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CLINICAL ARTICLE

Do comorbid self-reported depression and anxiety influence outcomes following surgery for cervical spondylotic myelopathy?

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OBJECTIVE Depression and anxiety are associated with inferior outcomes following spine surgery. In this study, the authors examined whether patients with cervical spondylotic myelopathy (CSM) who have both self-reported depression (SRD) and self-reported anxiety (SRA) have worse postoperative patient-reported outcomes (PROs) compared with patients who have only one or none of these comorbidities.

METHODS This study is a retrospective analysis of prospectively collected data from the Quality Outcomes Database CSM cohort. Comparisons were made among patients who reported the following: 1) either SRD or SRA, 2) both SRD and SRA, or 3) neither comorbidity at baseline. PROs at 3, 12, and 24 months (scores for the visual analog scale [VAS] for neck pain and arm pain, Neck Disability Index [NDI], modified Japanese Orthopaedic Association [mJOA] scale, EQ-5D, EuroQol VAS [EQ-VAS], and North American Spine Society [NASS] patient satisfaction index) and achievement of respective PRO minimal clinically important differences (MCIDs) were compared.

RESULTS Of the 1141 included patients, 199 (17.4%) had either SRD or SRA alone, 132 (11.6%) had both SRD and SRA, and 810 (71.0%) had neither. Preoperatively, patients with either SRD or SRA alone had worse scores for VAS neck pain (5.6 ± 3.1 vs 5.1 ± 3.3, p = 0.03), NDI (41.0 ± 19.3 vs 36.8 ± 20.8, p = 0.007), EQ-VAS (57.0 ± 21.0 vs 60.7 ± 21.7, p = 0.03), and EQ-5D (0.53 ± 0.23 vs 0.58 ± 0.21, p = 0.008) than patients without such disorders. Postoperatively, in multivariable adjusted analyses, baseline SRD or SRA alone was associated with inferior improvement in the VAS neck pain score and a lower rate of achieving the MCID for VAS neck pain score at 3 and 12 months, but not at 24 months. At 24 months, patients with SRD or SRA alone experienced less change in EQ-5D scores and were less likely

ABBREVIATIONS ACCF = anterior cervical corpectomy and fusion; ACDF = anterior cervical discectomy and fusion; ASA = American Society of Anesthesiologists; CDR = cervical disc replacement; CSM = cervical spondylotic myelopathy; EQ-VAS = EuroQol VAS; MCID = minimal clinically important difference; mJOA = modified Japanese Orthopaedic Association; NASS = North American Spine Society; NDI = Neck Disability Index; PRO = patient-reported outcome; QOD = Quality Outcomes Database; SRA = self-reported anxiety; SRD = self-reported depression; VAS = visual analog scale.

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to meet the MCID for EQ-5D than patients without SRD or SRA. Furthermore, patient self-reporting of both psychological comorbidities did not impact PROs at all measured time points compared with self-reporting of only one psychological comorbidity alone. Each cohort (SRD or SRA alone, both SRD and SRA, and neither SRD nor SRA) experienced significant improvements in mean PROs at all measured time points compared with baseline ($p < 0.05$).

CONCLUSIONS Approximately 12% of patients who underwent surgery for CSM presented with both SRD and SRA, and 29% presented with at least one symptom. The presence of either SRD or SRA was independently associated with inferior scores for 3- and 12-month neck pain following surgery, but this difference was not significant at 24 months. However, at long-term follow-up, patients with SRD or SRA experienced lower quality of life than patients without SRD or SRA. The comorbid presence of both depression and anxiety was not associated with worse patient outcomes than either diagnosis alone.

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KEYWORDS depression; anxiety; cervical spondylotic myelopathy; patient-reported outcomes; Quality Outcomes Database

Cervical spondylotic myelopathy (CSM) is an age-related degenerative condition of the cervical spine that results in spinal cord compression. Symptoms often develop insidiously and commonly involve sensory and motor deficits that can significantly impact patient quality of life.[1] The incidence of psychiatric disorders such as depression and anxiety is high in patients with degenerative spine disorders.[2–6] Specifically, depressed or anxious mood has been reported in more than one-third of patients with CSM and is associated with gait impairment.[7]

The negative association between psychiatric disorders, such as depression and anxiety, and postoperative pain and outcome is well established in the spine literature.[8–10] The debilitating impact of CSM on functional capacity and quality of life—coupled with the fairly high rate of psychiatric symptoms in this patient population—lead to the question of whether the combination of comorbid depression and anxiety further diminishes the quality of short- and long-term surgical outcomes in patients with CSM. Toward this end, we used the Quality Outcomes Database (QOD) CSM module to explore whether patients with CSM who have self-reported depression (SRD) and self-reported anxiety (SRA) have worse postoperative patient-reported outcomes (PROs) compared with those who have only one or none of these comorbidities.

Methods

Selection of Patients

This was a retrospective study of data prospectively collected from an augmented data set from the QOD Registry Cervical Module. Institutional review board approval from the University of California, San Francisco, was obtained and patient consent was waived due to the retrospective nature of the study.

The QOD Registry Cervical Module consists of a representative sample of patients—from each participating QOD site—who have undergone cervical surgery for degenerative disease, including disc herniation, stenosis (foraminal/central), instability, pseudarthrosis, and adjacent-segment disease. This augmented data set represents the coordination of 14 high-enrolling sites that combined their QOD Registry Cervical Module data and collected additional data points. Data were audited by a central team and by individual sites. The inclusion criteria of the augmented data set (the QOD CSM cohort) have been described previously.[11–18] We included adult patients aged ≥ 18 years with the following: 1) a surgical indication of CSM, 2) a predominant symptom of myelopathy, 3) a modified Japanese Orthopaedic Association (mJOA) score < 17, and 4) a history of elective surgery between January 2016 and December 2018. Patients were excluded if they had spinal infection, tumor, fracture, traumatic dislocation, deformity, or neurological paralysis due to preexisting spine disease or injury. We divided the patients into their respective cohorts depending on whether they reported 1) both SRD and SRA, 2) SRD or SRA alone, or 3) neither SRD nor SRA at a baseline preoperative encounter. It is important here to note that the symptoms of depression and/or anxiety were self-reported and not clinically diagnosed.

Study Variables

Demographic data included age, sex, race, insurance type, education level, and employment status. Baseline clinical characteristics included body mass index (BMI); smoking status; American Society of Anesthesiologists (ASA) grade; type of symptoms (arm weakness, arm pain, arm numbness, neck pain); location of pain (neck, arm); comorbidities (diabetes mellitus type 1 or 2, coronary artery disease, arthritis); procedure type (anterior cervical discectomy and fusion [ACDF], anterior cervical corpectomy and fusion [ACCF], cervical disc replacement [CDR], laminectomy with fusion, laminectomy without fusion, laminoplasty); and degree of cervical myelopathy, neck and arm pain, disability, and quality of life. Perioperative outcomes included estimated blood loss, length of hospital stay, readmission within 30 and 90 days, and reoperation within 30 days. Postoperative outcomes included PROs, change in PROs, meeting minimal clinically important differences (MCIDs) in PROs, and return to work and baseline activities.

