring program was queried to track opioid prescriptions. Patients were categorized as chronic users, acute users, and nonusers based on prescriptions filled. Comparison of means were carried out using analysis of variance and least squares means. Effect sizes and 95% confidence intervals were calculated. **Results:** In total, 184 patients who underwent RCR were included. Preoperatively, nonusers (n = 92) had superior PROMIS UE (30.6 vs 28.9 vs 26.1; $P < .05$) and PI scores (61.5 vs 64.9 vs 65.3; $P < .001$) compared with acute users (n = 65) and chronic users (n = 27), respectively. At 6 months postoperatively; nonusers demonstrated significantly greater PROMIS UE (41.7 vs 35.6 vs. 33.5; $P < .001$), lower PROMIS D (41.6 vs 45.8 vs 51.1; $P < .001$), and lower PROMIS PI scores (50.7 vs 56.3 vs 58.1; $P < .01$) when compared with acute and chronic users, respectively. Nonusers had lower PROMIS PI (47.9 vs 54.3 vs 57.4; $P < .0001$) and PROMIS D (41.6 vs 48.3 vs 49.2; $P = .0002$) scores compared with acute and chronic users at 1-year postoperatively. Nonusers experienced a significantly greater magnitude of improvement in PROMIS D 6 months postoperatively compared with chronic opioid users (−5.9 vs 0.0; $P < .01$). **Conclusions:** Patients undergoing RCR demonstrated superior PROMIS scores pre- and postoperatively if they did not use opioids within 3 months before surgery. **Level of Evidence:** III, retrospective comparative trial.

Managing pain is an important dilemma that providers face, as patient-reported pain on a numeric scale has become a fifth vital sign in patient care.[1] Over the past several decades, Americans have found themselves in an opioid epidemic, with increasing rates of opioid prescriptions, overdose, and accidental death secondary to overdose.[2,3] Nevertheless, opioids are an important aspect to postoperative pain management following musculoskeletal surgery, leaving orthopaedic surgeons responsible for a large number of nationwide prescriptions, which has caught the attention of government legislation.[4,5] With increasing rates of orthopaedic surgeries performed, orthopaedic surgeons have a unique opportunity to find alternative regimens and reducing the societal impact of opioid prescriptions.[6-12] This must strike a

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delicate balance with maintaining patient satisfaction following surgery, however, which has been shown to be intricately related to pain control.[7,13-16]

Pain control, through means of opioid consumption, also has been shown to directly affect patient outcomes following elective procedures in a dose-dependent manner,[17,18] with preoperative opioid use correlating to poor outcomes following elective spine, arthroplasty, and sports medicine orthopaedic surgeries.[19-24] Traditionally, surgical outcomes were assessed using a variety of patient-reported outcome measures that were restricted to certain patient populations and conditions to evaluate the response to specific interventions, limiting the ability of providers to compare these tools in a standardized fashion.[25-28] The Patient-Reported Outcomes Measurement Information System (PROMIS) is a contemporary platform using computerized adaptive testing (CAT) to collect patient outcomes, creating a uniform and standardizable metric. A number of these domains, such as physical function, mental health, and interference of function due to pain, are important predictors of patient outcomes.[29-31] This exciting development has enabled standardized comparisons across patient populations and surgical interventions to evaluate the impact of preoperative patient characteristics on postoperative surgical outcomes using PROMIS scales.[31-37]

Despite several investigations, which have validated the use of PROMIS in patients with shoulder pathology, there remains a paucity of literature examining the impact of preoperative opioid use on postoperative outcomes as assessed by PROMIS outcome measures.[36-40] Rotator cuff tears (RCTs) and subsequent recovery following rotator cuff repair (RCR) can cause significant pain, which traditionally have been treated with strong analgesics in the preoperative and immediate postoperative periods.[41-44] Beyond pain and function, there is also a significant relationship between anxiety/depression and rotator cuff repair outcomes.[45-47] However, the relationship of opioid analgesics on pain, function, and mood as measured by PROMIS scores in patients undergoing RCRs is yet to be well-defined. Although previous studies illustrate greater opioid use in patients with comorbid depression/anxiety who undergo RCR, there is a paucity of literature that examines the relationship of opioid use to mood scores in a quantitative manner.[48] The purpose of this study is to determine the influence of preoperative opioid use on PROMIS scores pre- and postoperatively in patients undergoing arthroscopic RCR. It was hypothesized that patients who are taking opioids before RCR would have worse postoperative patient-reported outcomes.

Methods

A retrospective review of patients aged >18 years of age with symptomatic RCT was completed. In this institutional review board-approved study (#14235; Henry Ford Hospital), patients who underwent primary arthroscopic RCR performed by 1 of 3 fellowship trained orthopaedic surgeons, affiliated with a single integrated health system, were included in this study. Patients with concomitant fractures, labral pathology, previous shoulder surgery, isolated subacromial decompression, unable or unwilling to complete PROMIS questionnaires, and records not retrievable from the statewide prescription drug—monitoring program (PDMP) were excluded. Once these patients were identified, date of surgery, date of preoperative PROMIS CAT form completion, date of postoperative PROMIS CAT form completion, and respective PROMIS PI, PROMIS UE, and PROMIS D scores were recorded. In addition, demographic data, including sex, age, race, ethnicity, body mass index, zip code, and smoking status were retrospectively collected from each patient's electronic medical record.

Preoperative narcotic use was confirmed by reviewing patient opioid prescription records within the statewide PDMP. This program verifies each prescription that was filled by the patient at a pharmacy, thereby serving as a more accurate surrogate of opioid use than previous studies based off prescriptions in the electronic medical record.[19,20] Patients were categorized based on their opioid prescription—filling practices before surgery.[19,49] Chronic users were defined as patients who had opioid prescriptions filled for greater than 30 days during the 3-month period before surgery (n = 27). Acute users were defined as patients who had a single opioid prescription filled within the 3 months before surgery, but not for a duration of greater than 30 consecutive days (n = 65). Finally, a nonuser was defined as a patient without any opioid prescription within the 3 months before surgery (n = 92). Additional data, including the quantity prescribed in the 3-month preoperative period, total number of days with an opioid prescription in the 3-month preoperative period, average daily dose measured in morphine milligram equivalents (MMEs), number of opioid prescriptions in the 3-month preoperative period, number of opioid prescriptions in the 1-month preoperative period, number of prescribers in the 3-month preoperative period, and number of prescribers in the 1-month preoperative period were also collected for each patient using the PDMP.

