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CLINICAL ARTICLE

What is the effect of preoperative depression on outcomes after minimally invasive surgery for adult spinal deformity? A prospective cohort analysis

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OBJECTIVE Depression has been implicated with worse immediate postoperative outcomes in adult spinal deformity (ASD) correction, yet the specific impact of depression on those patients undergoing minimally invasive surgery (MIS) requires further clarity. This study aimed to evaluate the role of depression in the recovery of patients with ASD after undergoing MIS.

METHODS Patients who underwent MIS for ASD with a minimum postoperative follow-up of 1 year were included from a prospectively collected, multicenter registry. Two cohorts of patients were identified that consisted of either those affirming or denying depression on preoperative assessment. The patient-reported outcome measures (PROMs) compared included scores on the Oswestry Disability Index (ODI), numeric rating scale (NRS) for back and leg pain, Scoliosis Research Society Outcomes Questionnaire (SRS-22), SF-36 physical component summary, SF-36 mental component summary (MCS), EQ-5D, and EQ-5D visual analog scale.

RESULTS Twenty-seven of 147 (18.4%) patients screened positive for preoperative depression. The nondepressed cohort had an average of 4.83 levels fused, and the depressed cohort had 5.56 levels fused per patient ($p = 0.267$). At 1-year follow-up, 10 patients still reported depression, representing a 63% decrease. Postoperatively, both cohorts demonstrated improvement in their PROMs; however, at 1-year follow-up, those without depression had statistically better outcomes based on the EQ-5D, MCS, and SRS-22 scores ($p < 0.05$). Patients with depression continued to experience

ABBREVIATIONS ALIF = anterior lumbar interbody fusion; ASD = adult spinal deformity; LLIF = lateral lumbar interbody fusion; MCS = mental component summary; MIS = minimally invasive surgery; NRS = numeric rating scale; ODI = Oswestry Disability Index; PI-LL = pelvic incidence minus lumbar lordosis; PROM = patient-reported outcome measure; SRS-22 = Scoliosis Research Society Outcomes Questionnaire; SVA = sagittal vertical axis; TLIF = transforaminal lumbar interbody fusion.

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higher NRS leg scores at 1-year follow-up (3.63 vs 2.22, p = 0.018). After controlling for covariates, the authors found that depression significantly impacted only 1-year follow-up MCS scores (β = 8.490, p < 0.05).

CONCLUSIONS Depressed and nondepressed patients reported similar improvements after MIS surgery, except MCS scores were more likely to improve in nondepressed patients.

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KEYWORDS depression; minimally invasive spinal surgery; adult spinal deformity; patient-reported outcome measures; mental health; deformity correction

In the era of value-based healthcare, an increased emphasis exists on optimizing outcomes. Identifying and addressing preoperative patient risk factors is one area of interest. Risk factors influencing postoperative outcomes after spine surgery, including those for deformity correction, are smoking, alcohol consumption, poor nutritional status, and glycemic control. If these risk factors are not optimized prior to spine surgery, they can have negative perioperative implications such as an increased risk for infection, poor wound healing, longer hospital stay, and greater healthcare expenditure. Another risk factor for poor postoperative outcomes is depression, which requires further study.

Mental illness is an increasingly identified health condition, with recent estimates indicating that its prevalence is 20% among the United States adult population.[1] Depression, a common psychological disorder, afflicts nearly 10% of Americans, and is rapidly increasing among adolescents and young adults.[2] Given this prevalence, preoperative screening—especially for patients considering complex surgery such as spinal deformity correction—is essential. Nearly 25% of patients with adult spinal deformity (ASD) have self-reported depression.[3]

Although pathological mechanisms have yet to be established, clinical correlates have been created relating the impact of depression on perioperative outcomes.[4–13] Depression has been associated with increased pain and poorer recovery after surgery.[14] Although positive screening for depression has been implicated with worse outcomes, the specific follow-up impact requires further clarity. Despite recent advancements in minimally invasive techniques, the literature has primarily focused on open correction of deformity and the outcomes among depressed patients. We found that minimally invasive surgery (MIS) techniques allow for faster recovery and fewer complications than open techniques for ASD,[15–17] and consequently, we hypothesized that depression may play less of a role in outcomes after MIS. This study sought to establish the impact of preoperative depression on outcomes after MIS for ASD.

