The Impact of Preoperative Depression and Health State on Quality-of-Life Outcomes after Anterior Cervical Diskectomy and Fusion

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Abstract

Study Design Retrospective cohort study.

Objective We sought to assess the predictive value of preoperative depression and health state on 1-year quality-of-life outcomes after anterior cervical diskectomy and fusion (ACDF).

Methods We analyzed 106 patients who underwent ACDF. All patients had either bilateral or unilateral cervical radiculopathy. Preoperative and 1-year postoperative health outcomes were assessed based on the visual analog scale, Pain Disability Questionnaire (PDQ), Patient Health Questionnaire (PHQ-9), and EuroQol-5 Dimensions (EQ-5D) questionnaire. Univariable and multivariate regression analyses were performed to assess for preoperative predictors of 1-year change in health status according to the EQ-5D.

Results Compared with preoperative health states, the ACDF cohort showed statistically significant improved PDQ (78.5 versus 57.9), PHQ-9 (9.7 versus 5.3), and EQ-5D (0.55 versus 0.68) scores at 1 year postoperatively and surpassed the minimum clinically important difference for the EQ-5D of 0.1 units (all $p \leq 0.01$). Multivariate linear regression indicated that anxiolytic use and higher EQ-5D preoperative scores were associated with less 1-year postoperative improvement in health status. Although not statistically significant, clinically important effects of preoperative depression, as measured by the PHQ-9, were observed on postoperative QOL outcome (−0.006, 95% confidence interval −0.014 to 0.001).

Keywords
- ACDF
- PHQ-9
- depression
- outcomes
- cervical fusion

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Conclusions Of patients who undergo ACDF with similar preoperative QOL health states, those with a greater degree of depression may have lower improvements in postoperative QOL compared with those with less depression. Patients with anxiety and better preoperative health states also attain less 1-year QOL improvements.

Introduction

Several studies have demonstrated that anterior cervical diskectomy and fusion (ACDF) leads to significant improvements in quality-of-life (QOL) outcomes.[1–5] However, to maximize the success of surgery and reduce complications and poor outcomes, optimal patient selection of surgical candidates is imperative. Better understanding of the preoperative predictors of postoperative outcomes will improve the patient selection for these elective procedures and enable targeted strategies for patients at higher risk. In addition, it will allow for more appropriate counseling of individual patients on the degree of the improvement they can expect from the surgery.

Prior studies have identified several demographic and clinical variables that can predict improved QOL outcomes in patients undergoing ACDF.[6–8] These predictive factors include male sex, younger age, nonsmoking status, greater segmental kyphosis, and lower preoperative pain and disability level. QOL outcomes have been evaluated via Odom's criteria, neck disability index, and pain intensity scales, such as the visual analog scale (VAS).[9–13] Prior studies on lumbar spine surgery have identified a strong negative correlation between psychological factors, such as depression, and clinical outcomes (i.e., patients with worse preoperative depression fare worse following surgery).[9–12,14,15] However, no study to date has analyzed the impact of depression or anxiety on the postoperative QOL outcomes after ACDF. In the present study, we sought to assess the impact of preoperative depression, as well as other baseline patient characteristics, on the QOL outcomes after ACDF. We hypothesized that ACDF would lead to significantly improved QOL outcomes in all patients as measured by the 1-year postoperative EuroQol-5 Dimensions (EQ-5D) Index, VAS-Arm, and Pain Disability Questionnaire (PDQ) scores; however, subjects with greater preoperative depression would have reduced improvement in the aforementioned QOL outcomes.

Institutional Review Board approval (no. 13-215) was obtained prior to initiation of the study.

Materials and Methods

Patient Selection

The electronic medical records were retrospectively reviewed at a single academic institution to identify the patient demographic information and QOL outcomes. The study patients were identified using our institutional Knowledge Program and by screening the records for patients who underwent ACDF for radiculopathy with autograft and plating between 2009 and 2011, with a minimum follow-up of 1 year. The Knowledge Program is patient-derived outcome assessment tool embedded in our electronic medical record that began collecting patient data in 2009. Our Quantitative Health Science Department prospectively administers the QOL questionnaires (VAS, PDQ, EQ-5D) at each preoperative and postoperative outpatient visit. Only patients with cervical radiculopathy were included. Patients were excluded if they were younger than 18 years or had previous cervical spine surgery, myelopathy, nonspondylotic causes of radicular pain (e.g., tumor, infection), neuromuscular disease (e.g., multiple sclerosis), or a workers' compensation claim.

