The Presence of Preoperative Depression Symptoms Does Not Hinder Recovery After Anterior Cruciate Ligament Reconstruction

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Background: The current literature suggests a link between psychosocial factors and poor surgical outcomes in patients with musculoskeletal complaints. However, there remains a limited body of literature examining the effect of depression on outcomes after anterior cruciate ligament reconstruction (ACLR).

Purpose: The primary purpose of this study was to compare postoperative function patient-reported outcome scores between patients with and patients without preoperative depression symptoms undergoing ACLR. Secondary goals included comparing postoperative pain interference and depression scores between the 2 groups.

Study Design: Cohort study; Level of evidence, 2.

Methods: In this single-center retrospective cohort study, pediatric and adult patients who underwent ACLR were included. The Physical Function (PF), Pain Interference (PI), and Depression (D) domain scores of the Patient-Reported Outcomes Measurement Information System (PROMIS) were collected preoperatively and at 6 and 12 months postoperatively. Patients were separated into clinical depression (CD) and no clinical depression (NCD) groups based on their preoperative PROMIS-D score.

Results: A total of 82 patients undergoing ACLR were included in this study. Of these, 19 (23%) patients met criteria for the CD group. Preoperatively, the CD group reported lower mean PROMIS-PF (33.3 vs 39.7, respectively; $P = .001$), higher PROMIS-PI (65.7 vs 59.2, respectively; $P < .01$), and higher PROMIS-D (62.4 vs 45.1, respectively; $P < .001$) scores than the NCD group. At 12 months postoperatively, the mean PROMIS-PF scores for the CD and NCD groups were 52.1 and 56.7, respectively ($P = .12$). The mean 12-month postoperative PROMIS-PI scores for the CD and NCD groups were 52.3 and 47.4, respectively ($P = .04$). At 12 months after ACLR, there was a substantial improvement in PROMIS-PF and PROMIS-PI scores for both the CD (delta = +18.8 and –13.4, respectively) and NCD (delta = +17.0 and –11.8) groups.

Conclusion: There was a significant improvement, which exceeded currently accepted minimal clinically important difference values, in PROMIS-PF scores at 12 months after ACLR, regardless of the presence of preoperative depression symptoms. These data suggest that having depression symptoms preoperatively does not significantly hinder a patient's recovery after ACLR.

Keywords: knee ligaments; ACL; depression; mental health; patient-reported outcomes

Anterior cruciate ligament (ACL) injuries are among the most common sports injuries, with an estimated incidence of 68.6 per 100,000 people[30] and reconstruction is widely considered the standard treatment of choice. Despite this consensus, it is well documented that many patients never return to their preinjury functional status,[21,33] prompting the need for further research to identify possible risk factors for poor outcomes after ACL reconstruction (ACLR).

Recent studies have identified psychological factors as potential risk factors for poor surgical outcomes.[1,2,14,18] One such important psychological factor is depression, which is a common comorbidity among surgical patients with musculoskeletal complaints.[2,31,36,37] One study found that 51% of patients undergoing surgery for shoulder instability had depression symptoms preoperatively.[36] Furthermore, sports-related injuries in particular have been associated with negative psychological responses[2,10,32] that could hinder a patient's rehabilitation after surgery.

While there is a growing body of work analyzing the impact of depression on musculoskeletal complaints, there remains a limited body of literature examining the relationship between depression and ACLR. Given the functional impairment caused by ACL injuries, as well as the difficulty and length of rehabilitation, it is important to consider psychosocial factors in the patient population undergoing ACLR. Furthermore, no studies examining the relationship

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between ACLR and depression have utilized the Patient-Reported Outcomes Measurement Information System (PROMIS) computer adaptive test (CAT), a patient-reported outcome measure that continues to grow in popularity in orthopaedic surgery practices.[3,5,19,22,29]

The primary goal of this study was to compare postoperative function patient-reported outcome scores between patients with and without preoperative depression symptoms undergoing ACLR. Secondary goals included comparing postoperative patient-reported outcome scores for pain interference and depression between these 2 groups. We hypothesized that (1) patients with preoperative depression symptoms would have lower PROMIS Physical Function (PF) scores after 12 months compared with patients without preoperative depression symptoms and (2) patients with preoperative depression symptoms would have a smaller improvement (ie, a smaller delta) in PROMIS-PF scores postoperatively compared with patients with no preoperative depression symptoms.