Methods

This study is a post hoc analysis of a prospectively collected, multicenter database of patients who underwent MIS for correction of ASD. For the purpose of this study, MIS was defined as fusion of > 3 levels with percutaneous screws and interbody fusion. All 10 institutions involved in this study provided institutional review board approval. Informed consent was obtained from all patients included in this cohort. All surgeons had training and experience with MIS techniques, and the surgical approaches were individualized to each patient at the discretion of the presiding surgeon. The approaches used for this study included anterior lumbar interbody fusion (ALIF), lateral lumbar interbody fusion (LLIF), and transforaminal lumbar interbody fusion (TLIF).

Inclusion criteria for this study included age ≥ 18 years and radiographic features including coronal Cobb angle ≥ 20°, pelvic incidence minus lumbar lordosis (PI-LL) ≥ 10°, or sagittal vertical axis (SVA) > 5 cm. This was not a consecutive series of patients; we included only patients who provided informed consent before participation in this study. Importantly, all patients must have had a minimum follow-up of 1 year to meet the inclusion criteria.

All demographic, operative, and health-related quality of life data were recorded in centralized, secured servers. Demographic data collected included age, sex, BMI, Charlson Comorbidity Index score, frailty index score, and smoking status. Outcomes were reassessed 1 year after the index MIS for ASD correction. Operative data collected included estimated blood loss, operative time, and number of levels fused. Health-related quality of life measures and patient-reported outcome measures (PROMs) included the Oswestry Disability Index (ODI), numeric rating scale (NRS), EQ-5D, EQ-5D visual analog scale, SF-36 physical component summary, SF-36 mental component summary (MCS), and Scoliosis Research Society Outcomes Questionnaire (SRS-22). Radiographic parameters were determined via expert review of 36-inch standing plain radiographs. Collected spinopelvic parameters included lumbar lordosis, pelvic incidence, pelvic tilt, PI-LL mismatch, SVA, T1 pelvic angle, and coronal balance.

Statistical Analysis

Prior to statistical analyses, patients were stratified into two cohorts, consisting of those either affirming or denying depression on preoperative assessment. All continuous variables are described as mean ± SD and categorical variables are described as number (percent). The Student t-test was utilized for parametric continuous data. The Mann-Whitney U-test was used for nonparametric continuous data. Categorical variables were analyzed via the chi-square test or ANOVA. A multiple linear regression model was used to control for covariates. A significance level of $\alpha = 0.05$ was used. IBM SPSS Statistics for Windows software (IBM Corp.) was used to perform the statistical analysis.

Results

Demographic Characteristics

One hundred forty-seven patients were eligible for in-

TABLE 1. Patient demographic characteristics

	Nondepressed (n = 120)	Depressed (n = 27)	p Value
Age, yrs	70.0 ± 9.6	65.1 ± 12.5	0.080
Female sex	77 (64)	21 (78)	0.28
Smoker	3 (3)	1 (4)	0.574
Prior surgery	59 (49)	12 (44)	0.395
BMI, kg/m^2	28.6 ± 5.7	29.5 ± 6.5	0.489
Charlson Comorbidity Index	2.1 ± 1.6	2.4 ± 1.5	0.351
Frailty index	3.2 ± 1.2	4.5 ± 1.4	<0.001*

Values are shown as number (%) or mean ± SD unless indicated otherwise.
* Significant ($p < 0.05$).