Study Outcomes

We collected 3-, 12-, and 24-month outcomes for each of the PROs. Specifically, neck and arm pain were measured using the visual analog scale (VAS) with scores ranging from 0 (no pain) to 10 (worst pain possible). Neck

TABLE 1. Baseline characteristics, perioperative outcomes, and complications for comparison between patient cohorts with either depression or anxiety versus those with neither depression nor anxiety

Variable	Either Depression or Anxiety (n = 199)	Neither Depression nor Anxiety (n = 810)	p Value
Age, yrs	60.2 ± 11.6	61.0 ± 11.9	0.37
Female	125 (62.8)	330 (40.7)	<0.001*
BMI	31.2 ± 6.3	29.9 ± 6.2	0.009*
Smoker	37 (18.6)	130 (16.0)	0.27
Comorbidities			
Diabetes mellitus	42 (21.1)	175 (21.6)	0.88
Coronary artery disease	18 (9.0)	74 (9.1)	0.97
Arthritis	58 (29.1)	213 (26.3)	0.43
Caucasian	166 (83.4)	592 (73.1)	0.001*
College-level education ≥4 yrs	73 (36.7)	290 (35.8)	0.83
Employed or employed & on leave	71 (35.7)	405 (50.0)	<0.001*
Insurance			0.11
Medicare	80 (40.2)	315 (38.9)	
Medicaid	24 (12.1)	47 (5.8)	
VA/government	5 (2.5)	18 (2.2)	
Private	87 (43.7)	421 (52.0)	
Presenting symptoms			
Arm weakness	58 (29.1)	252 (31.1)	0.59
Arm pain	97 (48.7)	358 (44.2)	0.25
Arm numbness	114 (57.3)	475 (58.6)	0.73
Neck pain	133 (66.8)	505 (62.3)	0.23
Predominant pain location			0.01*
Neck	74 (37.2)	241 (29.8)	
Arm	34 (17.1)	136 (16.8)	
Motor deficit	125 (62.8)	491 (60.6)	0.57
Independently ambulatory	154 (77.4)	673 (83.1)	0.15
Symptom duration, mos			0.67
<12	89 (44.7)	376 (46.4)	
>12	94 (47.2)	355 (43.8)	
ASA grade			0.44
1 or 2	102 (51.3)	440 (54.3)	
3 or 4	97 (48.7)	370 (45.7)	
Procedure breakdown			0.047*
ACDF	99 (49.7)	482 (59.5)	
ACCF	19 (9.5)	67 (8.3)	
CDR	8 (4.0)	25 (3.1)	
Laminectomy w/ fusion	53 (26.6)	159 (19.6)	
Laminectomy w/o fusion	14 (7.0)	48 (5.9)	
Laminoplasty	6 (3.0)	29 (3.6)	
mJOA, baseline	12.0 ± 2.8	12.2 ± 2.8	0.34
VAS neck pain, baseline	5.6 ± 3.1	5.1 ± 3.3	0.03*
VAS arm pain, baseline	5.0 ± 3.1	4.8 ± 3.5	0.36
NDI, baseline	41.0 ± 19.3	36.8 ± 20.8	0.007*
EQ-VAS, baseline	57.0 ± 21.0	60.7 ± 21.7	0.03*
EQ-5D, baseline	0.53 ± 0.23	0.58 ± 0.21	0.008*
Estimated blood loss, ml	94.5 ± 113	87.1 ± 135	0.42
Hospitalization duration, days	2.4 ± 2.4	2.0 ± 2.3	0.07

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TABLE 1. Baseline characteristics, perioperative outcomes, and complications for comparison between patient cohorts with either depression or anxiety versus those with neither depression nor anxiety

Variable	Either Depression or Anxiety (n = 199)	Neither Depression nor Anxiety (n = 810)	p Value
Discharge disposition			0.21
Home routine	156 (78.4)	665 (82.1)	
Home w/ home healthcare services	13 (6.5)	59 (7.3)	
Post– or non–acute care setting	28 (14.1)	77 (9.5)	
Another acute care facility	2 (1.0)	7 (0.9)	
Readmission w/in 30 days			0.67
Hematoma	0 (0)	3 (0.4)	
SSI	0 (0)	2 (0.2)	
Wound dehiscence	1 (0.5)	1 (0.1)	
Readmission w/in 90 days			0.85
Hematoma	0 (0)	3 (0.4)	
SSI	2 (1.0)	1 (0.1)	
Wound dehiscence	2 (1.0)	3 (0.4)	
DVT	0 (0)	2 (0.2)	
Reop w/in 30 days			0.39
Hematoma	0 (0)	2 (0.2)	
SSI	1 (0.5)	2 (0.2)	

DVT = deep vein thrombosis; SSI = surgical site infection; VA = Veterans Affairs.
Values are presented as mean ± SD or number (%) of patients unless otherwise indicated.
* Significant difference with $p < 0.05$.

and arm pain changes were calculated by obtaining the difference between the VAS pain score at each follow-up time point and the score at baseline. MCIDs in neck and arm pain were defined as a binary variable either achieving or not achieving the MCID (which is a score change of –2.6 points for neck pain and –4.1 for arm pain).[19–21] The degree of cervical myelopathy was assessed using the mJOA score, which defines myelopathy as follows: scores 15–17, mild; 12–14, moderate; and 0–11, severe.[22] To achieve MCID, patients with mJOA scores > 14 needed to improve by +1, those with mJOA scores of 12–14 needed to improve by +2, and those with mJOA scores < 12 needed to improve by +3.[23] Disability was determined by using the Neck Disability Index (NDI), which is used to assess the extent to which neck pain contributes to a patient's ability to perform activities of daily living by summing patient-reported pain ratings (ranging from 0 indicating no pain to 5 indicating worst pain possible) from 10 sections and converted to a percentage (out of 100%). MCID was met if patients underwent a change of –17.3%.[20] Health status was evaluated using the EuroQol VAS (EQ-VAS) score, which ranges from 0 (worst imaginable health) to 100 (best imaginable health). Health-related quality of life was measured using the EQ-5D, which is graded on a scale from –0.11 (state equivalent to being dead) to 1 (full health). MCID was achieved if patients experienced improvement of +0.0485.[20] Finally, patient satisfaction was evaluated using the North American Spine Society (NASS) patient satisfaction index with scores ranging from 1 to 4. A score of 1 indicates "the treatment met my expectations"; 2 indicates "I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome"; 3 indicates "I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome"; and 4 indicates "I am the same or worse than before treatment."

Statistical Analysis

Descriptive categorical variables were summarized using frequency counts and continuous variables using means. Linear regression was used for continuous variables, logistic regression was used for categorical variables, and ordinal logistic regression was used for ordinal variables. Paired and unpaired t-tests and ANOVA were utilized as appropriate. Multivariable analysis, including covariates reaching $p < 0.05$ on univariate comparisons among the different comparison groups, was used to compare the differences in PROs at 3-, 12-, and 24-month follow-ups between patients as follows: 1) those who had either SRD or SRA versus neither SRD nor SRA, and 2) those who had either SRD or SRA versus those who had both SRD and SRA. Missing data were handled with the MissForest imputation algorithm, which imputes all missing data using the mean/mode and then fits a random forest model to predict the missing values for each variable by going through an iterative process until a stopping criterion is met. This imputation algorithm was appropriate for this study because data were missing at random, as shown in Supplemental Fig. 1. All analyses were done using RStudio.