The Research Electronic Data Capture (REDCap) platform, a secure, web-based application system, was used to prospectively collect patient-reported outcomes.[50] Patient-reported outcomes were measured using PROMIS CAT forms, which were completed by patients undergoing RCR on a tablet computer during each preoperative and postoperative office visit. PROMIS pain interference (PROMIS PI), physical function upper extremity (PROMIS UE), and depression (PROMIS D) scores were collected during the

Table 1. Demographic Information

	Opioid Nonusers (N = 92)	Acute Opioid Users (N = 65)	Chronic Opioid Users (N = 27)	*P* Value
Sex				
Male	51 (55%)	38 (58%)	10 (37%)	.1557
Female	41 (45%)	27 (42%)	17 (63%)	
Age, N	92	65	27	.0802
Mean (SD)	60.2 (9.07)	57.0 (8.87)	58.6 (7.24)	
BMI, N	92	65	27	**.0125**
Mean (SD)	30.0 (4.94)	32.4 (6.02)	32.6 (6.62)	
Smoking status				
Never	51 (55%)	24 (37%)	7 (26%)	.0651
Current	10 (11%)	11 (17%)	3 (11%)	
Former	28 (30%)	26 (40%)	14 (52%)	
Unknown	3 (3%)	4 (6%)	3 (11%)	
Race				
White	61 (66%)	36 (55%)	11 (41%)	.0575
Black	18 (20%)	21 (32%)	13 (48%)	
Asian	3 (3%)	4 (6%)	0 (0%)	
Other	10 (11%)	4 (6%)	3 (11%)	

NOTE. *P* value significance at .05. Bold values denote statistically significant finding.

BMI, body mass index; SD, standard deviation.

preoperative, 6-month postoperative, and 1-year postoperative office visits. These PROMIS assessments have been shown to be relevant measures of rotator cuff pain and function.[36,51-54] The PROMIS CAT algorithm produces standardized T-scores based on normative U.S. population data (mean scores of 50 and standard deviations of 10). Greater PROMIS UE scores represent increased functional ability, greater PROMIS PI scores represent increased pain that interferes with daily activities, and greater PROMIS D scores represent greater levels of depression.[55]

Statistical Analysis

All continuous data are reported as mean ± standard deviation, whereas categorical data are reported as counts and column percentages (N [%]). For continuous variables, analysis of variance was used to detect differences in outcome scores among the 4 user groups. Pairwise comparisons among the user groups were accomplished using least-squares means. Univariate 2-group comparisons between acute users and chronic users for opioid data were analyzed using independent 2 sample *t*-tests for normally distributed variables and Wilcoxon signed rank tests for non-normally distributed variables. A priori power analysis was not performed given the retrospective nature of data collection being limited to data already present. Therefore, to improve clarity on the validity of data, the magnitude of change in PROMIS scores between time points and the respective effect sizes (Cohen's *d*) and 95% confidence intervals were calculated. Minimal clinically important difference (MCID) was identified using a distribution-based method (1/2 the standard deviation), and the percentage of patients that achieved MCID was calculated per study group and outcome measure.[56] Statistical significance was set at $P < .05$, and all tests were 2-sided. All analyses are performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

Results

A total of 184 patients were identified within the electronic medical record who underwent RCR between July 2017 and January 2020 and who had completed PROMIS PI, PROMIS UE, and PROMIS D forms preoperatively and 6 months' postoperatively. Of the 184 patients, 129 patients who underwent RCR also were found to have completed PROMIS forms around the 1-year postoperative period. Of the 184 patients, 92 were categorized as opioid nonusers, 65 as acute opioid users, and 27 as chronic opioid users. An even distribution of male and female patients was observed, with 99 (54%) males and 85 (46%) females. Opioid nonusers had lower body mass index compared with acute and chronic opioid users (30.0 vs 32.4 vs 32.6; $P = .013$). Other demographic findings were not statistically significant (Table 1). When we compared the prescription data, chronic opioid users had a significantly greater number of prescriptions written, number of days prescribed, and number of prescribers during the 3-month preoperative period (Table 2).

PROMIS scores were collected at similar time intervals (preoperative, 6-month, 1-year) across the 3 groups (Table 3). Table 4 compares preoperative and postoperative PROMIS scores between opioid users. Preoperative function (PROMIS UE) was observed to be the lowest in chronic opioid users and highest in nonusers ($P < .001$). Interference in daily activities attributed to pain preoperatively (PROMIS PI) was found to be the highest in chronic opioid users and lowest in nonusers ($P < .001$). At the 6-month postoperative timepoint, nonusers displayed significantly superior PROMIS UE, PROMIS PI, and PROMIS D scores compared with opioid users ($P < .05$). Moreover, chronic users failed to improve in the PROMIS D domain 6 months after surgery. At 1-year postoperatively, significantly superior scores across all PROMIS measures were observed in nonusers compared to chronic users (Table 4).

The magnitude of change in PROMIS scores between preoperative and postoperative time points are illustrated in Figure 1. The 95% confidence intervals of the effect sizes are demonstrated in Figure 2. At 6 months postoperatively, opioid nonusers, compared with chronic opioid users, experienced a significantly greater magnitude of improvement in PROMIS D (−5.9 vs 0.0; $P < .01$), but only approached significance in PROMIS PI and UE scores ($P < .07$). Moreover, at the 1-year postoperative mark, there was no significant difference between the magnitudes of change in the PROMIS

Table 2. Narcotic Prescription Data

	Acute Opioid Users (N = 65)	Chronic Opioid Users (N = 27)	*P* Value
Number of days prescribed in 3-month period	10.6 ± 7.6	76.2 ± 38.1	**<.001**
Daily dose in MME	23.8 ± 14.8	26.0 ± 20.5	**.618**
Number of prescriptions in 3-month preoperative period	1.4 ± 0.7	3.6 ± 1.8	**<.001**
Number of prescriptions in 1-month preoperative period	0.4 ± 0.6	1.3 ± 1.0	**<.001**
Number of prescribers in 3-month preoperative period	1.2 ± 0.5	1.7 ± 0.9	**.009**
Number of prescribers in 1-month preoperative period	0.4 ± 0.5	0.9 ± 0.7	**.002**

NOTE. *P* value significance at .05. Bold values denote statistically significant finding.
MME, morphine milliequivalent.