TABLE 2. Surgical details

	Nondepressed (n = 120)	Depressed (n = 27)	p Value
Posterior levels fused	4.83 ± 2.97	5.56 ± 3.17	0.267
Interbody levels fused	3.19 ± 1.46	3.12 ± 1.51	0.811
ALIF	2.29 ± 0.46	2.38 ± 0.52	0.672
LLIF	3.09 ± 0.88	2.93 ± 0.73	0.529
TLIF	2.20 ± 0.45	0	

Values are shown as mean ± SD unless indicated otherwise.

clusion because they underwent preoperative screening and MIS correction of ASD at one of the participating study group sites with a minimum follow-up of 1 year. After stratification, 27 patients had screened positive for depression in the preoperative period. Between the nondepressed and depressed cohorts, there were no significant differences in age (70 vs 65 years, $p > 0.05$), sex (64% vs 78% female, $p > 0.05$), smoking status (3% vs 4%, $p > 0.05$), prior surgical interventions (49% vs 44%, $p > 0.05$), BMI (29 vs 30 mg/kg^2, $p > 0.05$), or Charlson Comorbidity Index scores (2.1 vs 2.4, $p > 0.05$) (Table 1). However, patients with depression reported higher frailty index scores (4.5 vs 3.2, $p < 0.001$) (Table 1).

Operative Characteristics

The nondepressed cohort had 4.83 ± 2.97 levels fused per patient and the depressed cohort had 5.56 ± 3.17 levels fused per patient. In the nondepressed cohort, ALIF was used for 2.29 ± 0.46 levels, LLIF for 3.09 ± 0.88 levels, and TLIF for 2.20 ± 0.45 levels. In the depressed cohort, ALIF was used for 2.38 ± 0.52 levels and LLIF was used for 2.93 ± 0.73 levels. TLIF was not performed in the depressed cohort. No significant differences were observed in terms of the posterior levels fused between the depressed and nondepressed cohorts. No differences in the interbody levels fused were observed between the two cohorts ($p = 0.811$) (Table 2). There were no differences in terms of estimated blood loss (401 vs 722 ml), operating time (402 vs 465 minutes), or postoperative inpatient length of stay (5.8 vs 6.3 days). Rates of anterior versus posterior approaches and other surgical approaches used were similar between patients with and without depression ($p > 0.05$).

Functional Status

This study had the unique advantage of the inclusion of prospectively collected data at the 1-year follow-up period for all patients included in this cohort, which allowed for longitudinal evaluation of functional status. Importantly, these results showed that 63% of patients with depression did not report depressive symptoms 1 year after surgery (Table 3). In all measures of functional status, with the exception of SF-36 MCS and SRS-22 scores preoperatively, there were no differences between patients with and without depression. At the 1-year follow-up, patients without depression reported greater improvements in their EQ-5D scores compared to those with depression (0.83 vs 0.77, $p = 0.005$). This similar improvement was seen at the 1-year follow-up in terms of the MCS component of the SF-36 questionnaire (52 vs 41, $p = 0.001$) (Fig. 1). Over time, patients without depression had greater EQ-5D improvements compared to those with depression (0.09 vs 0.03, $p = 0.014$) (Table 2). Patients with depression continued to experience higher NRS back (4.26 vs 2.72, $p = 0.005$) and leg (3.63 vs 2.22, $p = 0.018$) pain scores at 1-year follow-up compared to those without depression. After controlling for covariates, including frailty, we found that depression significantly impacted only improvements in the MCS score ($\beta = 13.747$, $p < 0.01$) and 1-year follow-up MCS score ($\beta = 8.490$, $p < 0.05$). Among patients who were depressed at baseline, there was no significant difference in baseline frailty between those patients who were persistently depressed and those patients who recovered from their depression (4.24 vs 4.90, $p = 0.276$).