TABLE 2. Univariate comparison of clinical outcomes for depression or anxiety versus neither depression nor anxiety

Variable	Depression or Anxiety (n = 199)	Neither Depression nor Anxiety (n = 810)	Unadjusted p Value
3 mos			
VAS neck pain	3.3 ± 2.7	2.7 ± 2.4	0.005*
VAS neck pain change	–2.3 ± 3.1	–2.4 ± 3.2	0.85
MCID VAS neck pain	88 (44.2)	380 (46.3)	0.50
VAS arm pain	2.5 ± 3.0	2.2 ± 2.5	0.30
VAS arm pain change	–2.6 ± 3.5	–2.6 ± 3.5	0.98
MCID VAS arm pain	62 (31.2)	251 (31.0)	0.96
mJOA	13.9 ± 2.4	14.0 ± 2.4	0.69
mJOA change	1.9 ± 2.6	1.7 ± 2.5	0.51
MCID mJOA	110 (55.3)	406 (50.1)	0.19
NDI	25.8 ± 16.8	22.4 ± 16.2	0.01*
NDI change	–15.2 ± 18.0	–14.4 ± 18.9	0.59
MCID NDI	89 (44.7)	348 (43.0)	0.66
EQ-VAS	67.8 ± 18.9	70.5 ± 17.8	0.07
EQ-VAS change	10.8 (21.5)	9.9 (22.3)	0.58
EQ-5D	0.71 ± 0.19	0.74 ± 0.18	0.01*
EQ-5D change	0.17 ± 0.23	0.16 ± 0.21	0.55
MCID EQ-5D	132 (66.3)	550 (67.9)	0.68
NASS satisfaction†			0.98
1	144 (72.4)	561 (69.3)	
2	33 (16.6)	160 (19.8)	
3	7 (3.5)	35 (4.3)	
4	15 (7.5)	54 (6.7)	
Return to work	120 (60.3)	503 (62.1)	0.004*
Return to activities	67 (33.7)	280 (34.6)	0.521
12 mos			
VAS neck pain	3.3 ± 2.5	2.7 ± 2.5	0.004*
VAS neck pain change	–2.4 ± 3.4	–2.4 ± 3.2	0.92
MCID VAS neck pain	96 (48.2)	395 (48.8)	0.90
VAS arm pain	2.4 ± 2.5	2.3 ± 2.5	0.38
VAS arm pain change	–2.6 ± 3.2	–2.5 ± 3.5	0.82
MCID VAS arm pain	59 (29.6)	255 (31.5)	0.61
mJOA	13.5 ± 2.6	13.9 ± 2.4	0.07
mJOA change	1.5 ± 2.9	1.7 ± 2.7	0.48
MCID mJOA	97 (48.7)	392 (48.4)	0.93
NDI	23.1 ± 16.5	20.1 ± 16.7	0.02*
NDI change	–17.9 ± 19.1	–16.7 ± 19.4	0.43
MCID NDI	101 (50.8)	387 (47.8)	0.45
EQ-VAS	69.9 ± 15.8	70.8 ± 18.2	0.51
EQ-VAS change	12.9 ± 22.0	10.1 ± 23.6	0.11
EQ-5D	0.70 ± 0.19	0.75 ± 0.17	0.001*
EQ-5D change	0.17 ± 0.25	0.17 ± 0.21	0.97
MCID EQ-5D	133 (66.8)	571 (70.5)	0.33
NASS satisfaction†			0.58
1	127 (63.8)	522 (64.4)	
2	46 (23.1)	194 (24.0)	
3	9 (4.5)	45 (5.6)	
4	17 (8.5)	49 (6.0)	
Return to work	131 (65.8)	586 (72.3)	0.006*

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TABLE 2. Univariate comparison of clinical outcomes for depression or anxiety versus neither depression nor anxiety

Variable	Depression or Anxiety (n = 199)	Neither Depression nor Anxiety (n = 810)	Unadjusted p Value
12 mos (*continued*)			
Return to activities	75 (37.7)	297 (36.7)	0.81
24 mos			
VAS neck pain	2.9 ± 2.7	2.6 ± 2.6	0.16
VAS neck pain change	–2.8 ± 3.5	–2.5 ± 3.4	0.36
MCID VAS neck pain	103 (51.8)	398 (49.1)	0.51
VAS arm pain	2.3 ± 2.6	2.2 ± 2.7	0.85
VAS arm pain change	–2.7 ± 3.6	–2.5 ± 3.7	0.50
MCID VAS arm pain	77 (38.7)	275 (34.0)	0.22
mJOA	13.8 ± 2.3	14.1 ± 2.3	0.09
mJOA change	1.8 ± 2.9	1.9 ± 2.9	0.65
MCID mJOA	101 (50.8)	424 (52.3)	0.69
NDI	24.2 ± 17.5	19.8 ± 17.3	0.002*
NDI change	–16.7 ± 20.2	–17.0 ± 20.4	0.88
MCID NDI	107 (53.8)	388 (47.9)	0.14
EQ-VAS	66.7 ± 20.4	69.2 ± 20.2	0.12
EQ-VAS change	9.7 (24.5)	8.5 (25.6)	0.54
EQ-5D	0.69 ± 0.35	0.74 ± 0.28	0.05
EQ-5D change	0.16 ± 0.25	0.17 ± 0.23	0.70
MCID EQ-5D	127 (63.8)	568 (70.1)	0.10
NASS satisfaction†			0.28
1	138 (69.3)	547 (67.5)	
2	39 (19.6)	151 (18.6)	
3	9 (4.5)	46 (5.7)	
4	13 (6.5)	66 (8.1)	
Return to work	116 (58.3)	521 (64.3)	0.44
Return to activities	69 (34.7)	211 (26.0)	0.30

Values are presented as mean ± SD or number (%) of patients unless otherwise indicated.
* Significant difference with $p < 0.05$.
† Comparing NASS 1 and 2, indicating patient satisfaction, versus 3 and 4, indicating dissatisfaction.

Results

Descriptive and Preoperative Characteristics of Patients With One Self-Reported Psychological Symptom Versus None

From January 2016 through December 2018, 5289 patients were enrolled in the QOD Registry Cervical Module at the 14 participating sites. Overall, 1141 patients met the inclusion criteria and were included in the QOD CSM cohort. In total, 948 (83.1%) reached the 24-month follow-up. Of the 1141 patients, 199 (17.4%) patients self-reported having preoperative depression (119 [10.4%]) or anxiety (80 [7.0%]), while 810 (71.0%) had neither. We found that those who had SRD or SRA were more often female (62.8% vs 40.7%, $p < 0.001$) and Caucasian (83.4% vs 73.1%, $p = 0.001$), had higher BMI (31.2 ± 6.3 vs 29.9 ± 6.2, $p = 0.009$), and were less likely to be employed (35.7% vs 50.0%, $p < 0.001$) compared with those without any self-reported psychiatric symptoms (Table 1). Preoperatively, patients with SRD or SRA had worse VAS neck pain (5.6 ± 3.1 vs 5.1 ± 3.3, $p = 0.03$), NDI (41.0 ± 19.3 vs 36.8 ± 20.8, $p = 0.007$), EQ-VAS (57.0 ± 21.0 vs 60.7 ± 21.7, $p = 0.03$), and EQ-5D (0.53 ± 0.23 vs 0.58 ± 0.21, $p = 0.008$) compared with those without SRD or SRA.

Perioperative Outcomes for One Self-Reported Psychological Symptom Versus None

Table 1 shows the comparison of perioperative outcomes between the two cohorts. There was no difference in estimated blood loss (94.5 ± 113 vs 87.1 ± 135 ml, $p = 0.42$), length of hospitalization (2.4 ± 2.4 vs 2.0 ± 2.3 days, $p = 0.07$), and discharge disposition ($p = 0.21$). There also was no difference in the rates of readmission within 30 and 90 days and reoperation within 30 days (all $p > 0.05$).