METHODS

Study Design and Participants

This study was internally funded and approved by our health system's institutional review board before data collection. Prospectively collected data were reviewed for patients who underwent primary ACLR from June 19, 2017, to August 29, 2019, by 1 of 2 fellowship-trained sports medicine orthopaedic surgeons (E.C.M., V.M.) at a single academic tertiary-care orthopaedic center. Patients were identified using Current Procedural Terminology code 29888. All patients followed a standardized postoperative rehabilitation program with functional knee braces as prescribed by the 2 surgeons. Demographic data including age, race, employment status, and sex were collected using a standardized new patient form at the initial clinic visit. For employment status, 3 options were presented: *employed*, *unemployed*, or *other*; *other* was commonly used for patients who were not working at the time because of their injury. The data were stored electronically using Research Electronic Data Capture (REDCap), a HIPAA-compliant data management and collection instrument maintained by Vanderbilt University.

Both adult and pediatric patients were included in this study if they underwent the abovementioned surgical procedure and completed at least 1 set of PROMIS CAT forms preoperatively and at least 1 set of PROMIS CAT forms at 6 and 12 months postoperatively. For this study, a set of PROMIS CAT forms included the following domains: PF, Pain Interference (PI), and Depression (D). All PROMIS instruments are calibrated against a healthy reference population and have a mean t score of 50 with a standard deviation of 10. A higher score indicates more of the health domain in question. For example, a high PROMIS-PI or PROMIS-D score indicates more pain or depressive symptoms, while a high PROMIS-PF score indicates higher functional ability.[5] PROMIS CAT forms were administered in English electronically on iPads (Apple) in an ambulatory orthopaedic surgery sports medicine clinic as part of routine clinical care.[20] Patients who were unable to communicate in English (written or spoken) or who were unable to use a portable electronic tablet were excluded from analysis.

The PROMIS-D domain was used to evaluate a patient's depression symptoms, and the patients were divided into separate groups based on this score. A previous study reported PROMIS-D score equivalents with common depression screening questionnaires, including the Patient Health Questionnaire–9 (PHQ-9). A PROMIS-D score of 55 correlated with the same PHQ-9 score range that indicated positive screening criteria for mild clinical depression.[27] Patients with a PROMIS-D score $\geq$55 were placed into the clinical depression (CD) group, while patients with a score $<$55 were placed into the no clinical depression (NCD) group. Patients in the CD group were not administered any depression-related treatments (ie, counseling, medication).

Statistical Analysis

Independent-samples t tests were used to compare PROMIS-PF, PROMIS-PI, and PROMIS-D scores between the CD and NCD groups at the preoperative, 6-month, and 12-month time points. Demographic data were also compared using t tests and chi-square tests. Analysis of variance with Tukey post hoc analysis was used to compare PROMIS-PF, PROMIS-PI, and PROMIS-D scores of each group between the preoperative, 6-month, and 12-month time points. All analyses were performed using SPSS software (Version 25.0; IBM).

RESULTS

A total of 82 patients were included in this study; 63 were in the NCD group, while 19 were in the CD group (Table 1). The mean age of the total cohort was 29.9 years (range, 14.5-54.0 years). The mean ages for the CD and NCD groups were 26.7 and 30.8 years ($P = .15$), respectively. The range of ages for the CD group was 14.7 to 40.7 years, and the range of ages for the NCD group was 16.3 to 54.2 years.

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Ethical approval for this study was obtained from the Henry Ford Health System (study No. 11361).

TABLE 1
Patient Demographics[a]

	Total Cohort (N = 82)	Clinical Depression (n = 19)	No Clinical Depression (n = 63)	*P* Value
Age, y	29.9 ± 11.2	26.7 ± 8.5	30.8 ± 11.8	.15
Body mass index, kg/m^2	26.1 ± 4.8	27.1 ± 5.5	25.8 ± 4.5	.30
Sex				.75
Male	49 (61)	10 (53)	39 (62)	
Female	33 (39)	9 (47)	24 (38)	
Race				.06
White	47 (57)	9 (47)	38 (60)	
Black	9 (11)	5 (26)	4 (6)	
Other	26 (32)	5 (26)	21 (33)	
Employment				.18
Employed	25 (32)	6 (32)	19 (30)	
Unemployed	6 (7)	1 (5)	5 (8)	
Other	51 (61)	12 (63)	39 (63)	

[a]Data are reported as mean ± SD or n (%). *P* values are shown for comparison between the clinical depression and no clinical depression groups.

