Preoperative mental health status may not be predictive of improvements in patient-reported outcomes following an anterior cervical discectomy and fusion

Benjamin C. Mayo, BA, Dustin H. Massel, BS, Daniel D. Bohl, MD, MPH, Ankur S. Narain, BA, Fady Y. Hijji, BS, William W. Long, BA, Krishna D. Modi, BS, Bryce A. Basques, MD, Alem Yacob, MD, and Kern Singh, MD

Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois

OBJECTIVE Prior studies have correlated preoperative depression and poor mental health status with inferior patient-reported outcomes following lumbar spinal procedures. However, literature regarding the effect of mental health on outcomes following cervical spinal surgery is limited. As such, the purpose of this study is to test for the association of preoperative SF-12 Mental Component Summary (MCS) scores with improvements in Neck Disability Index (NDI), SF-12 Physical Component Summary (PCS), and neck and arm pain following anterior cervical discectomy and fusion (ACDF).

METHODS A prospectively maintained surgical database of patients who underwent a primary 1- or 2-level ACDF during 2014–2015 was reviewed. Patients were excluded if they did not have complete patient-reported outcome data for the preoperative or 6-week, 12-week, or 6-month postoperative visits. At baseline, preoperative SF-12 MCS score was assessed for association with preoperative NDI, neck visual analog scale (VAS) score, arm VAS score, and SF-12 PCS score. The preoperative MCS score was then tested for association with changes in NDI, neck VAS, arm VAS, and SF-12 PCS scores from the preoperative visit to postoperative visits. These tests were conducted using multivariate regression controlling for baseline characteristics as well as for the preoperative score for the patient-reported outcome being assessed.

RESULTS A total of 52 patients were included in the analysis. At baseline, a higher preoperative MCS score was negatively associated with a lower preoperative NDI (coefficient: -0.74 , $p < 0.001$) and preoperative arm VAS score (-0.06 , $p = 0.026$), but not preoperative neck VAS score (-0.03 , $p = 0.325$) or SF-12 PCS score (0.04 , $p = 0.664$). Additionally, there was no association between preoperative MCS score and improvement in NDI, neck VAS, arm VAS, or SF-12 PCS score at any of the postoperative time points (6 weeks, 12 weeks, and 6 months, $p > 0.05$ for each). The percentage of patients achieving a minimum clinically important difference at 6 months did not differ between the bottom and top MCS score halves ($p > 0.05$ for each).

CONCLUSIONS The results of this study suggest that better preoperative mental health status is associated with lower perceived preoperative disability but is not associated with severity of preoperative neck or arm pain. In contrast to other studies, the present study was unable to demonstrate that preoperative mental health is predictive of improvement in patient-reported outcomes at any postoperative time point following an ACDF.

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KEY WORDS mental health; depression; ACDF; anterior cervical discectomy and fusion; outcomes; SF-12; NDI; neck disability index; VAS; visual analog scale

ANTERIOR cervical discectomy and fusion (ACDF) is a reliable treatment option for neck pain and associated radiculopathy due to degenerative disc disease. However, some subsets of patients may not report significant improvements in pain and disability. Clinical success rates have been reported to occur in as few as 40%

of patients following multilevel fusion procedures.^{8,9,15} It has been suggested that a patient's mental health may have an effect on postoperative outcomes.^{21,25} Many psychosomatic and mood disorders have been considered to contribute to worse outcomes, though depression and anxiety have received the most attention in the literature.

ABBREVIATIONS ACDF = anterior cervical discectomy and fusion; CCI = Charlson Comorbidity Index; MCID = minimum clinically important difference; MCS = Mental Component Summary; NDI = Neck Disability Index; PCS = Physical Component Summary; PRO = patient-reported outcome; VAS = visual analog scale.

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While numerous studies have reported a correlation between preoperative mental health and outcomes following spinal surgery,^{2,10,31,32,34,39} others have failed to find an association.^{23,33} Additionally, a large majority of prior literature has focused on the effect of depression on outcomes following lumbar spine surgery, while outcomes following cervical spine surgery remain relatively unstudied.^{4,16,20,22,27,41}

One widely used questionnaire to assess patient health is the SF-12 Health Survey.^{17,19} The SF-12 can be reported as a total score, or as a Physical Component Summary (PCS) score and a Mental Component Summary (MCS) score. While the PCS evaluates a patient's physical health status, the MCS assesses emotional health and has been validated as an acceptable screening tool for depression.^{17–19,40} The purpose of this study is to test for association between preoperative mental health, as assessed by the SF-12 MCS, and change in patient-reported outcomes (PROs) following an ACDF.