Postoperative PROs in Patients With One Psychological Disorder Versus None

Univariable analysis of the postoperative clinical outcomes between the two cohorts is summarized in Table

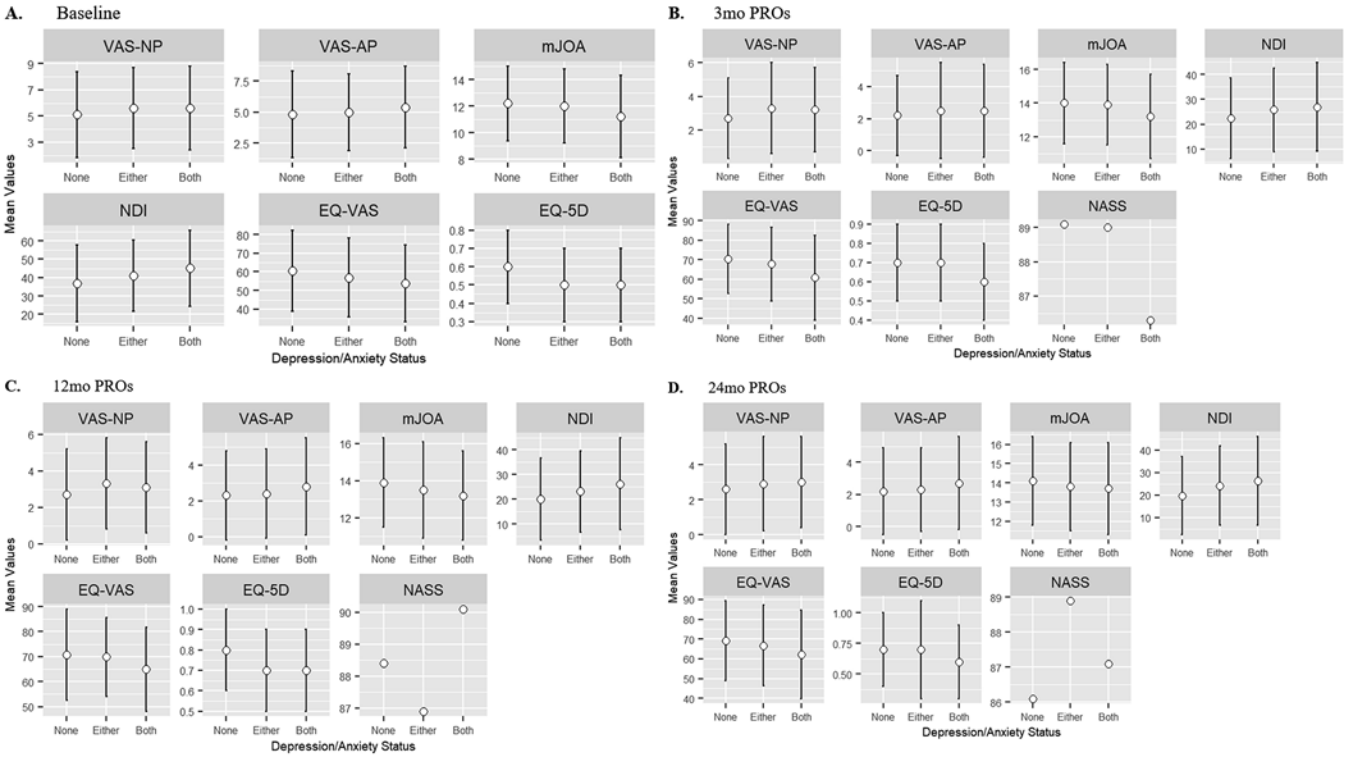

FIG. 1. Plots of baseline status and postoperative outcomes following surgery for CSM stratified by presence or absence of psychological disorder(s). Note that the NASS patient satisfaction index is reported as a percentage of patients who achieved scores of 1 and 2, indicating satisfaction with surgery. Baseline status (**A**), 3-month follow-up after surgery (**B**), 12-month follow-up after surgery (**C**), and 24-month follow-up after surgery (**D**).

2 and Fig. 1. At both 3- and 12-month follow-ups, patients with SRD or SRA reported worse VAS neck pain (3 months: 3.3 ± 2.7 vs 2.7 ± 2.4, p = 0.005; 12 months: 3.3 ± 2.5 vs 2.7 ± 2.5, p = 0.004), NDI (3 months: 25.8 ± 16.8 vs 22.4 ± 16.2, p = 0.01; 12 months: 23.1 ± 16.5 vs 20.1 ± 16.7, p = 0.02), and EQ-5D (3 months: 0.71 ± 0.19 vs 0.74 ± 0.18, p = 0.01; 12 months: 0.70 ± 0.19 vs 0.75 ± 0.17, p = 0.001) and less often returned to work (3 months: 60.3% vs 62.1%, p = 0.004; 12 months: 65.8% vs 72.3%, p = 0.006) compared with patients who did not have SRD or SRA. However, at the 24-month follow-up, the only difference in outcomes observed between the two cohorts was NDI, with patients who reported SRD or SRA having a worse NDI score (24.2 ± 17.5 vs 19.8 ± 17.3, p = 0.002).

Multivariable analysis (after controlling for significant covariates) of the postoperative clinical outcomes between the two cohorts is described in Table 3. At the 3-month follow-up, patients who had SRD or SRA experienced less improvement in VAS neck pain (β = 0.4, 95% CI [0.1–0.8], adjusted p = 0.02), had smaller VAS neck pain change (β = 0.4, 95% CI [0.1–0.8], adjusted p = 0.02), and less frequently met the MCID for VAS neck pain (OR 0.93, 95% CI [0.9–0.99], adjusted p = 0.02) compared with those without SRD or SRA. At the 12-month follow-up, patients who had SRD or SRA still experienced worse VAS neck pain (β = 0.4, 95% CI [0.05–0.8], adjusted p = 0.03) and smaller VAS neck pain change (β = 0.4, 95% CI [0.05–0.8], adjusted p = 0.03), but the difference in meeting the MCID for VAS neck pain disappeared (p > 0.05). However, patients with SRD or SRA had inferior outcomes in EQ-5D (β = –0.03, 95% CI [–0.06 to 0.007], adjusted p = 0.01), experienced a smaller change in EQ-5D (β = –0.03, 95% CI [–0.06 to 0.007], adjusted p = 0.01), and less often met the MCID for EQ-5D (OR 0.92, 95% CI [0.9–0.98], adjusted p = 0.01) compared with those without SRD or SRA. At the 24-month follow-up, all differences in VAS neck pain outcomes disappeared (all p > 0.05), but the patients with SRD or SRA still had a smaller change in EQ-5D (β = –0.04, 95% CI [–0.06 to 0.007], adjusted p = 0.02) and less often met the MCID for EQ-5D (OR 0.9, 95% CI [0.8–0.96], adjusted p < 0.001) compared with those without SRD or SRA.

Descriptive and Preoperative Characteristics of Patients With One Versus Multiple Self-Reported Psychological Symptoms

Of the 1141 patients included in the registry, 132 (11.6%) patients had both SRD and SRA (Table 4). There was no significant difference in the demographic characteristics between patients who reported either SRD or SRA and those who reported both SRD and SRA. Preoperatively, patients with both SRD and SRA reported worse baseline mJOA (11.2 ± 3.1 vs 12.0 ± 2.8, p = 0.02), NDI (45.1 ± 20.8 vs 41.0 ± 19.3, p = 0.07), and EQ-5D (0.47 ± 0.21 vs 0.53 ± 0.23, p = 0.008) compared with those with either SRD or SRA.