Subgroup Analysis

To determine if improvements in depression status (recovering to a nondepressed state after being previously depressed) normalized recovery of PROMs, the means of three cohorts (nondepressed, depressed to nondepressed, and persistently depressed) were compared (Table 4). A comparison of means between the patients who were in the nondepressed cohort and those patients who were depressed and then became nondepressed was performed. No significant differences ($p > 0.05$) were noted for a majority of PROMs, except in terms of the MCS scores preoperatively (53.52 vs 41.65, $p < 0.001$), at 1-year follow-up (52.36 vs 40.93, $p < 0.001$), and change over time (6.29 vs −0.04, $p = 0.032$), and the preoperative SRS-22 score (2.92 vs 2.52, $p = 0.005$).

Radiographic Parameters

Additional postoperative outcomes measured in this study were the changes in radiographic parameters in the preoperative versus postoperative period and at follow-up. Coronal vertical axis, thoracolumbar Cobb angle, lumbar Cobb angle, maximum Cobb angle, pelvic incidence, pelvic tilt, PI-LL, and SVA were measured at all time points (Fig. 2). There were no differences in any radiographic parameter between the preoperative and 1-year follow-up time point.

TABLE 3. Results of the bivariate analysis of functional status over time

	Nondepressed (n = 120)	Depressed (n = 27)	p Value
Persistent depression at 1 yr	10 (37)		
ODI			
Preop	45.6 ± 13.8	50.8 ± 18.6	0.101
1 yr	24.9 ± 16.2	34.39 ± 24.9	0.016*
Change over time	−20.9 ± 16.1	−16.4 ± 15.3	0.183
NRS back			
Preop	7.16 ± 2.04	7.15 ± 2.63	0.975
1 yr	2.72 ± 2.37	4.26 ± 3.19	0.005*
Change over time	−4.48 ± 2.73	−2.89 ± 3.49	0.011*
NRS leg			
Preop	5.34 ± 3.19	6.07 ± 2.70	0.269
1 yr	2.22 ± 2.6	3.63 ± 3.35	0.018*
Change over time	−3.11 ± 3.67	−2.44 ± 3.38	0.393
EQ-5D			
Preop	0.75 ± 0.06	0.73 ± 0.08	0.433
1 yr	0.83 ± 0.09	0.77 ± 0.12	0.005*
Change over time	0.09 ± 0.09	0.03 ± 0.08	0.014*
EQ-5D VAS			
Preop	59.30 ± 21.14	56.18 ± 26.39	0.549
1 yr	74.88 ± 16.34	67.25 ± 20.64	0.055
Change over time	15.50 ± 22.91	10.90 ± 22.42	0.417
PCS			
Preop	29.77 ± 6.64	28.41 ± 9.38	0.380
1 yr	39.16 ± 9.16	39.86 ± 12.69	0.755
Change over time	9.53 ± 9.50	10.54 ± 8.46	0.636
MCS			
Preop	53.52 ± 10.25	39.69 ± 9.94	<0.001*
1 yr	52.36 ± 10.86	41.01 ± 11.94	0.001*
Change over time	6.29 ± 11.20	0.45 ± 10.39	0.023*
SRS-22			
Preop	2.92 ± 0.54	2.46 ± 0.49	<0.001*
1 yr	3.62 ± 0.67	3.12 ± 0.83	0.001*
Change over time	0.70 ± 0.70	0.65 ± 0.67	0.733

PCS = physical component summary; VAS = visual analog scale.
Values are shown as number (%) or mean ± SD unless indicated otherwise.
* Significant ($p < 0.05$).

Discussion

ASD is a complex disease state that is associated with significant back pain and worsening loss of function.[18,19] The prevalence of ASD reportedly ranges from 1.4% to 32%, and the associated morbidity is costly to both patients and society.[20–24] Prior studies in the literature have established a link between preoperative depression and postoperative outcomes; however, little research has been done in the context of ASD. MIS approaches have been increasingly favored by surgeons due to the reduced morbidity and reduced recovery times. Theoretically, MIS approaches may yield superior PROMs in patients with depression due to quicker recovery times.[25–34] However, the role of depression on follow-up postoperative outcomes has yet to be determined in patients after MIS ASD correction.