UE scores relative to preoperative scores among the three study groups (Fig 1). However, the magnitude of improvement in PROMIS PI scores between non-users and chronic users at 1 year was significantly greater, as was the improvement in PROMIS D scores between nonusers and acute users. When looking at the percentage of patients that achieved MCID at final follow-up, 78%, 80%, and 47% of nonusers achieved MCID for PROMIS UE, PI and D, respectively. In comparison, achievement of MCID was similar for acute users (79%, 85%, 39%, respectively), but lower for chronic users (67%, 50%, 28%, respectively).

Discussion

In the current study of patients undergoing arthroscopic RCRs, the results demonstrate that patients who did not use opioids preoperatively reported significantly greater function and reduced pain and depression scores at 6-months and 1-year postoperatively compared with chronic users. It is also important to note that both acute and chronic opioid users began at lower preoperative function scores and greater pain interference scores than nonusers.

Chronic opioid use in this study is associated with lower functional scores and higher pain interference scores. This is true for the 6-month and 1-year time points. These results echo previous findings in various orthopaedic literature such as lumbar spine surgery, knee surgery, hip arthroplasty, and even shoulder arthroscopy.[57-60] In a similar, prospectively collected data review, Morris et al.[61] found that patients requiring preoperative opioids demonstrated significantly lower preoperative baseline and final patient-reported outcome scores after anatomic total shoulder arthroplasty. Williams et al.[62] demonstrated that patients undergoing arthroscopic RCR who received preoperative opioids had inferior preoperative and postoperative patient-reported outcomes scores, similar to the present investigation. However, both of these studies relied on patient self-reporting "yes or no" to preoperative opioid use, rather than quantifying the amount and duration of preoperative opioid use based on PDMP prescription data. Therefore, the data analysis in the current study further strengthens previous findings that preoperative opioid use can negatively influence levels of pain and function postoperatively.

This study also demonstrated that opioid nonusers had significantly greater magnitude of improvement in functional scores (PROMIS UE) compared with acute opioid users, but this difference is not found at 1 year. This in part may be due to patient attrition and lack of statistical power. This is depicted by the finding that the majority of the 95% confidence intervals of the effect sizes highlighted in Figure 2 include zero and are relatively wide for the 1-year findings, specifically for PROMIS UE. Although some of these results may not be statistically robust, they parallel similar findings, from a study using validated shoulder-centric outcome scores in patients who underwent arthroscopic RCR, by Williams et al. They found that patients without

Table 3. Administration of PROMIS Assessments: Days from Surgery

	Nonuser	Acute User	Chronic User	*P* Value
Administration of preoperative PROMIS assessment				
N	92	65	27	
Mean days (SD)	−42 (44.92)	−41 (45.87)	−50 (60.98)	.57
Administration of 6-month postoperative PROMIS assessments				
N	92	65	27	
Mean days (SD)	165 (46.14)	149 (60.01)	152 (54.1)	.17
Administration of 1-year postoperative PROMIS assessments				
N	69	42	18	
Mean days (SD)	675 (356.7)	601 (296.6)	523 (314.5)	.07

NOTE. *P* value significance at .05. Bold values denote statistically significant finding.
PROMIS, Patient-Reported Outcomes Measurement Information System; SD, standard deviation.

Table 4. PROMIS Data Comparison Among Opioid User Groups

	Nonuser	Acute User	Chronics User	ANOVA P Value	Pairwise Comparison P Value		
					Nonuser vs Acute User	Nonuser vs Chronic User	Acute User vs Chronic User
Preoperative PROMIS UE							
N	92	65	27	—	—	—	—
Mean (SD)	30.6 (5.57)	28.8 (5.43)	26.1 (5.28)	**.0001**	**.0389**	**.0002**	**.0314**
Effect Size (d) (95% CI)	—	—	—	—	−0.33 (−0.65, −0.01)	−0.83 (−1.27, −0.39)	−0.50 (−0.96, −0.05)
Preoperative PROMIS PI							
N	92	65	27	—	—	—	—
Mean (SD)	61.5 (4.56)	64.9 (5.30)	65.3 (4.98)	**<.0001**	**<.0001**	**.0005**	.6875
Effect Size (d) (95% CI)	—	—	—	—	0.69 (0.36-1.01)	0.80 (0.36-1.24)	0.08 (−0.37 0.53)
Preoperative PROMIS D							
N	92	65	27	—	—	—	—
Mean (SD)	47.6 (7.67)	49.2 (10.46)	51.1 (10.03)	.0695	.2921	.0836	.3611
Effect Size (d) (95% CI)	—	—	—	—	0.17 (−0.14, 0.49)	0.39 (−0.04, 0.82)	0.19 (−0.26, 0.63)
6-month PROMIS UE							
N	92	65	27	—	—	—	—
Mean (SD)	41.7 (9.58)	35.6 (9.39)	33.5 (7.48)	**<.0001**	**<.0001**	**<.0001**	.3222
Effect Size (d) (95% CI)	—	—	—	—	−0.64 (−0.97, −0.32)	−0.95 (−1.40, −0.51)	−0.25 (−0.70, 0.20)
6-month PROMIS PI							
N	91	64	27	—	—	—	—
Mean (SD)	50.7 (8.77)	56.3 (8.48)	58.1 (7.99)	**<.0001**	**<.0001**	**.0001**	.3649
Effect Size (d) (95% CI)	—	—	—	—	0.65 (0.32-0.98)	0.88 (0.44-1.33)	0.22 (−0.23, 0.67)
6 Month PROMIS D							
N	90	64	27	—	—	—	—
Mean (SD)	41.6 (8.35)	45.8 (10.88)	51.1 (10.70)	**<.0001**	**.008**	**<.0001**	**.0182**
Effect Size (d) (95% CI)	—	—	—	—	0.43 (0.11-0.76)	0.99 (0.54-1.44)	0.49 (0.04-0.95)
1-year PROMIS UE							
N	69	42	18	—	—	—	—
Mean (SD)	45.3 (11.66)	41.9 (11.05)	37.4 (8.89)	**.0056**	.1214	**.0081**	.1516
Effect Size (d) (95% CI)	—	—	—	—	−0.30 (−0.68, 0.09)	−0.76 (−1.29, −0.23)	−0.45 (−1.01, 0.11)
1-year PROMIS PI							
N	69	39	18	—	—	—	—
Mean (SD)	47.9 (9.02)	54.3 (10.34)	57.4 (8.18)	**<.0001**	**.0008**	**.0002**	.2471
Effect Size (d) (95% CI)	—	—	—	—	0.66 (0.26-1.06)	1.1 (0.56-1.65)	0.33 (−0.23, 0.89)
1-year PROMIS D							
N	68	39	18	—	—	—	—
Mean (SD)	41.6 (8.08)	48.3 (11.29)	49.2 (11.02)	**.0002**	**.0007**	**.0033**	.7394
Effect Size (d) (95% CI)					0.68 (0.28-1.09)	0.79 (0.25-1.32)	0.08 (−0.48, 0.64)

NOTE. *P* value significance at .05. Bold values denote statistically significant finding.