TABLE 2
PROMIS-D Scores Over Time[a]

	Total Cohort	Clinical Depression	No Clinical Depression	*P* Value
Preoperative	49.1 (47.0-51.2)	62.4 (58.8-66.0)	45.1 (43.5-46.7)	<.001
6 mo	41.9 (39.9-43.9)	46.5 (42.0-51.0)	40.5 (38.7-42.3)	.006
12 mo	42.7 (40.3-45.1)	47.3 (41.5-53.1)	41.2 (38.9-43.5)	.03

[a]Data are reported as mean (95% CI). *P* values are shown for comparison between the clinical depression and no clinical depression groups. PROMIS-D, Patient-Reported Outcomes Measurement Information System–Depression.

TABLE 3
PROMIS-PF Scores Over Time[a]

	Total Cohort	Clinical Depression	No Clinical Depression	*P* Value
Preoperative	38.2 (36.5-39.9)	33.3 (29.5-37.1)	39.7 (37.9-41.5)	.001
6 mo	50.7 (48.9-52.4)	49.1 (44.6-53.6)	51.1 (49.2-53.0)	.35
12 mo	55.6 (53.1-58.1)	52.1 (46.4-57.9)	56.7 (53.9-59.5)	.12
Delta (change)	+17.4	+18.8	+17.0	

[a]Data are reported as mean (95% CI). *P* values are shown for comparison between the clinical depression and no clinical depression groups. Delta was calculated by subtracting the preoperative score from the 12-month score. PROMIS-PF, Patient-Reported Outcomes Measurement Information System–Physical Function.

Overall, 38 of 82 patients had a concomitant meniscal or other ligamentous injury (10/19 in CD group; 28/63 in NCD group). The mean length of time between the date of surgery booking to the date of surgery was 28.5 days for the entire cohort (30.2 and 22.8 days for NCD and CD groups, respectively; $P = .18$). The date of injury was not captured in this database.

The mean PROMIS-D scores decreased significantly in both groups at 12 months postoperatively compared with the preoperative time point (Table 2). The mean preoperative PROMIS-D score for the total cohort was 49.1. The mean PROMIS-D score for the CD group decreased from 62.4 preoperatively to 47.3 at 12 months postoperatively ($P = .001$). The mean PROMIS-D score for the NCD group decreased from 45.1 preoperatively to 41.2 at 12 months postoperatively ($P = .01$).

The CD group had a lower preoperative PROMIS-PF score compared with the NCD group (33.3 vs 39.7, respectively; $P = .001$) (Table 3). Both groups demonstrated a substantial improvement (large delta) in PROMIS-PF scores. The CD group demonstrated a larger improvement in the PROMIS-PF score than the NCD group. The mean PROMIS-PF score in the CD group improved from 33.3 to 52.1 at 12-month follow-up ($P < .001$), while the NCD group showed an improvement from 39.7 to 56.7 ($P < .001$) at 12-month follow-up.

Both groups demonstrated an improvement (reduction) in PROMIS-PI scores (Table 4). The mean PROMIS-PI

TABLE 4
PROMIS-PI Scores Over Time[a]

	Total Cohort	Clinical Depression	No Clinical Depression	*P* Value
Preoperative	60.7 (59.1 to 62.3)	65.7 (62.1 to 69.3)	59.2 (57.5 to 60.9)	<.01
6 mo	49.3 (47.7 to 50.9)	51.4 (47.3 to 55.5)	48.7 (46.9 to 50.5)	.16
12 mo	48.6 (46.5 to 50.6)	52.3 (47.3 to 57.3)	47.4 (45.3 to 49.5)	.04
Delta (change)	–12.1	–13.4	–11.8	

[a]Data are reported as mean (95% CI). *P* values are shown for comparison between the clinical depression and no clinical depression groups. Delta was calculated by subtracting the preoperative score from the 12-month score. PROMIS-PI, Patient-Reported Outcomes Measurement Information System–Pain Interference.

score of the CD group decreased more than that of the NCD group (65.7 to 52.3 [$P < .001$] vs 59.2 to 47.4 [$P < .001$], respectively). There was a significant difference between the CD and NCD groups for both the mean preoperative (65.7 vs 59.2, respectively; $P < .01$) and 12-month postoperative (52.3 vs 47.4, respectively; $P = .04$) PROMIS-PI scores. The CD group reported higher PROMIS-PI scores at both the preoperative and 12-month time points compared with the NCD group.