Methods

Patient Population

After obtaining institutional review board approval, we reviewed a prospectively maintained surgical database of consecutive patients who underwent a primary 1- or 2-level ACDF performed by a single surgeon at a single academic institution during 2014–2015. Only cases during this time period were selected due to recent utilization of the SF-12 patient surveys at Rush University Medical Center. All patients were asked to fill out an SF-12 survey, a Neck Disability Index (NDI), and visual analog scale (VAS) pain scores for neck and arm preoperatively, as well as at the 6-week, 12-week, and 6-month postoperative visits. Only patients who completed each patient-reported outcome survey at all 4 appointments were included in the analysis.

Outcome Measures

The SF-12 is a widely used, concise survey that evaluates overall patient health. For both SF-12 subsections (MCS and PCS), a lower score indicates worse functional status. The NDI is used to evaluate self-rated disability in patients with neck pain. A higher NDI correlates with greater disability, and a lower score indicates minimal disability. VAS is a patient-reported, site-specific pain scale. For this scale, a score of 0 indicates no pain, while a score of 10 indicates maximal pain.

Preoperative MCS score as a continuous variable was tested for association with preoperative NDI, neck VAS, arm VAS, and SF-12 PCS scores. The cutoff between the top and bottom halves of preoperative MCS scores was 47.5. The change from preoperative score was calculated for NDI, neck VAS, arm VAS, and SF-12 PCS scores at 6 weeks, 12 weeks, and 6 months postoperatively. Previously, 3-month follow-up was demonstrated to be sufficient in detecting statistically significant improvements in PROs.³⁵ As such, 6-month follow-up was deemed appropriate in this study. These changes in patient-reported outcome scores were then tested for association with preoperative MCS score (continuous). Achievement of minimum clinical

TABLE 1. Baseline characteristics of the patient population

Variable	Value
Mean age, yrs	49.2 ± 9.4
Sex	
Female	22 (42.3)
Male	30 (57.7)
Smoking status	
Nonsmoker	47 (90.4)
Smoker	5 (9.6)
No. of levels	
1	30 (57.7)
2	22 (42.3)
Body mass index, kg/m ²	
<30 (nonobese)	33 (63.5)
>30 (obese)	19 (36.5)
Mean CCI	1.08 ± 1.32

cally important difference (MCID) at the 6-month postoperative visit for NDI, neck VAS, arm VAS, and SF-12 PCS scores was compared between patients in the bottom half of the preoperative MCS score and patients in the top half of the preoperative MCS score. According to previously reported MCID, values of 17.3, 2.6, 4.1, and 8.1 were used as the MCID for NDI, neck VAS, arm VAS, and SF-12 PCS scores, respectively.³⁵

Statistical Analysis

Statistical analysis was performed using Stata/MP (version 13.1 for Mac, StataCorp LP). First, the preoperative SF-12 MCS score was tested for association with preoperative NDI, neck VAS, arm VAS, and SF-12 PCS scores using bivariate regression to characterize baseline correlations. Second, change in NDI, neck VAS, arm VAS, and SF-12 PCS scores at each postoperative time point was tested for association with preoperative SF-12 MCS score using multivariate linear regression controlling for patient age, sex, smoking status, obesity, Charlson Comorbidity Index (CCI), insurance type, and the preoperative score for the PROs being assessed. Finally, patients in the top and bottom halves of preoperative MCS score were compared using multivariate linear regression controlling for all preoperative characteristics. A *p* value < 0.05 was used to determine statistical significance.

Results

A total of 81 patients underwent a primary 1- or 2-level ACDF during the time period and were eligible for the study. Of the 81 eligible patients, 52 (64.2%) completed all surveys at each scheduled visit and were included in the analysis. Using an SF-12 MCS score cutoff of 47.5, 26 patients were placed in the “bottom half” group and 26 patients were placed in the “top half” group. Table 1 provides demographic information regarding the study population.

The associations between preoperative MCS score and preoperative PROs are illustrated in Figs. 1 and 2. Lower

FIG. 1. Graph representing the association between preoperative mental health scores (SF-12 MCS) and preoperative NDI. Figure is available in color online only.