Quality-of-Life Outcome Measures

The preoperative and 1-year postoperative QOL scores including the VAS-Arm,[13] PDQ,[16] Patient Health Questionnaire-9 (PHQ-9),[17,18] and EQ-5D[19–21] were acquired via the institutional Knowledge Program. For all measures except the EQ-5D, a decrease in score represents improvement. The data has been systematically collected since 2009, in a prospective fashion, at the time of the patient visits. The minimum clinically important difference (MCID) identified a priori for each questionnaire in a 1-year time frame was as follows: VAS (2.6), PDQ (20), PHQ-9 (5), and EQ-5D (0.1).[4,22]

The PHQ-9 was used to assess the preoperative impact of depression on the QOL outcomes. The PHQ-9 is a self-administered assessment for depression in patients that evaluates the nine criteria in the *Diagnostic and Statistical Manual of Mental Disorders (*fifth edition*)* for major depressive disorder. Each of the nine questions is scored from 0 ("not at all") to 3 ("nearly every day"), making the total score range from 0 to 27. The total score is commonly categorized into one of five groups: no symptoms (score = 0 to 4), minimal symptoms (score = 5 to 9), minor depression (score = 10 to 14), moderately severe major depression (score = 15 to 19), and severe major depression (score = 20 to 27). In the present study, we used total PHQ-9 scores rather than categorical scores. Although not tested in the present population, the diagnostic validity of the PHQ-9 has been established in large multicenter analyses with other medical patients.[17,18]

The PDQ questionnaire records functional and psychosocial components of pain, with a total score between 0 and 150, with increasing pain reflected by an increasing score. The VAS questionnaire is a psychometric measure scored from 0 to 10 used to subjectively assess pain. The EQ-5D contains five dimensions of health state: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is scored from 0 to 3. An EQ-5D score is then calculated from these five dimension subscores. This score represents

the patient's quality-adjusted life-years (QALY), ranging from a QALY of 0 (death) to 1 (perfect health).[19–22]

Once identified, the patient sample was assessed for the impact of demographic factors and medications (i.e., antidepressants, narcotics) on postoperative QOL outcomes. Then, the patient sample was assessed for the impact of preoperative depression via PHQ-9 scores.

Statistical Analysis

Continuous data was expressed as the mean ± standard deviation (SD) whereas categorical data was expressed as count (percentage). The changes in scores for the four QOL measures were assessed by paired *t* tests. The primary aim was to assess the independent effect of preoperative depression and the preoperative QOL outcomes (health state) on 1-year postoperative QOL outcome change (EQ-5D postoperative score minus EQ-5D preoperative score). The variables that were marginally associated ($p < 0.2$) with EQ-5D QOL outcome improvements (via simple linear regression) were included in a multivariate linear regression model to assess for independent predictors of EQ-5D change. Additionally, each surgery was classified as either successful (1-year change in EQ-5D greater than or equal to 0.1, the MCID) or unsuccessful (1-year change in EQ-5D less than 0.1, the MCID). Again, the variables that were marginally associated ($p < 0.2$) with surgical success (via simple logistic regression) were included in a multivariate logistic regression model to assess for independent predictors of surgical success. Statistical analyses were performed using the JMP pro 10 statistical software (SAS Institute Inc., Cary, North Carolina, United States). A significance level of 0.05 was selected; however, the primary focus is placed on point estimates and 95% confidence intervals.

Table 1 Preoperative characteristics of 106 patients who underwent ACDF for cervical radiculopathy

Preoperative characteristics	Sample
Patients	106
Age (y)	52.5 ± 11.4
Male sex	66 (62%)
BMI (kg/m^2)	31.1 ± 6.3
Smoking history	67 (63%)
Diabetic	16 (15%)
Income ($)	54,500 ± 14,400
Antidepressants	42 (40%)
Anxiolytics	18 (17%)
Narcotics	69 (65%)
Radiculopathy laterality	
Bilateral	48 (45%)
Unilateral right	36 (34%)
Unilateral left	22 (21%)
Levels	
C3–C4	5 (5%)
C4–C5	30 (28%)
C5–C6	49 (46%)
C6–C7	22 (21%)

Abbreviations: ACDF, anterior cervical diskectomy and fusion; BMI, body mass index.