TABLE 3. Multivariable comparison of clinical outcomes at 3, 12, and 24 months

Variable	β (95% CI)	OR (95% CI)	Adjusted p Value
3 mos			
VAS neck pain	0.4 (0.1 to 0.8)		0.02*
VAS neck pain change	0.4 (0.1 to 0.8)		0.02*
MCID VAS neck pain		0.93 (0.9 to 0.99)	0.02*
VAS arm pain	0.13 (–0.3 to 0.5)		0.52
VAS arm pain change	0.3 (–0.2 to 0.8)		0.24
MCID VAS arm pain		0.97 (0.9 to 1.04)	0.39
mJOA	0.1 (–0.2 to 0.5)		0.55
mJOA change	0.2 (–0.1 to 0.5)		0.28
MCID mJOA		1.03 (0.95 to 1.1)	0.41
NDI	1.4 (–0.8 to 3.6)		0.21
NDI change	1.4 (–0.8 to 3.6)		0.21
MCID NDI		0.97 (0.9 to 1.04)	0.40
EQ-VAS	–0.5 (–3.1 to 2.0)		0.68
EQ-VAS change	–0.5 (–3.1 to 2.0)		0.68
EQ-5D	–0.01 (–0.05 to 0.007)		0.14
EQ-5D change	–0.01 (–0.05 to 0.007)		0.14
MCID EQ-5D		0.94 (0.9 to 1.01)	0.08
NASS satisfaction†		0.99 (0.9 to 1.04)	0.66
Return to work		1.01 (0.96 to 1.1)	0.82
Return to activities		0.99 (0.9 to 1.1)	0.80
12 mos			
VAS neck pain	0.4 (0.05 to 0.8)		0.03*
VAS neck pain change	0.4 (0.05 to 0.8)		0.03*
MCID VAS neck pain		0.96 (0.9 to 1.02)	0.15
VAS arm pain	0.04 (–0.3 to 0.4)		0.82
VAS arm pain change	0.2 (–0.3 to 0.7)		0.41
MCID VAS arm pain		0.97 (0.9 to 1.04)	0.47
mJOA	–0.2 (–0.59 to 0.1)		0.21
mJOA change	–0.03 (–0.4 to 0.3)		0.86
MCID mJOA		0.98 (0.9 to 1.06)	0.57
NDI	1.4 (–0.8 to 3.7)		0.21
NDI change	1.4 (–0.8 to 3.7)		0.21
MCID NDI		0.98 (0.9 to 1.04)	0.49
EQ-VAS	1.3 (–1.2 to 3.9)		0.30
EQ-VAS change	1.3 (–1.2 to 3.9)		0.30
EQ-5D	–0.03 (–0.06 to 0.007)		0.01*
EQ-5D change	–0.03 (–0.06 to 0.007)		0.01*
MCID EQ-5D		0.92 (0.9 to 0.98)	0.01*
NASS satisfaction†		0.99 (0.9 to 1.04)	0.68
Return to work		1.02 (0.97 to 1.07)	0.52
Return to activities		1.01 (0.95 to 1.08)	0.68
24 mos			
VAS neck pain	0.06 (–0.3 to 0.4)		0.77
VAS neck pain change	0.06 (–0.3 to 0.4)		0.77
MCID VAS neck pain		0.97 (0.9 to 1.03)	0.36
VAS arm pain	–0.02 (–0.6 to 0.2)		0.35
VAS arm pain change	–0.007 (–0.6 to 0.2)		0.98
MCID VAS arm pain		1.02 (0.95 to 1.1)	0.52

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TABLE 3. Multivariable comparison of clinical outcomes at 3, 12, and 24 months

Variable	β (95% CI)	OR (95% CI)	Adjusted p Value
24 mos (*continued*)			
mJOA	−0.1 (−0.5 to 0.2)		0.39
mJOA change	−0.3 (−0.8 to 0.1)		0.17
MCID mJOA		0.96 (0.9 to 1.04)	0.34
NDI	2.3 (−0.2 to 4.8)		0.07
NDI change	2.3 (−0.2 to 4.8)		0.07
MCID NDI		1.0 (0.95 to 1.12)	0.79
EQ-VAS	−0.6 (−3.6 to 2.4)		0.70
EQ-VAS change	−0.6 (−3.6 to 2.4)		0.70
EQ-5D	−0.03 (−0.08 to 0.01)		0.18
EQ-5D change	−0.04 (−0.06 to −0.007)		0.02*
MCID EQ-5D		0.9 (0.8 to 0.96)	<0.001*
NASS satisfaction†		1.02 (0.97 to 1.1)	0.38
Return to work		0.99 (0.9 to 1.1)	0.84
Return to activities		1.00 (0.9 to 1.1)	0.89

β coefficients and 95% CIs are presented for patients with depression or anxiety, with those with neither as the reference group, for multivariable analyses. The β coefficient represents the average degree of change in the outcome variable when patients with depression or anxiety are considered, compared with those with neither. If the β coefficient is positive, then patients with depression or anxiety have a higher value for that outcome variable than those with neither. ORs and 95% CIs are presented for categorical variables.

* Significant difference with $p < 0.05$.

† Comparing NASS 1 and 2, indicating patient satisfaction, versus 3 and 4, indicating dissatisfaction.

Perioperative Outcomes in Patients With One Versus Multiple Psychological Disorders

Between the two cohorts, there were no significant differences in estimated blood loss, length of hospitalization, discharge disposition, or readmission within 30 and 90 days and reoperation within 30 days (all $p > 0.05$) (Table 4).

Postoperative PROs in Patients With One Versus Multiple Psychological Disorders

Univariable analysis data of the postoperative PROs in the two patient groups are shown in Table 5 and Fig. 1. At the 3-month follow-up, patients with both SRD and SRA demonstrated worse mJOA (13.2 ± 2.5 vs 13.9 ± 2.4, $p = 0.01$), EQ-VAS (60.8 ± 21.7 vs 67.8 ± 18.9, $p = 0.003$), and EQ-5D (0.63 ± 0.21 vs 0.71 ± 0.19, $p = 0.001$) than patients with either SRD or SRA. At the 12-month follow-up, patients with both SRD and SRA demonstrated worse EQ-VAS (65.0 ± 16.8 vs 69.9 ± 15.8, $p = 0.009$) but more often met the MCID for EQ-5D (78.8% vs 66.8%, $p = 0.02$) and more often returned to work (79.5% vs 65.8%, $p = 0.02$) than patients with either SRD or SRA. At the 24-month follow-up, the only difference was in the change in myelopathy, with patients with both SRD and SRA experiencing greater change in mJOA scores (2.5 ± 3.5 vs 1.8 ± 2.9, $p = 0.046$) compared with patients with either SRD or SRA.

Multivariable analysis (after accounting for covariates) of the postoperative PROs between the two groups is summarized in Table 6. At all follow-up time points, there were no significant differences in the measured outcomes between the two groups.

Multivariable analysis to determine the predictors for patients not meeting the MCID for PROs after surgery at the 24-month follow-up was conducted using backward stepwise selection. Results are shown in Supplemental Tables 1 and 2 for patients with depression and/or anxiety and those with neither depression nor anxiety, respectively.

Discussion

To the authors' knowledge, this is the largest study to date that has explored the association between comorbid SRD and SRA and long-term PROs following surgery in patients with CSM. At baseline, patients with either SRD or SRA had worse neck pain, neck disability, health status, and quality of life compared with the patients without these self-reported symptoms. Importantly, there was an additive association whereby the combination of both SRD and SRA (compared with either alone) was associated with worse baseline myelopathy severity, neck disability, and quality of life. Despite presenting with worse baseline disease, patients with both SRD and SRA reported mean improvement in all measured outcomes. In multivariable adjusted 24-month analyses, patients with either SRD or SRA demonstrated a lower degree of change in and achievement of MCIDs in quality of life. However, when patients with comorbid SRD and SRA were compared with those with only SRD or SRA, we found no significant differences in the measured outcomes between the two groups at all follow-up time points.