ANOVA, analysis of variance; CI, confidence interval; D, Depression; PI, Pain Interference; PROMIS, Patient-Reported Outcomes Measurement Information System; SD, standard deviation; UE, Upper Extremity.

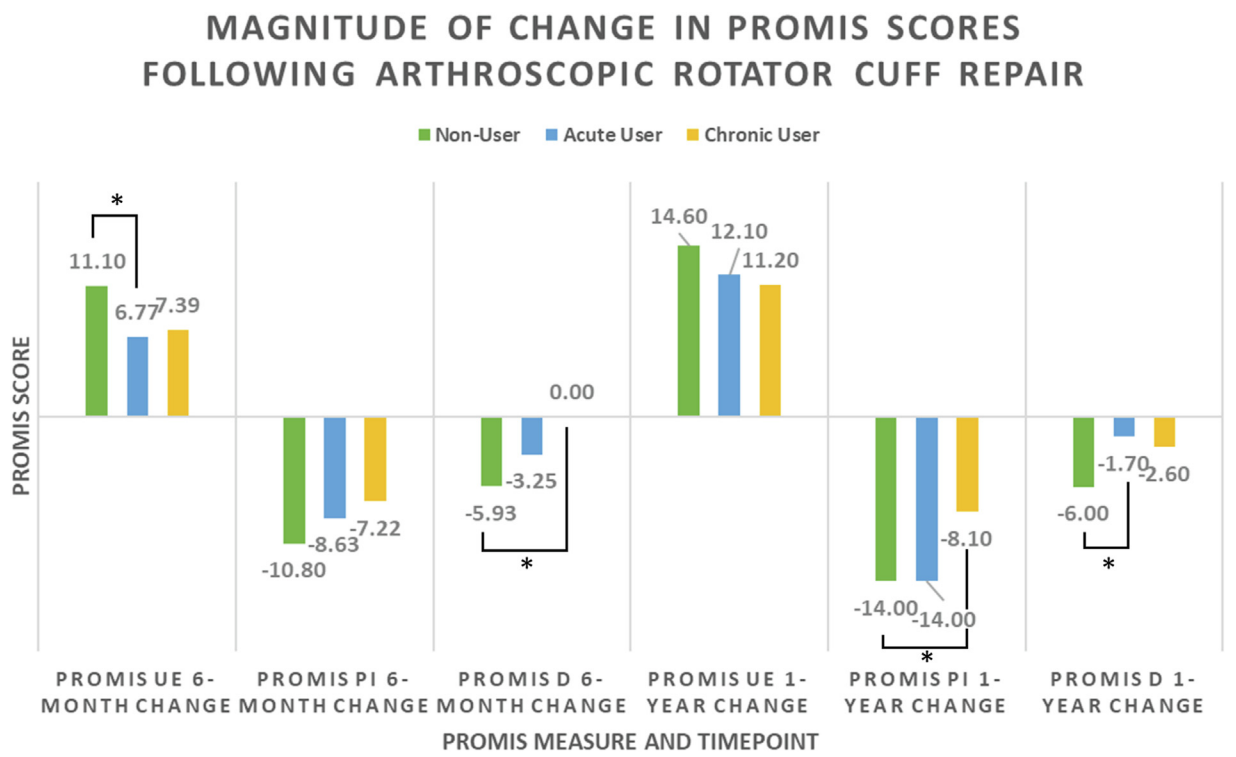

Fig 1. Changes in postoperative PROMIS scores compared with preoperative levels. *Denotes significant difference. (D, Depression; PI, Pain Interference; PROMIS, Patient-Reported Outcome Measurement Information System; UE, Upper Extremity.).

preoperative opioid use had no difference in magnitude of improvement in American Shoulder and Elbow Surgeons (37.9 vs 36.4; $P = .351$), Constant (26.7 vs 31.8; $P = .350$), and Simple Shoulder Test (4.1 vs 3.5; $P = .06$) to patients with preoperative opioid use, respectively.[62] The main difference here being is that the current study employed the use of PROMIS scores to track patient-reported outcomes compared with more traditionally used shoulder-centric scores used in the aforementioned studies. The literature has shown that PROMIS questionnaires are quicker to administer, with a lower question burden, and have favorable psychometric properties in rotator cuff patients.[54,63]

In concert with these previous investigations, the current study's findings indicate that opioid use preoperatively may delay improvement of functional outcomes, as the magnitude of improvement in functional outcomes among opioid users appeared to lag behind those of nonusers at 6 months postoperatively, before reaching a similar level of improvement in the long-term. The timing of improvement may be of paramount importance. As the majority of postoperative rehabilitation following rotator cuff repair occurs during the first 6 months postoperatively, and the gains from physical therapy and rehabilitation may be intimately related to the patient's ability to adhere to the rehabilitation regimen and tolerance of exercises. These data illustrate a significantly greater magnitude of improvement within the first 6 months in nonusers, and that there is a potential delay in improvement among opioid users. This might influence clinicians to identify which patients may require prolonged physical therapy or an adjusted regimen to account for this delay. In addition, opioid nonusers reported superior outcome scores across all time points, so while the magnitude of improvement was similar, the start and end points were superior among non-users.