DISCUSSION

There is a growing body of research examining the impact of clinical depression on musculoskeletal injuries and the subsequent recovery from surgery.[14,24,31,36] However, to date, there remains a paucity of work analyzing the impact of clinical depression specifically on patients undergoing ACLR. In a cohort of patients undergoing ACLR, we found substantial improvements in PROMIS-PF scores in both the CD and the NCD groups, with improvements (deltas) in both groups exceeding the currently accepted minimal clinically important difference (MCID) of 4.6.[7]

It is noteworthy that patients in both the CD and the NCD groups experienced substantial improvements in PROMIS-PF scores after surgery. Both groups approached a PROMIS-PF score of 50, which is the standardized mean score of a healthy reference population (52.1 and 56.7, respectively, for CD and NCD groups; $P = .12$), with the magnitude of the change in scores far greater than the previously reported MCID of 4.6 points in patients with ACL injuries.[7] This substantial improvement is similar to a prior study that reported large improvements in function scores after ACLR, and it supports that study's conclusion that ACLR is equally as effective in patients with and without depression.[14] These findings provide key information for orthopaedic surgeons treating depressed patients with ACL injuries, in that such patients are still likely to have favorable functional outcomes after surgery. Furthermore, the large improvement in PROMIS-PF scores in both groups can help providers guide patients' expectations during preoperative counseling, as their outcomes are likely to be positive, regardless of preoperative depression symptoms.

The improvement in PROMIS-PF scores in our study is similar to the results of previous studies examining the effect of depression on functional outcomes after shoulder surgery. Weekes et al[36] compared outcomes in patients with and without preoperative depression who underwent shoulder stabilization surgery. Both patient groups had a significant improvement in postoperative outcomes at 12-month follow-up; however, the patients in the depressed group had lower outcome scores. Werner et al[37] had similar results for patients undergoing total shoulder arthroplasty. These authors found a significant improvement in postoperative American Shoulder and Elbow Surgeons (ASES) scores compared with preoperative scores in patients both with and without depression, but patients in the depression group had lower final ASES scores compared with patients in the no depression group.

Despite the improvement in PROMIS-PF scores in both the CD and the NCD groups, there appears to be a trend in that the CD group had worse outcome scores than the NCD group at 6- and 12-month follow-up. In our study, the PROMIS-PF scores were higher at each time point in the NCD group compared with the CD group. With the exception of the preoperative time point, there was no statistically significant difference between the 2 function scores at 6- and 12-month follow-up; however, we hypothesize that this is likely because the study was underpowered. Past studies have reported similar findings of orthopaedic surgical patients with depression symptoms having worse outcome scores at long-term follow-up.[14,31,36,37]

Another notable finding was the decrease in the PROMIS-D score in the CD group at 12 months after surgery. Undergoing treatment for ACL injuries can be emotionally distressing for patients, which could account for the high prevalence of depression symptoms in patients undergoing ACLR. We hypothesize that the drastic improvement in function and pain at 12 months after surgery played a role in the decreasing PROMIS-D scores. This should provide reassurance for providers that even if their patients have high levels of emotional distress leading up to the ACLR procedure, this is likely to improve in the long term after surgery. Whether patients undergoing ACLR with a history of depression have a better or worse prognosis compared with those with depression symptoms that occurred concomitant with their ACL injury is an important question that warrants further research. A past study suggested that novel depression symptoms were

associated with increased risks of mortality and morbidity after cardiac surgery; however, the authors did not directly compare those outcomes to patients who had a history of depression.[26]