TABLE 4. Baseline characteristics, perioperative outcomes, and complications of patients for comparison between cohorts with depression or anxiety alone versus both depression and anxiety

Variable	Depression or Anxiety (n = 199)	Both Depression & Anxiety (n = 132)	p Value
Age, yrs	60.2 ± 11.6	58.4 ± 11.2	0.17
Female	125 (62.8)	86 (65.2)	0.67
BMI	31.2 ± 6.3	30.3 2 ± 7.8	0.25
Smoker	37 (18.6)	37 (28.0)	0.06
Comorbidities			
Diabetes mellitus	42 (21.1)	28 (21.2)	0.98
Coronary artery disease	18 (9.0)	16 (12.1)	0.38
Arthritis	58 (29.1)	55 (41.7)	0.02*
Caucasian	166 (83.4)	112 (84.8)	0.73
≥4 yrs of college-level education	73 (36.7)	41 (31.1)	0.57
Employed or employed & on leave	71 (35.7)	51 (38.6)	0.85
Insurance			0.11
Medicare	80 (40.2)	45 (34.1)	
Medicaid	24 (12.1)	8 (6.1)	
VA/government	5 (2.5)	5 (3.8)	
Private	87 (43.7)	71 (53.8)	
Presenting symptoms			
Arm weakness	58 (29.1)	45 (34.1)	0.35
Arm pain	97 (48.7)	69 (52.3)	0.53
Arm numbness	114 (57.3)	87 (65.9)	0.11
Neck pain	133 (66.8)	91 (68.9)	0.69
Predominant location of pain			0.06
Neck	74 (37.2)	37 (28.0)	
Arm	34 (17.1)	17 (12.9)	
Motor deficit	125 (62.8)	79 (59.8)	0.59
Independently ambulatory	154 (77.4)	105 (79.5)	0.67
Symptom duration, mos			0.01*
<12	89 (44.7)	46 (34.8)	
≥12	94 (47.2)	68 (51.5)	
ASA grade			0.19
1 or 2	102 (51.3)	58 (43.9)	
3 or 4	97 (48.7)	74 (56.1)	
Procedure breakdown			0.29
ACDF	99 (49.7)	74 (56.1)	
ACCF	19 (9.5)	13 (9.8)	
CDR	8 (4.0)	4 (3.0)	
Laminectomy w/ fusion	53 (26.6)	26 (19.7)	
Laminectomy w/o fusion	14 (7.0)	6 (4.5)	
Laminoplasty	6 (3.0)	9 (6.8)	
mJOA, baseline	12.0 ± 2.8	11.2 ± 3.1	0.02*
VAS neck pain, baseline	5.6 ± 3.1	5.6 ± 3.2	0.98
VAS arm pain, baseline	5.0 ± 3.1	5.4 ± 3.3	0.36
NDI, baseline	41.0 ± 19.3	45.1 ± 20.8	0.07
EQ-VAS, baseline	57.0 ± 21.0	53.9 ± 20.6	0.18
EQ-5D, baseline	0.53 ± 0.23	0.47 ± 0.21	0.008*
Estimated blood loss, ml	94.5 ± 113	90.6 ± 105	0.75
Hospitalization duration, days	2.4 ± 2.4	2.1 ± 1.8	0.32

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TABLE 4. Baseline characteristics, perioperative outcomes, and complications of patients for comparison between cohorts with depression or anxiety alone versus both depression and anxiety

Variable	Depression or Anxiety (n = 199)	Both Depression & Anxiety (n = 132)	p Value
Discharge disposition			0.77
Home routine	156 (78.4)	100 (75.8)	
Home w/ home healthcare services	13 (6.5)	14 (10.6)	
Post– or non–acute care setting	28 (14.1)	16 (12.1)	
Another acute care facility	2 (1.0)	2 (1.5)	
Readmission w/in 30 days			0.62
Hematoma	0 (0)	1 (0.8)	
SSI	0 (0)	0 (0)	
Readmission w/in 90 days			0.06
Hematoma	1 (0.5)	0 (0)	
SSI	0 (0)	0 (0)	
Wound dehiscence	2 (1.0)	0 (0)	
DVT	2 (1.0)	0 (0)	
Reop w/in 30 days			0.39
Hematoma	0 (0)	1 (0.8)	
SSI	1 (0.5)	0 (0)	

Values are presented as mean ± SD or number (%) of patients unless otherwise indicated.
* Significant difference with $p < 0.05$.

It has been well established in previous studies that symptoms of depression and anxiety result in poorer pain and functional outcomes and lower satisfaction and quality of life after surgery for various degenerative spine conditions.[9,10,24] However, these studies mainly focused on the lumbar spine or a patient population with general degenerative cervical conditions. Moreover, studies exploring outcomes past the 12-month period are lacking. Our study is unique in that it specifically pertains to CSM patients and reports outcomes 24 months after surgery. In our study, after controlling for significant differences in baseline characteristics between the two cohorts with and without SRD or SRA, we found that an observed difference in neck pain at 3 and 12 months did not persist through the 24-month follow-up. A study by Goh et al. using their prospectively collected registry of 104 patients found that patients with poor preoperative mental health status—as indicated by the SF-36 Mental Component Summary assessment—who were undergoing ACDF for cervical myelopathy demonstrated similar rates of achievement of MCID in pain and disability/functional status, as well as similar rates of satisfaction at the 24-month follow-up.[25] One possible explanation for the poorer early neck pain outcomes in patients reporting SRD and/or SRA may be postural, with patients with depression exhibiting a higher incidence of head flexion and thoracic kyphosis[26,27] that may contribute to symptoms in the early phases after surgery. Alternatively, the difference may be predominantly due to psychological reasons, with patients with depressive or anxious symptoms more likely to catastrophize pain[28,29] and/or hold lower expectations and subjective perceptions of improvement in pain shortly after surgery.[8,9,30] Catastrophizing of pain—with increased reported pain intensity—may obscure the improvements observed in other short-term functional and myelopathy outcomes. However, neck symptoms gradually improve with recovery of function at longer follow-up. Altered perception of pain is another factor that may also account for our observation that patients with either depression or anxiety report lower improvements in quality of life after surgery compared with patients without these symptoms despite similar improvements in functional outcomes. Regardless of the mechanism, patients with depressive disorders are a subgroup of patients undergoing spine surgeries who may exhibit worse preoperative clinical status and postoperative outcomes.