Results

Demographics

In all, 106 patients underwent ACDF and were included based on the aforementioned inclusion criteria (►**Table 1**). As the primary focus of the present study was on estimating the effect of preoperative depression via the PHQ-9 on change in QOL via the EQ-5D, justification of the sample size was based on the desired precision of this estimate. With an MCID of 0.1 in the EQ-5D, 100 observations would allow estimation of this effect with precision of 0.02, assuming at most six independent variables in the linear regression model and a standard error of 0.01.

The patient sample was 62% male (66/106) and had an average age of 52.5 years, an average body mass index of 31.1, and an average annual income of $54,500. Moreover, 67 patients (63%) were current or former smokers, 16 (15%) had diabetes, 42 (40%) were taking an antidepressant medication, 18 (17%) were taking an anxiolytic medication, and 69 (65%) were taking a narcotic medication. No significant differences existed in QOL outcomes between male and female subjects. In addition, demographic factors, such as age, ethnicity, smoking history, and body mass index, medication usage, laterality of radiculopathy, and level of surgery were statistically analyzed between male and female patients using the Fisher exact test. No significant differences were observed. No peri- or postoperative complications occurred for the ACDF cohort over the 1-year period. Five fellowship-trained spine surgeons performed all of the operations. There were no significant differences in number of surgeries, surgical technique, patient characteristics, surgical approaches, levels operated, or postoperative outcome among the surgeons.

One-Year QOL Outcomes

At 1 year postoperatively, a statistically significant improvement in QOL outcomes was observed for all dependent variables (►**Table 2**), including (preoperative versus postoperative) the VAS-Arm (4.4 versus 3.7), PDQ functional component (48.1 versus 35.1), PDQ psychosocial component (30.4 versus 22.8), PDQ total (78.5 versus 57.9), PHQ-9 (9.7 versus 5.3), and EQ-5D (0.55 versus 0.68; $p < 0.01$ for all questionnaires). However, only the average improvement in EQ-5D surpassed the MCID.

Regression Analysis

Regression analysis was performed with change in EQ-5D (postoperative EQ-5D minus preoperative EQ-5D) as the dependent variable (►**Tables 3** and **4**). Simple linear regression analyses indicated that smoking history, income,

Table 2 Preoperative and 1-Year Postoperative Quality-of-Life Outcomes

	ACDF ($n = 106$)	p Value
VAS		
Preoperative	4.4 ± 3.1	0.01
Postoperative 1 y	3.7 ± 3.2	
Change	−0.7 ± 2.7	
PDQ FC		
Preoperative	48.1 ± 21.9	0.0004
Postoperative 1 y	35.1 ± 25.8	
Change	−10.6 ± 23.3	
PDQ PC		
Preoperative	30.4 ± 14.8	0.0001
Postoperative 1 y	22.8 ± 17.4	
Change	−6.8 ± 13.3	
PDQ total		
Preoperative	78.5 ± 35.1	<0.0001
Postoperative 1 y	57.9 ± 42.4	
Change	−19.9 ± 29.6	
PHQ-9		
Preoperative	9.7 ± 6.9	<0.01
Postoperative 1 y	5.3 ± 5.4	
Change	−4.3 ± 3.7	
EQ-5D index		
Preoperative	0.55 ± 0.26	<0.0001
Postoperative 1 y	0.68 ± 0.24	
Change	0.14 ± 0.21	

Abbreviations: ACDF, anterior cervical diskectomy and fusion; EQ-5D, EuroQol-5 Dimensions; FC, functional component; PC, psychosocial component; PDQ, Pain Disability Questionnaire; PHQ-9, Patient Health Questionnaire; VAS, visual analog scale.
Note: For all measures except the EQ-5D Index, a decrease in score represents improvement.

anxiolytic use, and all preoperative QOL scores (EQ-5D, PHQ-9, PDQ total, and VAS scores) were marginally associated ($p < 0.2$) with 1-year improvement in health status (EQ-5D change). When included in a multiple linear regression model, anxiolytic use (coefficient = −0.115; $p = 0.02$) and EQ-5D QALY baseline (coefficient = −0.532; $p < 0.0001$) were significantly negative predictors of postoperative EQ-5D improvement. Therefore, the average change in EQ-5D scores was 0.115 units less for patients using anxiolytics compared with patients not using anxiolytics. For each unit increase in EQ-5D QALY baseline, the average change in EQ-5D QALY was 0.532 units less. Although not statistically significant, the confidence interval for PHQ-9 baseline (−0.014, 0.001) includes clinically important effects. Linear regression assumptions of normality, linearity, and constant variance were confirmed.