The clinical relevance of the observed improvement in patient-reported outcomes is important to consider. Currently, there is a lack of published MCID values for PROMIS UE, PROMIS PI, and PROMIS D in rotator cuff patients. Using the distribution-based method for determining MCID, a contemporary systematic review proposes that half of the standard deviation often accurately estimates the threshold of discrimination for appreciable change when assessing health related quality of life.[56] Although simplistic, this method suggests that a change of 5 points or more in PROMIS scores is meaningful given the standardized scoring system of 50-point means, and 10-point standard deviations. Previous studies have used this method to estimate MCID in arthroplasty and carpal tunnel patients.[39,55,64] By these standards, nonusers and acute opioid users achieved MCID at similar rates, but chronic

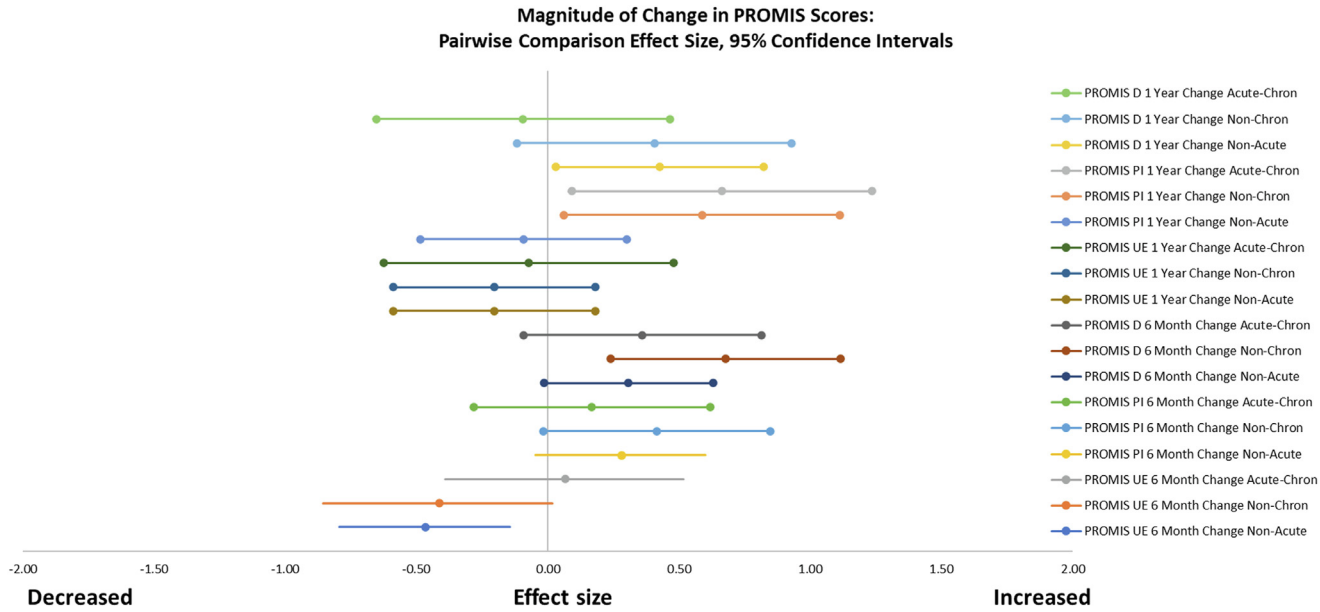

Fig 2. Magnitude of change in PROMIS scores: pairwise comparison effect sizes, 95% confidence intervals. (D, Depression; PI, Pain Interference; PROMIS, Patient-Reported Outcome Measurement Information System; UE, Upper Extremity.).

opioid users achieved MCID at a lower rate as depicted in the results section. Given the nature of cuff tears, most of which are chronic and often not indicated for surgery until after conservative measures are exhausted,[65] these findings inherently carry implications for many patients who live in pain for prolonged periods preoperatively. Patients undergoing conservative treatments who rely on opioids for adequate pain control in order to sufficiently complete these rehabilitative protocols present a target population that may benefit most from alternative pain regimens. The results of this study imply that opioid analgesia, perhaps during nonoperative treatment of RCTs, may associate with a delay in improvement in the early postoperative period following operative intervention.

Pain scores and functional scores following surgical RCR have been well-documented in the literature, however the role of depression scores is an evolving area of study. Cho et al.[66] have demonstrated that 26% of patients scheduled to undergo RCR experience depression. However, that particular study did not delineate the role of opioid use as a contributing factor. Studies have shown the limbic system to be one of a few locations in the brain that is rich in opioid receptors.[67] This same area is highly involved in mood regulation as well. Furthermore, opioid misuse in patients with depressive symptoms has been shown to increase risk in developing major depressive disorder.[68,69] Therefore, opioid use must be looked at as a serious player in the role of depressed mood in the orthopaedic patient. At both 6 months and 1 year after RCR, chronic preoperative opioid use was associated with significantly worse PROMIS D scores in the present study. Furthermore, acute users had significantly less improvement in PROMIS D compared with nonusers at 6 months. Meanwhile, chronic users had significantly less improvement compared to nonusers at 1 year. These findings are supported by a previous investigation from Kazmers et al.,[70] showing that hand clinic patients with a history of baseline opioid use demonstrated significantly worse scores on all patient-reported outcomes, and a significantly greater proportion of patients with PROMIS D scores exceeding 60 (1 SD above the mean). However, their study relied on patients self-reporting their opioid use and did not attempt to quantify amount or duration of opioid use. Meanwhile studies in RCR populations have shown that patients with preoperative opioid use are more likely to be associated with a comorbid diagnosis of depression/anxiety or are taking antidepressants/anxiolytics at greater proportions.[48,62] Yet, there is limited literature that describes the relationship between preoperative opioid use and mood specific scores in patients undergoing RCR, like the current study does. Therefore, additional prospective investigation is required to further delineate the interrelationship between opioid use and depressive mood as it pertains to the degree of influence on outcomes following rotator cuff repair.

Tracking opioid use in patients accurately can be challenging. This study employed the use of a statewide PDMP to monitor prescription filling as a surrogate for patient opioid use, as used in prior studies.[19,20,24,71,72] These databases have been shown to be accurate in terms of tracking prescription filling.[73]

In the current study, aside from an equivalent daily MME dose, chronic opioid users had significantly more days prescribed, prescribers, and prescriptions filled when compared to acute users. This demonstrates a distinct difference between these two samples of patients further supporting the criteria used to group our study population that is also in line with the definition provided by the Centers for Disease Control and Prevention for chronic opioid use (i.e., usage most days for at least 3 months).[74] In addition, the similar daily MME dose data, but significantly different days prescribed and prescriptions filled data between the opioid use groups demonstrates that perhaps it is the chronicity of opioid use, rather than the amount taken, that is most influential in patient outcomes.