In this study, validated PROMs from 147 patients who underwent MIS for ASD correction were collected before and after intervention. This study revealed that, at 1-year follow-up, those with preoperative depression had lower SRS-22 scores, greater disability as measured by ODI scores, more leg pain, more back pain, and poorer health states as measured by the EQ-5D and SF-36 MCS. The true impact was recognized after accounting for covariates such as frailty. Depression only had significant outcomes on the results of SF-36 MCS, suggesting that the depressed cohort largely experienced depression secondary to their deformity. This result was predicted, given that the MCS surveys for vitality, social and emotional functioning, and mental health, which are all domains that depression can affect. It was also found that transitioning from depressed to nondepressed status largely normalized recovery.

Lafage et al.[35] evaluated 513 patients who underwent open surgery for deformity correction by using ODI, SF-36, and SRS-22R. They found that depressed patients (defined as having low MCS scores) had greater ODI scores ($p < 0.001$) and worse SF-36 ($p < 0.001$) and SRS-22R ($p < 0.001$) scores on 2-year follow-up, when compared to nondepressed patients (defined as having high MCS scores). The present study is, however, the first to explore the correction of ASD with MIS and its relationship to mental health. Therefore, a suggestion may be made that open surgery is more suitable for nondepressed patients, whereas MIS can yield improvements in both patient groups (except in terms of MCS scores).

A recent study identified that ASD patients with mental health disorders are at higher risk for postoperative complications such as infection and respiratory pathology.[36] Hence, the root cause of depression in patients with ASD must be identified in the preoperative period and may be optimized prior to surgery to improve postoperative outcomes.

The present study uniquely showed that depression could be improved significantly by deformity correction because the number of patients who screened positive for depression decreased by 63% after surgery. Complete reduction of this cohort size may not be possible due to some of these patients likely experiencing a multifactorial undiagnosed/subclinical depressive disorder, limiting them from following a structured postoperative rehabilitation plan. These results have been reported previously in the literature, with a similar phenomenon being observed among depressed patients with degenerative spine disease.[37]

The baseline health-related quality of life outcomes and PROMs were similar between the depressed and nondepressed cohorts. Although both cohorts benefited from improvement in values postoperatively, the depressed group did not see the same degree/quantity of improvement. This may imply that depression interferes with the capacity to achieve as much improvement from MIS ASD correction. When the differences between the PROMs