Despite demonstrating similar levels of satisfaction, we found that patients with SRD or SRA experienced less improvement in EQ-5D scores and were less likely to meet EQ-5D MCID compared with patients without SRD or SRA at the 24-month follow-up. A single-institution retrospective study done by Doi et al. found similar results demonstrating worse health-related quality-of-life status as indicated by EQ-5D and SF-12 scores at least 12 months following surgery in patients with compared with those without depression or anxiety.[1] However, Doi et al. observed significant improvements in all quality-of-life outcome metrics and comparable satisfaction levels in the two cohorts. The dissociation between satisfaction and quality of life may have been related to the content and formulation of the questions in the EQ-5D or the constraints posed by the four NASS satisfaction categories. Our study further illustrates the persistence of the negative effect of preoperative psychological symptoms on postoperative quality of life—to a clinically relevant extent—up to 24 months

TABLE 5. Univariate comparison of clinical outcomes for depression or anxiety alone versus both depression and anxiety

Variable	Depression or Anxiety (n = 199)	Both Depression & Anxiety (n = 132)	Unadjusted p Value
3 mos			
VAS neck pain	3.3 ± 2.7	3.2 ± 2.5	0.75
VAS neck pain change	–2.3 ± 3.1	–2.4 ± 3.5	0.79
MCID VAS neck pain	88 (44.2)	67 (50.8)	0.25
VAS arm pain	2.5 ± 3.0	2.5 ± 2.9	0.82
VAS arm pain change	–2.6 ± 3.5	–2.8 ± 3.3	0.49
MCID VAS arm pain	62 (31.2)	43 (32.6)	0.79
mJOA	13.9 ± 2.4	13.2 ± 2.5	0.01*
mJOA change	1.9 ± 2.6	2.0 ± 3.1	0.75
MCID mJOA	110 (55.3)	66 (50.0)	0.35
NDI	25.8 ± 16.8	26.9 ± 17.8	0.57
NDI change	–15.2 ± 18.0	–18.2 ± 19.8	0.17
MCID NDI	89 (44.7)	64 (48.5)	0.50
EQ-VAS	67.8 ± 18.9	60.8 ± 21.7	0.003*
EQ-VAS change	10.8 (21.5)	6.9 (22.3)	0.11
EQ-5D	0.71 ± 0.19	0.63 ± 0.21	0.001*
EQ-5D change	0.17 ± 0.23	0.16 ± 0.22	0.73
MCID EQ-5D	132 (66.3)	98 (74.2)	0.12
NASS satisfaction†			0.49
1	144 (72.4)	91 (68.9)	
2	33 (16.6)	23 (17.4)	
3	7 (3.5)	3 (2.3)	
4	15 (7.5)	15 (11.4)	
Return to work	120 (60.3)	85 (64.4)	0.08
Return to activities	67 (33.7)	51 (38.6)	0.32
12 mos			
VAS neck pain	3.3 ± 2.5	3.1 ± 2.5	0.64
VAS neck pain change	–2.4 ± 3.4	–2.5 ± 3.1	0.70
MCID VAS neck pain	96 (48.2)	66 (50.0)	0.76
VAS arm pain	2.4 ± 2.5	2.8 ± 2.7	0.21
VAS arm pain change	–2.6 ± 3.2	–2.5 ± 3.3	0.93
MCID VAS arm pain	59 (29.6)	44 (33.3)	0.48
mJOA	13.5 ± 2.6	13.2 ± 2.4	0.31
mJOA change	1.5 ± 2.9	2.0 ± 3.2	0.13
MCID mJOA	97 (48.7)	65 (49.2)	0.93
NDI	23.1 ± 16.5	26.2 ± 18.6	0.11
NDI change	–17.9 ± 19.1	–18.9 ± 19.2	0.66
MCID NDI	101 (50.8)	72 (54.5)	0.5
EQ-VAS	69.9 ± 15.8	65.0 ± 16.8	0.009*
EQ-VAS change	12.9 (22.0)	11.1 (21.7)	0.47
EQ-5D	0.70 ± 0.19	0.68 ± 0.20	0.25
EQ-5D change	0.17 ± 0.25	0.21 ± 0.22	0.14
MCID EQ-5D	133 (66.8)	104 (78.8)	0.02*
NASS satisfaction†			0.36
1	127 (63.8)	87 (65.9)	
2	46 (23.1)	32 (24.2)	
3	9 (4.5)	4 (3.0)	
4	17 (8.5)	9 (6.8)	
Return to work	131 (65.8)	105 (79.5)	0.02*
Return to activities	75 (37.7)	49 (37.1)	0.95

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TABLE 5. Univariate comparison of clinical outcomes for depression or anxiety alone versus both depression and anxiety

Variable	Depression or Anxiety (n = 199)	Both Depression & Anxiety (n = 132)	Unadjusted p Value
24 mos			
VAS neck pain	2.9 ± 2.7	3.0 ± 2.6	0.60
VAS neck pain change	–2.8 ± 3.5	–2.6 ± 3.5	0.71
MCID VAS neck pain	103 (51.8)	68 (51.5)	0.97
VAS arm pain	2.3 ± 2.6	2.7 ± 2.9	0.2
VAS arm pain change	–2.7 ± 3.6	–2.7 ± 3.9	0.86
MCID VAS arm pain	77 (38.7)	50 (37.9)	0.88
mJOA	13.8 ± 2.3	13.7 ± 2.4	0.77
mJOA change	1.8 ± 2.9	2.5 ± 3.5	0.046*
MCID mJOA	101 (50.8)	78 (59.1)	0.14
NDI	24.2 ± 17.5	26.3 ± 19.6	0.34
NDI change	–16.7 ± 20.2	–18.8 ± 21.1	0.37
MCID NDI	107 (53.8)	64 (48.5)	0.35
EQ-VAS	66.7 ± 20.4	62.3 ± 22.4	0.07
EQ-VAS change	9.7 (24.5)	8.4 (26.6)	0.65
EQ-5D	0.69 ± 0.22	0.65 ± 0.23	0.4
EQ-5D change	0.16 ± 0.25	0.18 ± 0.25	0.53
MCID EQ-5D	127 (63.8)	94 (71.2)	0.16
NASS satisfaction†			0.62
1	138 (69.3)	85 (64.4)	
2	39 (19.6)	30 (22.7)	
3	9 (4.5)	7 (5.3)	
4	13 (6.5)	10 (7.6)	
Return to work	116 (58.3)	88 (66.7)	0.21
Return to activities	69 (34.7)	55 (41.7)	0.18

Values are presented as mean ± SD or number (%) of patients unless otherwise indicated.
* Significant difference with $p < 0.05$.
† Comparing NASS 1 and 2, indicating patient satisfaction, versus 3 and 4, indicating dissatisfaction.

after surgery. Altogether, spine surgeons may benefit from considering the lasting impact that psychological burden may have on clinical outcomes and identifying the patients at risk preoperatively.

We also explored if there was an additive association of multiple psychological symptoms with postoperative outcomes in patients undergoing surgery for CSM. In multivariable adjusted analysis, we found no significant differences in the measured outcomes between patients who reported both SRD and SRA at baseline and those who reported either SRD or SRA alone. Our results are supported by those of Mangan et al., who in their analysis of patients with SRD and/or SRA undergoing ACDF for degenerative cervical disease found no difference in pain, neck disability, and functional outcomes in patients with either depression or anxiety and patients with both anxiety and depression.[31] These findings fail to support an additive impact of self-reported psychological symptoms on postoperative outcomes and quality of life. These patients—although their baseline disease severity was worse than that of patients with SRD or SRA alone—may undergo surgery with apparent results that are similar to and as positive as those in patients with either psychological symptom alone.

In our study, we found no significant difference in postoperative neck disability and functional outcome between patients with and those without depression or anxiety, even after controlling for baseline differences. This finding contrasts with those of previous studies reporting psychological stresses as significant predictors of neck disability.[32,33] Moreover, in a study Phan et al. explored the relationship between depression and clinical outcomes following ACDF and found that depression and preoperative functional deficits were associated with a trend toward poorer postoperative functional outcomes after adjusting for baseline characteristics.[34] These studies, however, did not specifically consider patients with CSM, included both surgical and nonsurgical cohorts, and only considered a short follow-up time point (< 12 months). Also, functional outcome was evaluated with different assessment tools, with our study utilizing the mJOA score while other studies used the physical component of SF-12 or the Nurick score.