Simple logistic regression analysis showed that PDQ baseline ($p = 0.12$), antidepressant use ($p = 0.15$), EQ-5D QALY baseline ($p < 0.0001$), and PHQ-9 baseline ($p = 0.07$) were marginally associated with a successful surgery (1-year improvement in EQ-5D exceeding the MCID). When included in a multivariate logistic regression model, only EQ-5D QALY baseline ($p = 0.0005$) remained a significant independent predictor of surgical success. The odds of a successful surgery decreased 99% for each unit increase in the EQ-5D QALY baseline score (odds ratio = 0.01; 95% confidence interval 0.001 to 0.11). Thus the main benefit of surgery was seen in those with poor preoperative health states. Linearity in the logistic regression was confirmed to be reasonable.

Discussion

Up to 20% of people experience symptoms of depression at some point during their lives.[9,10,14,15] In the candidates for spine surgery with chronic neck or low back pain, the prevalence of depression is greater than 50%.[9,10,14,15] Previous studies have shown that ACDF leads to statistically and clinically significant (greater than MCID) postoperative outcomes.[1–5] However, few have focused on identifying the predictive factors for superior clinical outcomes following ACDF. Those studies that have been performed did not investigate the impact of psychosocial factors on the outcomes. Peolsson et al performed three studies.[6–8] The first was a prospective study ($n = 103$) of factors that predict postoperative outcome of ACDF, as measured by the neck disability index, at 1 and 2 years postoperatively.[6] Results indicated that male sex, nonsmoking status, greater segmental kyphosis, and a low pain and disability level were significant preoperative predictors of superior outcome following ACDF. In the second study,[7] the authors conducted a similar prospective analysis ($n = 34$) of predictive factors for outcomes after ACDF measured at 1 and 3 years after surgery. The authors found that nonsmoking status, low pain level, and normal rating on the Distress and Risk Assessment Method (not measured in the authors' first study) were the best preoperative predictors of a good outcome following ACDF. The final study prospectively investigated the short-term postoperative outcomes following an ACDF in predicting the long-term outcomes.[8] Results indicated that the short-term outcomes measured via neck disability index and VAS scores were more useful in predicting the long-term outcomes than the baseline preoperative characteristics.

Few studies have examined the influence of depression on the outcomes following cervical spine surgeries. O'Neill et al retrospectively analyzed the clinical outcomes of patients ($n = 40$) receiving ACDF for the treatment of adjacent segment disease.[23] Using the Zung depression scale, the authors found reduced depression scores ($p = 0.049$; not exceeding the MCID) at 2 years postoperatively. This change suggests some value to the surgery in improving patient QOL, but such improvement may not be clinically recognized by the surgeon (i.e., improvement was less than the MCID). Much research has been done on this topic in the lumbar spine.[9–12,14,15] Adogwa et al analyzed the predictive value of the

Table 3 Associations among patient characteristics and change in EQ-5D Index with linear regression

Variable	Univariable		Multivariable		
	Coefficient	*p* Value	Coefficient	95% CI	*p* Value
Age	−0.001	0.43			
Female sex	0.005	0.90			
BMI	−0.001	0.86			
Smoking history	0.078	0.06	0.022	−0.056, 0.101	0.57
Diabetes	−0.036	0.53			
Income (per $1,000)	−0.002	0.17	−0.001	−0.003, 0.002	0.46
Anxiolytic use	−0.113	0.04	−0.115	−0.208, −0.022	0.02
Antidepressant use	0.049	0.24			
Narcotic use	−0.036	0.40			
Multiple vertebral levels	−0.030	0.48			
EQ-5D QALY score preoperative	−0.406	<0.0001	−0.532	−0.732, −0.332	<0.0001
PHQ-9 preoperative	0.007	0.01	−0.006	−0.014, 0.001	0.10
PDQ total preoperative	0.002	0.01			
VAS preoperative	0.009	0.18	−0.003	−0.016, 0.010	0.62