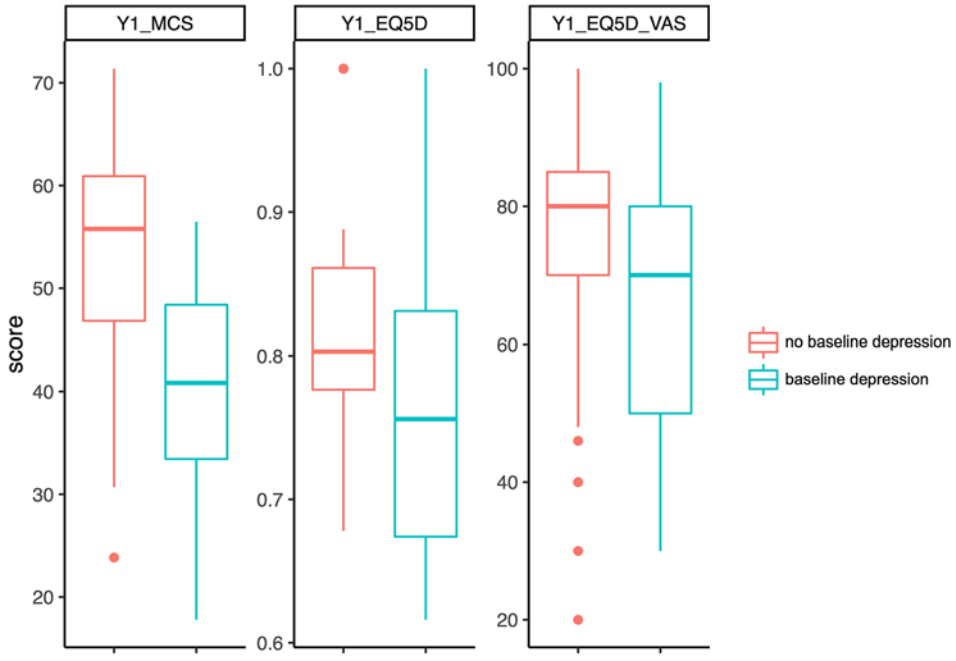

FIG. 1. Box plots showing functional outcome scores between nondepressed and depressed patients. Y1 = 1-year. Figure is available in color online only.

collected at each cohort's time stamp were compared, patients without depression had significantly better outcomes based on the MCS scale. Importantly, those with preoperative depression tended to experience persistently higher postoperative ODI and NRS back and leg scores compared to those in the nondepressed cohorts. Despite greater postoperative improvement in the nondepressed cohort, those in the depressed cohort still experienced significant improvements in ODI score after surgery.

Similar to the present study, Morrissette et al. observed poorer preoperative mental health states in patients with depression compared to those without depression.[38] Interestingly, they found that patients with depression experienced significant improvements in mental health and mental health states after surgery that were comparable to those of patients without depression.[38] Furthermore, from a PROM standpoint, Morrissette et al.[38] found that patients with lower baseline PROMs were more likely to have longer length of stay and be discharged to rehabilitation facilities instead of home. Although prior studies have reported increased complication rates in patients with depression and lower baseline PROMs, depression did not seem to affect the rate of postoperative complications in the study presented by Morrissette et al.[38] These results suggest that, despite poorer baseline mental health status, patients with depression remain excellent surgical candidates who are able to obtain significant improvements in their postoperative PROMs.

However, it is important to note that this negative correlation with poor self-reported mental health is not uniform across the literature. Cushnie et al. found that patients with the worst self-reported depression had the most significant improvement in their ODI scores.[39] Additionally, Ng et al.[40] found that patients with mental health conditions did not have worse postoperative outcomes after undergoing posterior lumbar decompression for lumbar spinal stenosis. This ongoing controversy further highlights the need for additional research into the role of mental illness, specifically depression, in the preoperative period.

Additional measures used in this study to evaluate the success of surgery were radiographic parameters. There were no statistically significant differences in the radiographic measurements obtained during both the preoperative and follow-up periods between the depressed and nondepressed groups. Given this similarity in terms of radiographic deformity burden, it may be surmised that patients with self-reported depression broadly have poorer quality health status that is more attributable to their mental health and other comorbidities, as opposed to their deformity.

Ultimately, despite the diverse conclusions regarding the impact of mental health on postoperative outcomes, there remains a suggestion that psychological assessments should be part of the standard preoperative workup for patients admitted for spine surgery.[41–46]

Limitations

The depressed cohort consisted of only 27 patients, which was relatively outnumbered by the nondepressed cohort. This inequality in cohort size and the small study size may have limited the power of the study. Because self-reported depression is different from clinical depression, stronger correlations between depression and postoperative outcomes could have been made if each patient had undergone a psychiatric evaluation or had taken a

TABLE 4. Comparison of PROMs between patients who were nondepressed, patients who went from depressed to nondepressed, and patients who were persistently depressed to assess for normalization of recovery: results of the multivariate analysis, after controlling for covariates