FIG. 2. Graph representing the association between preoperative mental health scores (SF-12 MCS) and preoperative arm VAS. Figure is available in color online only.

preoperative MCS was associated with higher preoperative NDI (coefficient -0.74 , 95% CI -1.08 to -0.39 ; $p < 0.001$ [Fig. 1]) and higher preoperative arm VAS score (coefficient -0.06 , 95% CI -0.11 to -0.01 ; $p = 0.026$ [Fig. 2]). Preoperative MCS score was not associated with the preoperative neck VAS score (coefficient: -0.03 , 95% CI -0.09 to 0.02 ; $p = 0.325$). Finally, preoperative MCS was not associated with preoperative SF-12 PCS (coefficient: 0.04 , 95% CI -0.11 to 0.24 ; $p = 0.664$).

The associations between preoperative MCS score and changes in PROs from preoperative to postoperative visits are provided in Table 2. MCS score was not associated with change in NDI from the preoperative visit at any of the postoperative visits (6-week, $p = 0.929$; 12-week, $p = 0.667$; 6-month, $p = 0.838$). Preoperative MCS score was not associated with change in neck VAS score from the preoperative visit at any postoperative visit (6-week, $p = 0.586$; 12-week, $p = 0.468$; 6-month, $p = 0.742$). Similarly, preoperative MCS score was not associated with change in arm VAS score from the preoperative visit at any postoperative visit (6-week, $p = 0.125$; 12-week, $p = 0.635$; 6-month, $p = 0.297$). Finally, preoperative MCS score was not associated with change in SF-12 PCS score from the preoperative visit at any postoperative visit (6-week, $p = 0.217$; 12-week, $p = 0.368$; 6-month, $p = 0.538$).

Information on the achievement of MCID for each of the PROs is provided in Tables 3 and 4. There were no differences between the upper and lower halves of preoperative MCS scores for percentage of patients achieving MCID for NDI (42.3% vs 53.9%, $p = 0.788$), neck VAS (57.7% vs 50.0%, $p = 0.519$), arm VAS (38.5% vs 38.5%, $p = 1.00$), or SF-12 PCS (57.7% vs 65.4%, $p = 0.489$) score. There were also no significant differences in mean preoperative MCS score between those patients who achieved MCID and those who did not for NDI ($p = 0.730$), neck VAS ($p = 0.883$), arm VAS ($p = 0.284$), and SF-12 PCS ($p = 0.503$) scores.

Discussion

Several risk factors have been theorized to affect PROs following spinal surgery. While some of these risk fac-

tors such as patient age and sex are not modifiable, certain medical comorbidities can be adequately treated prior to surgery. Recently, there has been an increasing focus on preoperative depression and other mental health symptoms as they have demonstrated the potential to impair the degree of improvement in PROs following spinal surgery.^{34,37} However, a majority of prior literature has evaluated the effect of depression on outcomes of lumbar spinal surgery, while cervical spine literature remains sparse. In this context, the purpose of this study was to evaluate whether preoperative mental health was predictive of change in outcomes in patients undergoing ACDF.

The results of this study suggest that the preoperative SF-12 MCS score is not predictive of changes in disability or pain from pre- to postoperative visits. Consistent with these results, the patients with the lowest preoperative MCS scores achieved MCID in NDI, neck VAS, arm VAS, and SF-12 PCS scores at similar rates to the patients with the highest preoperative MCS score. This suggests that surgeons should not necessarily assume that a patient with poor preoperative mental health status is likely to experience worse outcomes than a patient with no psychosomatic symptoms.

To our knowledge, no studies have reported the lack of an association between preoperative mental health status and worse outcomes following cervical spine surgery. However, few studies have examined this relationship for cervical fusion, relative to the lumbar spine literature. The results of the present study are similar to those reported by Ng et al. in a study of 100 patients with spinal stenosis who underwent posterior lumbar decompression; neither preoperative anxiety nor depression demonstrated an association with postoperative PRO measures.³³ In a similar study examining depression and multiple other psychosomatic symptoms, Herron et al. concluded that postoperative outcomes following lumbar spine surgery were not predicted by any preoperative psychological condition.²¹ Similarly, Katz et al. demonstrated no association between preoperative depression and postoperative satisfaction or improvement in PROs following lumbar spine decompression with or without fusion.^{23,24} Lastly, depression was not found to be associated with postoperative pain or disability, despite