The implications from the results of our study are several. Our results suggest that successful surgical outcomes

TABLE 6. Multivariable comparison of clinical outcomes at 3, 12, and 24 months

Variable	β (95% CI)	OR (95% CI)	Adjusted p Value
3 mos			
VAS neck pain	−0.4 (−0.98 to 0.2)		0.19
VAS neck pain change	0.2 (−0.5 to 0.98)		0.54
MCID VAS neck pain		1.01 (0.9 to 1.1)	0.81
VAS arm pain	−0.3 (−0.96 to 0.4)		0.38
VAS arm pain change	−0.2 (−0.99 to 0.6)		0.63
MCID VAS arm pain		0.99 (0.89 to 1.1)	0.92
mJOA	−0.4 (−0.97 to 0.1)		0.15
mJOA change	−0.4 (−0.9 to 0.07)		0.10
MCID mJOA		0.94 (0.8 to 1.1)	0.31
NDI	−0.8 (−4.4 to 2.9)		0.69
NDI change	0.2 (−4.0 to 4.4)		0.92
MCID NDI		0.98 (0.9 to 1.1)	0.77
EQ-VAS	−3.9 (−8.2 to 0.4)		0.07
EQ-VAS change	−3.4 (−8.4 to 1.5)		0.17
EQ-5D	−0.04 (−0.08 to 0.004)		0.08
EQ-5D change	−0.04 (−0.08 to 0.004)		0.08
MCID EQ-5D		1.05 (0.96 to 1.2)	0.31
NASS satisfaction†		0.98 (0.9 to 1.1)	0.58
Return to work		0.90 (0.8 to 1.03)	0.12
Return to activities		1.08 (0.97 to 1.2)	0.16
12 mos			
VAS neck pain	−0.4 (−1.0 to 0.1)		0.14
VAS neck pain change	0.2 (−0.6 to 0.9)		0.60
MCID VAS neck pain		0.98 (0.9 to 1.1)	0.74
VAS arm pain	0.1 (−0.5 to 0.6)		0.84
VAS arm pain change	0.2 (−0.6 to 0.9)		0.66
MCID VAS arm pain		1.01 (0.9 to 1.1)	0.92
mJOA	−0.007 (−0.5 to 0.5)		0.98
mJOA change	−0.02 (−0.6 to 0.5)		0.95
MCID mJOA		1.01 (0.9 to 1.1)	0.87
NDI	0.7 (−3.1 to 4.6)		0.71
NDI change	1.7 (−2.5 to 5.9)		0.43
MCID NDI		0.97 (0.9 to 1.1)	0.59
EQ-VAS	−3.0 (−6.6 to 0.5)		0.10
EQ-VAS change	−2.5 (−7.4 to 2.3)		0.31
EQ-5D	0.006 (−0.04 to 0.05)		0.77
EQ-5D change	0.006 (−0.04 to 0.05)		0.77
MCID EQ-5D		1.1 (1.0 to 1.2)	0.05
NASS satisfaction†		1.04 (0.97 to 1.1)	0.29
Return to work		0.9 (0.8 to 1.0)	0.06
Return to activities		1.03 (0.9 to 1.1)	0.55
24 mos			
VAS neck pain	−0.3 (−0.9 to 0.3)		0.30
VAS neck pain change	0.3 (−0.5 to 1.1)		0.43
MCID VAS neck pain		0.98	0.77
VAS arm pain	0.07 (−0.5 to 0.7)		0.82
VAS arm pain change	0.2 (−0.6 to 1.1)		0.65
MCID VAS arm pain		0.95 (0.9 to 1.1)	0.38

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TABLE 6. Multivariable comparison of clinical outcomes at 3, 12, and 24 months

Variable	β (95% CI)	OR (95% CI)	Adjusted p Value
24 mos (*continued*)			
mJOA	0.2 (–0.4 to 0.7)		0.54
mJOA change	0.5 (–0.2 to 1.3)		0.14
MCID mJOA		1.07 (0.95 to 1.2)	0.27
NDI	–0.7 (–4.6 to 3.3)		0.75
NDI change	0.4 (–4.2 to 5.0)		0.87
MCID NDI		0.9 (0.8 to 1.01)	0.07
EQ-VAS	–2.4 (–7.1 to 2.3)		0.32
EQ-VAS change	–1.8 (–7.5 to 4.0)		0.54
EQ-5D	0.4 (–0.2 to 1.02)		0.23
EQ-5D change	–0.03 (–0.07 to 0.02)		0.30
MCID EQ-5D		1.01 (0.9 to 1.1)	0.84
NASS satisfaction†		1.0 (0.9 to 1.1)	0.91
Return to work		0.9 (0.8 to 1.03)	0.13
Return to activities		1.07 (0.98 to 1.2)	0.13

β coefficients and 95% CIs are presented for patients with depression or anxiety, with those with both as the reference group, for multivariable analyses. The β coefficient represents the average degree of change in the outcome variable when patients with depression or anxiety are considered, compared with those with both disorders. If the β coefficient is positive, then patients with depression or anxiety had a higher value for that outcome variable than those with both disorders. ORs and 95% CIs are presented for categorical variables.

* Significant difference with $p < 0.05$.

† Comparing NASS 1 and 2, indicating patient satisfaction, versus 3 and 4, indicating dissatisfaction.

may depend not only on successful surgery, but also on a given patient's physical and mental comorbidities. We found that patients with either depression or anxiety do worse overall but still improve after surgery (as established in the literature). The unique clinical question that we addressed through our study is whether patients with both depression and anxiety have outcomes that are additively worse than those of patients with either depression or anxiety alone. The important clinical implication presented in our study is that surgeons may counsel this patient population that while their postoperative outcomes may not be as favorable as those of patients without either psychological symptom, their outcomes will likely not be doubly worse. This knowledge may also guide future investigations, such as preoperative management of psychological symptoms to improve outcomes after surgery.

Study Limitations

There are several limitations associated with this study. Because this was a retrospective analysis of a prospective registry data set, selection bias may be present. Also, the self-reporting nature of depression and anxiety in this study could have resulted in a cohort sample that may not fully represent the following patients: 1) those who are clinically diagnosed with depression and/or anxiety and 2) those who are aggregated via a more structured selection process. However, there is a precedent of using SRD and SRA as a proxy for the clinical diagnosis of depression and anxiety in the literature.[31,35–38] Thus, our results expand on this previous literature. Additionally, given that this study is registry based, the data lack granularity, such as the duration and severity of SRD and/or SRA and any treatments pre- and/or postsurgery that could have influenced the measured outcomes. Finally, we assessed the association between baseline SRD and/or SRA and spine-relevant PROs but did not query SRD and/or SRA at postoperative time points. Thus, we lacked data on the persistence of these psychological symptoms after surgery. Future studies may be performed to investigate depression and/or anxiety at follow-up time points and leverage depression- and/or anxiety-specific PROs.

Conclusions

About 12% of patients who underwent surgery for CSM presented with both SRD and SRA, whereas 29% of patients had at least one of the symptoms. Although patients who had SRD or SRA presented with worse clinical status at baseline, patients on average, regardless of the presence of psychological symptoms, experienced improvement after surgery. Whereas patients with SRD or SRA reported less improvement in neck pain after surgery compared with those without SRD or SRA at short-term follow-up, this difference was not significant at long-term follow-up. Instead, at long-term follow-up, patients with SRD or SRA experienced smaller improvements in quality of life and were less likely to meet the MCID for quality of life compared with patients without SRD or SRA. No additive effect on outcomes following surgery was observed for patients who had the comorbid presence of both SRD and SRA psychological symptoms.

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