	Nondepressed (n = 120)	p Value	Depressed to Nondepressed (n = 17)	p Value	Persistently Depressed (n = 10)
ODI					
Preop	45.6 ± 13.8	0.198	50.41 ± 17.98	0.9	51.4 ± 20.55
1 yr	24.9 ± 16.2	0.243	30.28 ± 26.3	0.25	41.38 ± 22.04
Change over time	−20.9 ± 16.1	0.853	−20.12 ± 16.72	0.07	−10.02 ± 10.57
NRS back					
Preop	7.16 ± 2.04	0.779	7.00 ± 3.1	0.67	7.4 ± 1.65
1 yr	2.72 ± 2.37	0.079	3.88 ± 3.48	0.4	4.9 ± 2.69
Change over time	−4.48 ± 2.73	0.072	−3.12 ± 3.92	0.64	−2.5 ± 2.76
NRS leg					
Preop	5.34 ± 3.19	0.338	6.12 ± 2.62	0.92	6.00 ± 2.98
1 yr	2.22 ± 2.6	0.126	3.29 ± 3.24	0.53	4.2 ± 3.65
Change over time	−3.11 ± 3.67	0.760	−2.82 ± 3.49	0.45	−1.8 ± 3.26
EQ-5D					
Preop	0.75 ± 0.06	0.590	0.76 ± 0.09 (n =13)	0.11	0.70 ± 0.05 (n = 9)
1 yr	0.83 ± 0.09	0.450	0.81 ± 0.12 (n =14)	0.02†	0.71 ± 0.07 (n = 10)
Change over time	0.09 ± 0.09	0.285	0.06 ± 0.07 (n =11)	0.06	−0.002 ± 0.07 (n = 9)
EQ-5D VAS					
Preop	59.30 ± 21.14	0.857	60.46 ± 28.93 (n = 13)	0.35	50.00 ± 22.36 (n =9)
1 yr	74.88 ± 16.34	0.463	71.64 ± 21.25 (n =14)	0.22	61.10 ± 19.09 (n = 10)
Change over time	15.50 ± 22.91	0.679	12.45 ± 27.59 (n =11)	0.73	9 ± 15.35 (n = 9)
PCS					
Preop	29.77 ± 6.64	0.246	27.61 ± 10.22	0.55	29.75 ± 8.09
1 yr	39.16 ± 9.16	0.972	39.25 ± 13.69 (n = 16)	0.73	41.08 ± 11.21 (n = 8)
Change over time	9.53 ± 9.50	0.624	10.78 ± 10.05 (n = 16)	0.81	10.06 ± 4.28 (n = 8)
MCS					
Preop	53.52 ± 10.25	<0.001*	41.65 ± 13.68	0.08	33.84 ± 8.71
1 yr	52.36 ± 10.86	<0.001*	40.93 ± 10.56 (n =16)	0.37	37.21 ± 8.66 (n = 8)
Change over time	6.29 ± 11.20	0.032*	−0.04 ± 8.69 (n =16)	0.79	1.43 ± 13.84 (n = 8)
SRS-22					
Preop	2.92 ± 0.54	0.005*	2.52 ± 0.49	0.47	2.37 ± 0.5
1 yr	3.62 ± 0.67	0.061	3.28 ± 0.86	0.17	2.84 ± 0.74
Change over time	0.70 ± 0.70	0.738	0.76 ± 0.62	0.3	0.46 ± 0.74

Values are shown as mean ± SD unless indicated otherwise.

* Significant between the nondepressed and depressed to nondepressed cohorts ($p < 0.05$).

† Significant between the depressed to nondepressed and persistently depressed cohorts ($p < 0.05$).

validated psychiatric assessment at the time of admission. Investigation into whether the reportedly depressed patients experienced clinical depression and were on medication before surgery was not performed; this may have impacted the PROMs.[47] Although it may be inferred that the depressed cohort was experiencing depression secondary to their deformity, due to solitary improvements in SF-36 MCS, a definitive distinction cannot be made between primary depression and secondary depression without psychological assessments. Even if the patients had depression secondary to deformity, it is unknown if the depression can be attributed to pain or worries about appearance. The future of such research should focus on obtaining granular data points, such as details regarding therapeutic regimens and postoperative pharmacotherapy for mental health and their effects on PROMs, as well as socioeconomic considerations among groups with similar demographic characteristics. Replicating the same studies in pediatric and elderly age groups will further the corpus of literature on deformity correction.