TABLE 2. Preoperative MCS score association with patient-reported outcome measures

Variable	Mean $\pm$ SD	Change $\pm$ SD	Coefficient $\pm$ SE	95% CI	p Value*
NDI					
Preop	42.8 $\pm$ 18.5				
6-wk	35.8 $\pm$ 19.1	-7.0 $\pm$ 17.6	0.02 $\pm$ 0.20	-0.40 to 0.43	0.929
12-wk	30.2 $\pm$ 21.6	-12.6 $\pm$ 17.5	-0.09 $\pm$ 0.21	-0.34 to 0.52	0.667
6-mo	26.4 $\pm$ 22.4	-16.4 $\pm$ 20.1	0.05 $\pm$ 0.23	-0.43 to 0.53	0.838
VAS neck					
Preop	6.0 $\pm$ 2.6				
6-wk	3.5 $\pm$ 2.4	-2.5 $\pm$ 2.6	-0.01 $\pm$ 0.03	-0.07 to 0.04	0.586
12-wk	3.3 $\pm$ 2.7	-2.7 $\pm$ 2.8	-0.02 $\pm$ 0.02	-0.07 to 0.03	0.468
6-mo	3.0 $\pm$ 2.8	-3.0 $\pm$ 3.2	0.01 $\pm$ 0.03	-0.05 to 0.07	0.742
VAS arm					
Preop	5.7 $\pm$ 2.5				
6-wk	2.4 $\pm$ 2.2	-3.3 $\pm$ 2.8	-0.04 $\pm$ 0.02	-0.08 to 0.01	0.125
12-wk	2.4 $\pm$ 2.6	-3.3 $\pm$ 2.9	-0.01 $\pm$ 0.02	-0.06 to 0.04	0.635
6-mo	2.5 $\pm$ 2.4	-3.2 $\pm$ 3.1	-0.03 $\pm$ 0.02	-0.07 to 0.02	0.297
SF-12 PCS					
Preop	33.1 $\pm$ 8.2				
6-wk	36.0 $\pm$ 9.1	2.2 $\pm$ 8.2	0.18 $\pm$ 0.14	-0.11 to 0.48	0.217
12-wk	40.0 $\pm$ 10.9	5.6 $\pm$ 9.9	0.15 $\pm$ 0.17	-0.19 to 0.50	0.368
6-mo	41.1 $\pm$ 10.8	8.1 $\pm$ 10.5	0.09 $\pm$ 0.15	-0.20 to 0.39	0.538

* p values were calculated using multivariate regression controlling for age, sex, smoking status, BMI category, CCI, number of levels, and preoperative outcome value.

depressed patients having a lower return to work rate following lumbar fusion.³⁶

The findings of the present study challenge the majority of previously published literature suggesting an association between preoperative psychological symptoms and postoperative outcomes following spinal surgery.^{1,3–7,26,30,32,34} While many of these studies evaluated outcomes of lumbar spine surgery, few have assessed cervical spine patients. In a study of 151 patients undergoing surgery for cervical radiculopathy, Skeppholm et al. reported that patients with high preoperative mental distress reported worse overall outcomes at 2 years following surgery.³⁷ Likewise, Alvin et al. concluded that patients with greater preoperative depression had less improvement in quality of life following posterior cervical fusion.⁴ Two other studies assessed the effect of preoperative depression on postoperative patient-reported pain and disability, reporting that patients with higher levels of depression experienced inferior outcomes following cervical disc replacement.^{20,41} However, none of these studies assessed patients undergoing ACDF.

While several studies do conclude that preoperative mental health is associated with postoperative outcomes following cervical spine surgery, such conclusions are not supported by our results. The relatively few studies published reporting no association may be due to publication bias, a well-reported occurrence in which positive results are more likely to be published than studies reporting negative results.^{11,13,14,28,29} This trend of preferentially publishing studies that demonstrate a significant effect may overrepresent the effect of mental health on PROs following cervical and lumbar spine surgery.