Limitations

This study is not without limitations. Primarily, opioid usage was determined using a statewide PDMP. This online platform tracks prescriptions as they are filled; however, it cannot be confirmed whether a patient is taking the medication as prescribed. Although pain diaries have been used for accurate medication tracking in previous studies, that still relies on self-reporting, which can be inaccurate as well.[75] Although arbitrary, the categorization of opioid users in the current study had significant differences in opioid use longevity and produced detectable differences in pain and function scores. Furthermore, the chronic user group displayed a number of days prescribed that was more than half of the days within the 3-month window, which is in line with guidelines from the Centers for Disease Control and Prevention for chronic opioid use.[74] We did not collect postoperative opioid data, as this was not within the objective for the study, but can represent a confounding factor present in the study. In addition, not all postoperative patients followed up at 1 year (129/184, 70.1%). Although this is a sizeable loss, previous research has shown that 6 months is adequate time for PROMIS CAT forms to be sensitive to clinical change.[36] Finally, potentially confounding RCT characteristics were not collected. The current study did not stratify or subcategorize opioid users based on RCT characteristics such as tear size, tendon retraction, number of tendons involved, or whether certain procedures also were performed in addition to RCR such as biceps tenotomy/tenodesis. Some of these factors have been shown to be contributors to pain and dysfunction postoperatively.[76,77] However, there is research to indicate that psychosocial factors may play a greater role in postoperative pain than do structural characteristics of the cuff tear itself.[78] There is also some merit in including a heterogenous sample of rotator cuff pathology and repairs, as it makes the current findings more generalizable when counseling patients about opioid use before RCR.

Conclusions

Patients undergoing RCR demonstrated superior PROMIS scores pre- and postoperatively if they did not use opioids within 3 months before surgery.

References

1. Baker DW. History of The Joint Commission's Pain Standards: Lessons for today's prescription opioid epidemic. *JAMA* 2017;317:1117-1118.
2. Gomes T, Tadrous M, Mamdani MM, Paterson JM, Juurlink DN. The burden of opioid-related mortality in the United States. *JAMA Netw Open* 2018;1:e180217.
3. Jones CM, Lurie P, Woodcock J. Addressing prescription opioid overdose: Data support a comprehensive policy approach. *JAMA* 2014;312:1733-1734.
4. Schoenfeld AJ, Jiang W, Chaudhary MA, Scully RE, Koehlmoos T, Haider AH. Sustained prescription opioid use among previously opioid-naive patients insured through TRICARE (2006-2014). *JAMA Surg* 2017;152:1175-1176.
5. Sabatino MJ, Kunkel ST, Ramkumar DB, Keeney BJ, Jevsevar DS. Excess opioid medication and variation in prescribing patterns following common orthopaedic procedures. *J Bone Joint Surg Am* 2018;100:180-188.
6. Moutzouros V, Jildeh TR, Khalil LS, et al. A multimodal protocol to diminish pain following common orthopedic sports procedures: Can we eliminate postoperative opioids? *Arthroscopy* 2020;36:2249-2257.
7. Trasolini NA, McKnight BM, Dorr LD. The opioid crisis and the orthopedic surgeon. *J Arthroplasty* 2018;33:3379-3382 e3371.
8. Mall NA, Chalmers PN, Moric M, et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. *Am J Sports Med* 2014;42:2363-2370.
9. Jensen AR, Cha PS, Devana SK, et al. Evaluation of the trends, concomitant procedures, and complications with open and arthroscopic rotator cuff repairs in the Medicare population. *Orthop J Sports Med* 2017;5:2325967117731310.
10. Herzog MM, Marshall SW, Lund JL, Pate V, Mack CD, Spang JT. Trends in Incidence of ACL reconstruction and concomitant procedures among commercially insured individuals in the United States, 2002-2014. *Sports Health* 2018;10:523-531.
11. Frank RM, Chalmers PN, Moric M, Leroux T, Provencher MT, Romeo AA. Incidence and changing trends of shoulder stabilization in the United States. *Arthroscopy* 2018;34:784-792.
12. Abrams GD, Frank RM, Gupta AK, Harris JD, McCormick FM, Cole BJ. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. *Am J Sports Med* 2013;41:2333-2339.
13. Secrist ES, Freedman KB, Ciccotti MG, Mazur DW, Hammoud S. Pain management after outpatient anterior cruciate ligament reconstruction: A systematic review of randomized controlled trials. *Am J Sports Med* 2016;44:2435-2447.
14. Warrender WJ, Syed UAM, Hammoud S, et al. Pain management after outpatient shoulder arthroscopy: A