The high prevalence of depression symptoms in our ACLR cohort contributes to the existing literature that details the link between depression and musculoskeletal injuries.[2,14,31,36] In our study, 23% of patients undergoing ACLR had symptoms consistent with screening criteria for mild clinical depression; prevalence as high as 42% was reported in a previous study examining depression in ACLR.[14] This reported prevalence is substantially higher than the estimated 9% prevalence of depression at any given time in the United States.[23] We hypothesize that the high prevalence of depression in the ACLR patient population could be because of the functional impairment caused by ACL injuries; these patients can no longer be as active as they would like to be, leading to significant emotional distress.[9]

While the prevalence of depression symptoms in our ACLR cohort was high compared with the national average, there have been even higher rates of depression reported in patients with shoulder complaints.[8,11,34,36] One study found that 51% of patients undergoing stabilization surgery for shoulder instability were found to have significant depression symptoms preoperatively.[36] Additionally, 55% of patients undergoing arthroscopic subacromial decompression were found to have evidence of depression before surgery.[11] A possible explanation for the difference in the prevalence of depression between ACLR and shoulder complaints is that shoulder conditions requiring surgery and ACL injuries present different types of abnormalities with respect to onset and chronicity. ACL injuries are more commonly acute in nature and are functional injuries, whereas shoulder injuries tend to be more chronic and degenerative in nature. As a result, depression may have less of a role in the former compared with the latter.

Despite the well-documented detrimental effect of depression on surgical outcomes,[4,6,12,15,16] there have been few studies in the literature that examine its effect on ACLR outcomes.[14,18,24,25] Moreover, none of these studies used PROMIS CAT forms to evaluate physical function and depression. It is likely that mental health and depression are closely linked to patient outcomes and recovery after surgery. This study provides more data on a poorly studied interaction between depression and ACLR. Further research is warranted to determine if addressing or even recognizing the presence of clinical depression before the surgical intervention affects ACLR outcomes.

Our study did have important limitations. First, the results from the relatively small sample size of patients led to an underpowered study (post hoc power was 20.9%). Our cohort with depression symptoms may not be truly representative of all patients undergoing ACLR with depression. However, our number of patients with depression is similar to a previous study that analyzed outcomes in patients undergoing ACLR with depression.[14] Additionally, our study had a larger total cohort of patients examined.[14] Second, the floor effect of the PROMIS-D[13,17] could make it difficult to stratify between patients with low and very low levels of depression. In our study, there was a floor effect of 17%. Although this is substantial, floor effects are inherent limitations of mental health patient-reported outcome scores collected in the orthopaedic surgery setting, and more education for patients is needed regarding the importance of diligently filling out these forms.[13,17] Third, we did not use patients with a confirmed major depressive disorder diagnosis from a psychiatrist, nor did we stratify depression based on severity. Furthermore, we did not differentiate patients in the CD group based on whether they had a history of depression before their ACL injury. However, given the novelty of this work, we felt that it was important to initially evaluate patients using broader categories before subdividing levels of depression. Fourth, our study included both pediatric and adult patients, but only the adult PROMIS CAT forms were utilized because of clinic limitations. However, research has shown a strong correlation between the pediatric and adult PROMIS instruments.[28,35] Fifth, factors such as baseline physical activity before injury or return to work/play were not taken into account, nor did we study time to return to sports or work as a risk factor for depression. However, our additional analysis comparing the delta of PROMIS scores from preoperatively to postoperatively provides valuable insight to help adjust for this limitation. Finally, our findings may not be fully generalizable because our study occurred at a single academic medical center. However, many ACLR procedures are performed at academic medical centers; thus, our findings are likely representative of a large portion of sports medicine orthopaedic surgeons. Future multicenter studies with larger numbers are warranted to confirm or refute our findings and to address the last limitation noted. Despite these limitations, this study had the largest sample size of patients to date for analyzing outcomes in patients with depression who underwent ACLR, and our findings add to the existing literature in the field.

CONCLUSION

Overall, there was a significant increase, which exceeded currently accepted MCID values, in PROMIS-PF scores at 12 months after ACLR, regardless of the presence of preoperative depression symptoms. These data suggest that having depression symptoms preoperatively does not significantly hinder a patient's recovery after ACLR. These findings should be reassuring for surgeons and patients, but future work is warranted to determine if additional support or a biopsychosocial approach can further improve clinical outcomes in clinically depressed patients.

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