Abbreviations: BMI, body mass index; CI, confidence interval; EQ-5D, EuroQol-5 Dimensions; PDQ, Pain Disability Questionnaire; PHQ-9, Patient Health Questionnaire; QALY, quality-adjusted life-years; VAS, visual analog scale.
Note: Negative coefficients indicate less change in EQ-5D. For the multivariable model, $R^2 = 0.33$ and root mean square error = 0.18.

preoperative Zung depression scale on the QOL outcomes (mainly the Oswestry Disability Index improvement) and patient satisfaction after revision lumbar surgery.[14,15] The authors found that increasing preoperative Zung depression score (indicating greater depression) was significantly associated with less 2-year improvement for revision posterior lumbar instrumented fusion (i.e., greater preoperative depression leads to worse postoperative outcomes). In a prospective study ($n = 102$) of psychological predictors for lumbar surgery, Trief et al found that lack of postoperative improvement in pain or functional abilities was associated with increased preoperative anxiety ($p < 0.01$) or increased depression ($p < 0.05$) using the Zung depression scale.[9] LaCaille et al ($n = 73$) also found that increasing depression severity strongly predicted poorer patient outcomes after lumbar fusion.[10]

In the present study, we sought to assess the predictive value of preoperative depression and current health status (current QOL), along with other demographic factors, on 1-year patient QOL outcomes after ACDF for cervical radiculopathy. Our initial hypothesis was that those patients with greater preoperative depression would have decreased postoperative improvement. When analyzed by both linear and logistic regression, preoperative PHQ-9 scores were not statistically significantly associated with postoperative EQ-5D improvement. However, focus must be placed on the point estimate and confidence interval. The point estimate of −0.006 showed that, in this sample, greater preoperative depression led to smaller improvement in QOL outcomes. More specifically, when comparing two patients with similar preoperative QOL health states, the patient with more severe depression was shown to have worse QOL outcome

Table 4 Associations among patient characteristics and successful surgery with logistic regression

Variable	Odds ratio (95% CI)	*p* Value
Smoking history	2.56 (0.83, 8.22)	0.10
Antidepressant use	2.44 (0.83, 7.61)	0.11
PDQ preoperative	0.99 (0.96, 1.02)	0.46
EQ-5D QALY score preoperative	0.01 (0.0001, 0.32)	0.02
PHQ-9 preoperative	0.94 (0.83, 1.07)	0.38

Abbreviations: EQ-5D, EuroQol-5 Dimensions; PDQ, Pain Disability Questionnaire; PHQ-9, Patient Health Questionnaire; QALY, quality-adjusted life-year.
Note: Successful surgery defined using the accepted minimum clinically important difference of a preoperative to postoperative change in EQ-5D ≥ 0.1.

improvement. It is plausible that this effect is as large as −0.014 or as small as 0.001, which is a range that does not include the EQ-5D MCID of 0.1. However, this effect may still be clinically important beyond the MCID. The direction of the effect aligns with the clinical observations that motivated this study. All patients improved, but those with depression trended toward less improvement than those without depression. Thus, investigations with larger cohorts are needed to explore the significance of the association and to further define it, as well as to study what defines a clinically important change in EQ-5D. If verified, this result agrees with studies on lumbar spine surgery, which have found a significantly negative correlation between preoperative depression and the postoperative QOL outcomes.[9–12,14,15] Regarding the VAS improvement, the MCID was not achieved at 1 year, which is likely due to multiple reasons, including the sample size and follow-up duration. Given that patients had, on average, a low baseline VAS score (4.4), the room for improvement was minimal (MCID of 2.6). Surgery was still chosen as treatment in these patients with low preoperative VAS scores because of overall low QOL (i.e., EQ-5D) scores, patient preference, or nonimprovement with conservative measures over time. The VAS scores have been shown to significantly vary from patient subjective evaluation of pain, especially in the early postoperative period.[24,25] However, this lack of surpassing the MCID did not impact our statistical analyses as the EQ-5D score, which is considered the gold standard for evaluating patient QOL, was the primary measure utilized.[4,20]

The present study's results highlight potential differences between the cervical and lumbar spine surgery patient populations. Specifically, in comparison with the patients having lumbar spine surgery, the patients having cervical spine surgery may have a shorter duration of pain or be less affected by psychosocial variables, thereby deriving greater benefit from surgery. However, studies with direct comparisons between cervical and lumbar spine surgery groups have been sparse.[26,27] Further research may be necessitated to better understand the differences between these patient populations.