systematic review of randomized controlled trials. *Am J Sports Med* 2017;45:1676-1686.
15. Park SY, An HS, Lee SH, Suh SW, Kim JL, Yoon SJ. A prospective randomized comparative study of postoperative pain control using an epidural catheter in patients undergoing posterior lumbar interbody fusion. *Eur Spine J* 2016;25:1601-1607.
16. Jones J Jr, Southerland W, Catalani B. The importance of optimizing acute pain in the orthopedic trauma patient. *Orthop Clin North Am* 2017;48:445-465.
17. Pizzi LT, Toner R, Foley K, et al. Relationship between potential opioid-related adverse effects and hospital length of stay in patients receiving opioids after orthopedic surgery. *Pharmacotherapy* 2012;32:502-514.
18. Cozowicz C, Olson A, Poeran J, et al. Opioid prescription levels and postoperative outcomes in orthopedic surgery. *Pain* 2017;158:2422-2430.
19. Jildeh TR, Taylor KA, Khalil LS, et al. Risk factors for postoperative opioid use in arthroscopic meniscal surgery. *Arthroscopy* 2019;35:575-580.
20. Jildeh TR, Taylor KA, Tramer JS, et al. Risk factors for postoperative opioid use in arthroscopic shoulder labral surgery. *Arthroscopy* 2020;36:1813-1820.
21. Lawrence JT, London N, Bohlman HH, Chin KR. Preoperative narcotic use as a predictor of clinical outcome: Results following anterior cervical arthrodesis. *Spine (Phila Pa 1976)* 2008;33:2074-2078.
22. Lee D, Armaghani S, Archer KR, et al. Preoperative opioid use as a predictor of adverse postoperative self-reported outcomes in patients undergoing spine surgery. *J Bone Joint Surg Am* 2014;96:e89.
23. Morris BJ, Laughlin MS, Elkousy HA, Gartsman GM, Edwards TB. Preoperative opioid use and outcomes after reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2015;24:11-16.
24. Khalil LS, Jildeh TR, Ussef N, et al. Extensor mechanism ruptures and reruptures: Perioperative opioid management. *J Knee Surg* 2022;35:167-175.
25. Brodke DJ, Saltzman CL, Brodke DS. PROMIS for orthopaedic outcomes measurement. *J Am Acad Orthop Surg* 2016;24:744-749.
26. Hung M, Baumhauer JF, Latt LD, et al. Validation of PROMIS (R) Physical Function computerized adaptive tests for orthopaedic foot and ankle outcome research. *Clin Orthop Relat Res* 2013;471:3466-3474.
27. Robins RJ, Anderson MB, Zhang Y, Presson AP, Burks RT, Greis PE. Convergent validity of the Patient-Reported Outcomes Measurement Information System's Physical Function Computerized Adaptive Test for the knee and shoulder injury sports medicine patient population. *Arthroscopy* 2017;33:608-616.
28. Tyser AR, Beckmann J, Franklin JD, et al. Evaluation of the PROMIS physical function computer adaptive test in the upper extremity. *J Hand Surg Am* 2014;39:2047-2051 e2044.
29. Cella D, Yount S, Rothrock N, et al. The Patient-Reported Outcomes Measurement Information System (PROMIS): Progress of an NIH Roadmap cooperative group during its first two years. *Med Care* 2007;45:S3-S11.
30. Fries JF, Witter J, Rose M, Cella D, Khanna D, Morgan-DeWitt E. Item response theory, computerized adaptive testing, and PROMIS: Assessment of physical function. *J Rheumatol* 2014;41:153-158.
31. Makhni EC, Meadows M, Hamamoto JT, Higgins JD, Romeo AA, Verma NN. Patient Reported Outcomes Measurement Information System (PROMIS) in the upper extremity: The future of outcomes reporting? *J Shoulder Elbow Surg* 2017;26:352-357.
32. Chen RE, Papuga MO, Voloshin I, et al. Preoperative PROMIS scores predict postoperative outcomes after primary ACL reconstruction. *Orthop J Sports Med* 2018;6:2325967118771286.
33. Ho B, Houck JR, Flemister AS, et al. Preoperative PROMIS scores predict postoperative success in foot and ankle patients. *Foot Ankle Int* 2016;37:911-918.
34. Kenney RJ, Houck J, Giordano BD, Baumhauer JF, Herbert M, Maloney MD. Do Patient Reported Outcome Measurement Information System (PROMIS) scales demonstrate responsiveness as well as disease-specific scales in patients undergoing knee arthroscopy? *Am J Sports Med* 2019;47:1396-1403.
35. Padilla JA, Rudy HL, Gabor JA, et al. Relationship between the patient-reported outcome measurement information system and traditional patient-reported outcomes for osteoarthritis. *J Arthroplasty* 2019;34:265-272.
36. Fisk F, Franovic S, Tramer JS, et al. PROMIS CAT forms demonstrate responsiveness in patients following arthroscopic rotator cuff repair across numerous health domains. *J Shoulder Elbow Surg* 2019;28:2427-2432.
37. Tramer JS, Khalil LS, Fidai MS, et al. Mental health and tobacco use are correlated with PROMIS upper extremity and pain interference scores in patients with shoulder pathology. *Musculoskelet Surg* 2022;106:69-74.
38. Anthony CA, Glass NA, Hancock K, Bollier M, Wolf BR, Hettrich CM. Performance of PROMIS instruments in patients with shoulder instability. *Am J Sports Med* 2017;45:449-453.
39. Chen RE, Papuga MO, Nicandri GT, Miller RJ, Voloshin I. Preoperative Patient-Reported Outcomes Measurement Information System (PROMIS) scores predict postoperative outcome in total shoulder arthroplasty patients. *J Shoulder Elbow Surg* 2019;28:547-554.
40. Dowdle SB, Glass N, Anthony CA, Hettrich CM. Use of PROMIS for patients undergoing primary total shoulder arthroplasty. *Orthop J Sports Med* 2017;5:2325967117726044.
41. Haack M, Sanchez E, Mullington JM. Elevated inflammatory markers in response to prolonged sleep restriction are associated with increased pain experience in healthy volunteers. *Sleep* 2007;30:1145-1152.
42. Chae SH, Lee JE, Kim MJ, Yoo JC. Evaluation of analgesic efficacy and opioid sparing effect of pregabalin after arthroscopic rotator cuff repair surgery: A retrospective cohort study. *J Orthop Sci* 2020;26:599-603.
43. Cheesman Q, DeFrance M, Stenson J, et al. The effect of preoperative education on opioid consumption in patients undergoing arthroscopic rotator cuff repair: A prospective, randomized clinical trial-2-year follow-up. *J Shoulder Elbow Surg* 2020;29:1743-1750.
44. Gumina S, Candela V, Passaretti D, Venditto T, Mariani L, Giannicola G. Sleep quality and disturbances in patients