Interestingly, the preoperative MCS score was associated with preoperative perceived disability and arm pain, but it was not associated with patient-reported neck pain. These results imply that disability and arm pain may be more closely correlated to mental health than neck pain. However, causation cannot be inferred due to the retrospective nature of this study. It is unclear if worse mental health status leads to an increased reporting of disability, or if worse disability leads to worse mental health status. Consistent with the results demonstrated in the current study, depression has been associated with patient-reported disability in patients scheduled to undergo spine surgery.^{12,38}

The present study is not without limitations. First, all procedures were performed by a single surgeon at a single academic center, limiting the generalizability to other patient populations and surgeons. Second, there are inherent biases present with all retrospective studies, and, as mentioned previously, causality cannot be determined.

TABLE 3. Percentage of patients who achieved MCID by MCS half

Variable	No. of Patients (%)		p Value*
	Bottom Half (n = 26)	Top Half (n = 26)	
NDI	11 (42.3)	14 (53.9)	0.788
VAS neck	15 (57.7)	13 (50.0)	0.519
VAS arm	10 (38.5)	10 (38.5)	1.00
SF-12 PCS	15 (57.7)	17 (65.4)	0.489

* p values were calculated using multivariate regression controlling for age, sex, smoking status, BMI category, CCI, and preoperative outcome value.

TABLE 4. MCS score association with attainment of MCID in patient-reported outcome measures.

Variable	No. of Patients	Mean MCS $\pm$ SD	p Value*
NDI			0.730
MCID not achieved	27	49.0 $\pm$ 11.8	
MCID achieved	25	43.8 $\pm$ 13.9	
VAS neck			0.883
MCID not achieved	24	45.7 $\pm$ 13.1	
MCID achieved	28	47.2 $\pm$ 13.1	
VAS arm			0.284
MCID not achieved	32	46.3 $\pm$ 11.8	
MCID achieved	20	46.9 $\pm$ 15.0	
SF-12 PCS			0.503
MCID not achieved	32	46.9 $\pm$ 13.5	
MCID achieved	20	45.8 $\pm$ 12.3	

* p values were calculated using multivariate regression controlling for age, sex, smoking status, body mass index category, CCI, insurance status, and preoperative outcome value.

Third, the total number of patients who completed all surveys was small, with a patient loss of 35.8% due to nonresponse. At 80% power and $\alpha = 0.05$, a sample size of 56 would be sensitive enough to detect effect sizes (for mean differences) for all PROs included.³⁵ As such, our population of 52 patients may be slightly underpowered to detect an association between preoperative mental health status and changes in disability and pain. However, none of the results demonstrated trends toward significance, so this is unlikely. While longer follow-up would strengthen the results of the study, statistically significant improvements in neck VAS score, arm VAS score, NDI, SF-12 PCS score, and EQ-5D at 3 months postoperatively have been demonstrated in other instances.³⁵ Fourth, the sensitivity and specificity of the mental health cutoff is limited by the use of only one survey. However, the SF-12 MCS has been demonstrated to be acceptable for detecting both active and recent depressive disorders in the general population.⁴⁰ Finally, the evolution of mental health postoperatively for improvement could not be analyzed because of lack of survey response during follow-up. Previously, Vilagut et al.⁴⁰ noted that the optimal SF-12 MCS score cutoff for detection of depressive disorders was 40.2–45.6. Thus, our cutoff value of 48 may represent an adequate point for detection of depressive disorders.

Conclusions

The present study suggests that preoperative mental health status (assessed using the SF-12 MCS) is not predictive of change in NDI, neck VAS, arm VAS, or SF-12 PCS score from preoperative to postoperative time points following ACDF. Although increased preoperative disability was associated with lower preoperative MCS score, patients with worse mental health status demonstrated similar improvements in PRO measures following ACDF. Future studies assessing alternative preoperative variables may discover alternative predictors of worse outcomes following cervical spine surgery.

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Author Contributions

Conception and design: Singh, Mayo, Massel, Bohl, Basques, Yacob. Acquisition of data: Singh, Mayo, Massel, Narain, Long, Modi. Analysis and interpretation of data: Singh, Mayo, Massel, Bohl, Narain, Hijji, Basques, Yacob. Drafting the article: Singh, Mayo, Massel, Narain, Hijji, Long, Modi, Basques. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Singh. Statistical analysis: Singh, Mayo, Massel, Bohl, Narain, Basques. Administrative/technical/material support: Singh, Narain, Hijji. Study supervision: Singh.

Correspondence

Kern Singh, Department of Orthopaedic Surgery, Rush University Medical Center, 1611 W Harrison St., Ste. 300, Chicago, IL 60612. email: kern.singh@rushortho.com.