The two variables that did show clinically important and statistically significant associations with lower postoperative QOL outcomes were anxiolytic use and higher preoperative EQ-5D score. The former may indicate that patients with anxiety do worse after surgery than those without. However, this result needs to be validated using anxiety-measuring questionnaires in future studies. The latter indicates that patients who are in better health states preoperatively do not incur as much improvement in QOL compared with patients who are in worse health states preoperatively, which is essentially the result of a ceiling effect and the limitations in quantifying QOL. Specifically, with a maximum score of 1 on the EQ-5D, patients with higher preoperative scores had less room to improve than patients with lower preoperative scores, which led to the conclusion that higher preoperative EQ-5D scores were associated with lower postoperative improvements in QOL because these patients already were at a high QOL prior to surgery per their responses on the EQ-5D. We do not recommend that the decision to operate is simply based on the EQ-5D score, but more so a variety of clinical factors, including subjective assessment of QOL, outside the scope of this study. It was important to include the EQ-5D QALY baseline score in the multivariate model as it controls for the level of preoperative QOL and therefore allows for a fair comparison of depression states. By adjusting for the preoperative EQ-5D, we compared EQ-5D improvement in patients with the same preoperative EQ-5D but who differed only in their depression level. Because higher PHQ-9 scores (depression) are associated with lower EQ-5D scores (poor QOL), if preoperative EQ-5D had not been adjusted for in the model, the results would have been confounded due to greater potential for improvement among the depressed.

It is important to differentiate between patients with chronic pain and patients with preoperative depression. Spine surgeons are commonly hesitant to treat these patients given the possibility of worse outcomes. Multiple studies have shown that the severity or duration of chronic pain has a negative correlation with postoperative outcome.[28–31] In patients with lumbar spine symptoms, depression and chronic pain have been shown to be linked and to predict worse postoperative outcomes.[32] This result has not been shown for patients having cervical spine surgery and is not addressed in this study. Separating the effects of depression from chronic pain syndromes will allow for better patient selection.

The authors acknowledge certain limitations that must be considered when interpreting the results of the present study. First, a notable limitation to consider is the validity of patient responses in answering the questions related to depression on the PHQ-9 or EQ-5D questionnaire. Depression has a stigma, and some patients may manipulate their responses such that they are not perceived as depressed by clinicians. In addition, confounding factors such as who administers the questionnaire to the patient, when the questionnaire is administered, and the patient's current emotional state may influence the responses. However, these questionnaires have been validated as accurate measures of depression in previous studies.[13,16–18] In addition, our patient sample had an average baseline PHQ-9 score in the "mild" range of depression per PHQ-9 categories that limited the strength of our hypothesis testing, which may have been different had more severely depressed patients (higher baseline PHQ-9 scores) been part of the sample. In addition, the QOL data was limited to 1 year postoperatively, which is less than the ideal 2-year or more follow-up window, but still important in assessing the initial data trends and providing patients with the appropriate counseling postoperatively. Finally, retrospective analyses have inherent limitations in complete/accurate data collection. Despite these limitations, the present study's methodologies agree with those of previous analyses on predictive factors for surgical outcomes.[14,15] Thus, with sufficient corroboration through future prospective analyses, the results of this study are useful to those conducting comparative effectiveness research in the spine

surgery patient population. Furthermore, the results can be used to better counsel patients on expected postoperative improvement.

Conclusion

In this sample of patients who underwent ACDF with similar preoperative QOL health states, those with a greater degree of depression trended toward lower improvements in postoperative QOL compared with those with less depression. Thus, depression may be an important consideration in identifying those patients most likely to improve with ACDF surgery. Patients with anxiety may incur a lower degree of postoperative improvement than other patients. Future prospective studies with larger sample sizes and patients with higher levels of depression are needed to corroborate these findings.

Disclosures
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