with different-sized rotator cuff tear. *Musculoskelet Surg* 2016;100:33-38.
45. Lau BC, Scribani M, Wittstein J. The effect of preexisting and shoulder-specific depression and anxiety on patient-reported outcomes after arthroscopic rotator cuff repair. *Am J Sports Med* 2019;47:3073-3079.
46. Lau BC, Scribani M, Wittstein J. Patients with depression and anxiety symptoms from adjustment disorder related to their shoulder may be ideal patients for arthroscopic rotator cuff repair. *J Shoulder Elbow Surg* 2020;29:S80-S86.
47. Park JH, Rhee SM, Kim HS, Oh JH. Effects of anxiety and depression measured via the hospital anxiety and depression scale on early pain and range of motion after rotator cuff repair. *Am J Sports Med* 2021;49:314-320.
48. Cronin KJ, Mair SD, Hawk GS, Thompson KL, Hettrich CM, Jacobs CA. Increased health care costs and opioid use in patients with anxiety and depression undergoing rotator cuff repair. *Arthroscopy* 2020;36:2655-2660.
49. Anthony CA, Westermann RW, Bedard N, et al. Opioid demand before and after anterior cruciate ligament reconstruction. *Am J Sports Med* 2017;45:3098-3103.
50. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377-381.
51. Anthony CA, Glass N, Hancock K, Bollier M, Hettrich CM, Wolf BR. Preoperative performance of the patient-reported outcomes measurement information system in patients with rotator cuff pathology. *Arthroscopy* 2017;33:1770-1774 e1771.
52. Guo EW, Elhage K, Cross AG, et al. Establishing and comparing reference preoperative Patient-Reported Outcomes Measurement Information System (PROMIS) scores in patients undergoing shoulder surgery. *J Shoulder Elbow Surg* 2021;30:1223-1229.
53. Patterson BM, Orvets ND, Aleem AW, et al. Correlation of Patient-Reported Outcomes Measurement Information System (PROMIS) scores with legacy patient-reported outcome scores in patients undergoing rotator cuff repair. *J Shoulder Elbow Surg* 2018;27:S17-s23.
54. Schwarz I, Smith JH, Houck DA, Frank RM, Bravman JT, McCarty EC. Use of the Patient-Reported Outcomes Measurement Information System (PROMIS) for operative shoulder outcomes. *Orthop J Sports Med* 2020;8:2325967120924345.
55. Bernstein DN, Houck JR, Mahmood B, Hammert WC. Minimal clinically important differences for PROMIS physical function, upper extremity, and pain interference in carpal tunnel release using region- and condition-specific PROM tools. *J Hand Surg Am* 2019;44:635-640.
56. Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med Care* 2003;41:582-592.
57. Aneizi A, Sajak PMJ, Alqazzaz A, et al. Impact of preoperative opioid use on 2-year patient-reported outcomes in knee surgery patients [Published online September 8, 2020]. *J Knee Surg*, doi:10.1055/s-0040-1716358
58. Lu Y, Beletsky A, Cohn MR, et al. Perioperative opioid use predicts postoperative opioid use and inferior outcomes after shoulder arthroscopy. *Arthroscopy* 2020;36:2645-2654.
59. Smith E, Klemt C, Sabeh K, Tirumala V, Kwon YM. Patient-reported outcomes associated with preoperative opioid use in revision total hip arthroplasty: A propensity score-matched cohort study. *J Am Acad Orthop Surg* 2021;29:e330-e336.
60. Weiner JA, Snavely JE, Johnson DJ, Hsu WK, Patel AA. Impact of preoperative opioid use on postoperative patient-reported outcomes in lumbar spine surgery patients. *Clin Spine Surg* 2021;34:E154-e159.
61. Morris BJ, Sciascia AD, Jacobs CA, Edwards TB. Preoperative opioid use associated with worse outcomes after anatomic shoulder arthroplasty. *J Shoulder Elbow Surg* 2016;25:619-623.
62. Williams BT, Redlich NJ, Mickschl DJ, Grindel SI. Influence of preoperative opioid use on postoperative outcomes and opioid use after arthroscopic rotator cuff repair. *J Shoulder Elbow Surg* 2019;28:453-460.
63. Gulledge CM, Smith DG, Ziedas A, Muh SJ, Moutzouros V, Makhni EC. Floor and ceiling effects, time to completion, and question burden of PROMIS CAT domains among shoulder and knee patients undergoing nonoperative and operative treatment. *JB JS Open Access* 2019;4:e0015.1-7.
64. Khalil LS, Darrith B, Franovic S, Davis JJ, Weir RM, Banka TR. Patient-Reported Outcomes Measurement Information System (PROMIS) Global Health Short Forms demonstrate responsiveness in patients undergoing knee arthroplasty. *J Arthroplasty* 2020;35:1540-1544.
65. Keener JD, Patterson BM, Orvets N, Chamberlain AM. Degenerative rotator cuff tears: Refining surgical indications based on natural history data. *J Am Acad Orthop Surg* 2019;27:156-165.
66. Cho CH, Seo HJ, Bae KC, Lee KJ, Hwang I, Warner JJ. The impact of depression and anxiety on self-assessed pain, disability, and quality of life in patients scheduled for rotator cuff repair. *J Shoulder Elbow Surg* 2013;22:1160-1166.
67. Knoll AT, Carlezon WA Jr. Dynorphin, stress, and depression. *Brain Res* 2010;1314:56-73.
68. Grattan A, Sullivan MD, Saunders KW, Campbell CI, Von Korff MR. Depression and prescription opioid misuse among chronic opioid therapy recipients with no history of substance abuse. *Ann Fam Med* 2012;10:304-311.
69. Semenkovich K, Chockalingam R, Scherrer JF, et al. Prescription opioid analgesics increase risk of major depression: New evidence, plausible neurobiological mechanisms and management to achieve depression prophylaxis. *Mo Med* 2014;111:148-154.
70. Kazmers NH, Stephens AR, Tyser AR. Effects of baseline opioid medication use on patient-reported functional and psychological impairment among hand clinic patients. *J Hand Surg Am* 2019;44:829-839.
71. Pennings JS, Khan I, Hills JM, Coronado RA, Devin CJ, Archer KR. Classifying chronic opioid use before spine surgery: Comparison of self-report and prescription drug monitoring program (PDMP) reporting. *Spine J* 2020;20:1795-1797.
72. Tan TL, Rondon AJ, Wilt Z, et al. Understanding opioid use after total hip arthroplasty: A comprehensive analysis

of a mandatory prescription drug monitoring program. *J Am Acad Orthop Surg* 2020;28:e917-e922.
73. Hozack BA, Rivlin M, Graham J, Lutsky KF, Beredjiklian PK. Validation of the prescription drug monitoring program Web site. *J Opioid Manag* 2019;15:495-498.
74. Dowell D, Haegerich TM, Chou R. CDC Guideline for Prescribing Opioids for Chronic Pain—United States, 2016. *MMWR Recomm Rep* 2016;65:1-49.
75. Stone AA, Shiffman S, Schwartz JE, Broderick JE, Hufford MR. Patient compliance with paper and electronic diaries. *Control Clin Trials* 2003;24:182-199.
76. Mall NA, Kim HM, Keener JD, et al. Symptomatic progression of asymptomatic rotator cuff tears: a prospective study of clinical and sonographic variables. *J Bone Joint Surg Am* 2010;92:2623-2633.
77. Walch G, Nove-Josserand L, Boileau P, Levigne C. Subluxations and dislocations of the tendon of the long head of the biceps. *J Shoulder Elbow Surg* 1998;7:100-108.
78. Ravindra A, Barlow JD, Jones GL, Bishop JY. A prospective evaluation of predictors of pain after arthroscopic rotator cuff repair: Psychosocial factors have a stronger association than structural factors. *J Shoulder Elbow Surg* 2018;27:1824-1829.