Conclusions

Depressed and nondepressed patients reported similar improvements after MIS surgery, except MCS scores, which were more likely to improve in nondepressed patients. Nevertheless, the number of patients who screened positive for depression on follow-up after surgery de-

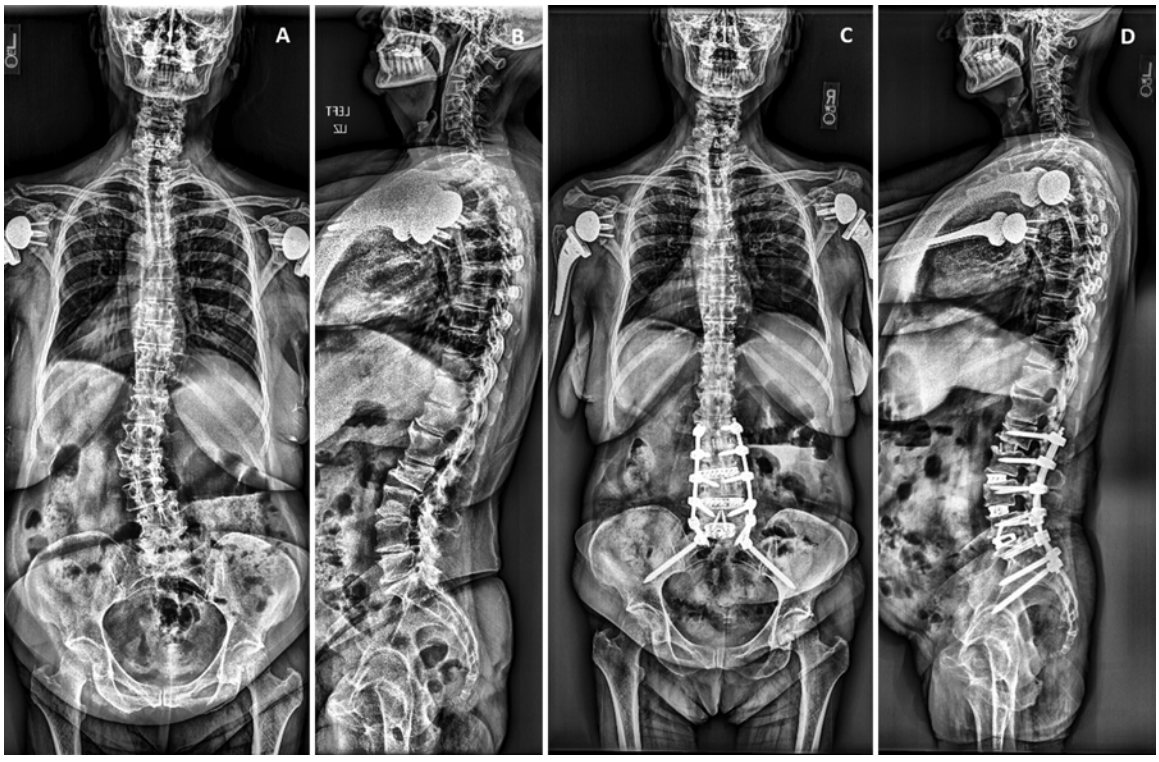

FIG. 2. Standing radiographs (anteroposterior and lateral views, respectively) obtained in a 69-year-old female with depression at the preoperative (**A and B**) and postoperative (**C and D**) time points. This patient underwent an L2–5 LLIF, L5–S1 ALIF, and L2-pelvis MIS posterior spinal fusion.

creased by 63%, suggesting the significant role that surgery has on the postoperative mental health of patients with ASD.

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