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Presurgical biopsychosocial factors predict multidimensional patient: outcomes of interbody cage lumbar fusion

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Abstract

BACKGROUND CONTEXT: Interbody cage lumbar fusion (ICLF) has been advanced to improve arthrodesis; however, little attention has been given to quality of life and functional outcomes. Studies suggest that psychosocial factors may be important modifiers of low back surgical outcomes.
PURPOSE: To depict outcomes of ICLF surgery across multiple dimensions and to investigate presurgical biopsychosocial predictors of these outcomes.
STUDY DESIGN/SETTING: A retrospective-cohort research design was used that involved completion of presurgical medical record reviews and postsurgical telephone outcome surveys at least 18 months after surgery. Presurgical variablesPresur

support for this spinal fusion technique, few were conducted independent of the developers of ICLF. In one such study [14], the interbody cages did not show the superior fusion rates as compared with other surgical techniques initially reported by the developers of the apparatus. Poor outcomes from such surgical procedures could have a considerable effect on the limited resources of health care systems and subject patients and their families to increased financial and physical burdens. Moreover, the primary emphasis within the extant spinal fusion literature is on biomechanical outcomes with little attention given to quality of life and functional ability. Thus, it appears that evidence about the long-term benefits of the ICLF is, at this time, limited.

Characteristics of patients at risk for poor fusion outcomes are not clearly identified in the literature. For instance, examination of patients' age and smoking status has produced mixed results [6,8,9,11,13,15–19] with regard to arthrodesis (ie, solid fusion) and patient outcomes. More consistent findings with patients with LBP, patients with chronic pain, and patients undergoing other surgical procedures [20–24] suggest a potentially important relationship between psychosocial factors, such as presurgical depression, smoking, and litigation status, and multidimensional ICLF outcomes. Patient characteristics and psychosocial factors could offer a basis for targeted interventions and improving patient selection, thereby also improving spinal fusion outcomes. To date, these characteristics are not adequately addressed. Therefore, the purpose of the present study was to examine ICLF outcomes across several qualitatively different variables and to investigate a multivariate predictive model based on biopsychosocial presurgical variables.

Methods

Study design

A retrospective-cohort design was used in this study. This design involved coding of presurgical information from medical records and assessing postsurgical patient outcomes through telephone surveys. This study received institutional review board approval, and access to patient medical records was granted by Workers' Compensation Fund of Utah (WCFU) and a multispecialty occupational medicine clinic.

Patient characteristics

Patients were eligible for inclusion if they had undergone ICLF, had no presurgical diagnosis of vertebral fracture, and were at least 18 months after surgery at the time of follow-up assessment. Potential participants were identified by current procedural terminology codes in the clinic and WCFU databases. All patients were initially approached for participation by means of a contact letter, which introduced the study, its purpose and procedures, confidentiality of information, and made a request for their voluntary participation. The total population included 73 patients who, at the time of their ICLF, ranged in age from 18 to 72 years (mean 43.84, SD 10.69). Sixty-six percent of these patients were men (48), whereas all were white.

Procedures

Presurgical medical record data were collected by using a standardized review procedure [8,9]. The data abstractor and telephone interviewer was a trained graduate student uninvolved with the treatment of the patients, who routinely met with the authors to review and resolve coding issues. Presurgical radiology reports for each patient's lumbar spine were also obtained and independently reviewed. A diagnostic pathophysiologic severity rating was calculated for each patient by one of the authors (A.L.C.), who is trained in orthopedic medicine. The biopsychosocial variables coded for this study included age at the time of surgery, smoking history, depressive disorder documented in preoperative medical records, litigation defined as patient private lawyer involvement in their case at the time of surgery, and presurgical diagnostic severity rating. For all patients, the operating surgeons routinely reviewed postoperative radiographs and reported the progression of bone consolidation. Thus, arthrodesis was determined by reviewing medical records for the surgeon's assessment of the radiographs. The final determination of arthrodesis was coded as a dichotomous variable.

Patients who agreed to participate in the study were contacted for completion of the telephone-based outcome survey. The surveys followed a detailed script used previously by the authors [8,9] and were completed in one 30- to 45-minute session.

Materials and instruments

Diagnostic Severity Rating Index (DSRI)

The DSRI provided a summary score based on a combination of seven indices of spinal pathophysiology [8,9]. To assess reliability of the DSRI, a second physician (W.B.), blind to the patient's identity, independently reviewed 25% of the same presurgical radiology reports. Mean agreement was 93%, demonstrating excellent interrater reliability with the primary physician-rater's DSRI scores.

Patient satisfaction

Four patient satisfaction questions used previously [6,8,9] included the following: the patient's quality-of-life improvement from the surgery, satisfaction with the outcome of the procedure, whether they would consider having the procedure again, and their perceived back and leg pain improvement after surgery.

Disability status

Disability status was determined at the time of the outcome survey by asking patients whether they currently receive total disability benefits for their low back condition.

Stauffer-Coventry Index (SCI)

The SCI [25] is a widely used index for identifying good, fair, or poor outcomes after surgery, and it contains four questions that ask the patient about pain relief, work status, restriction of physical activities, and analgesic medication usage. The surgical outcome category is designated on the basis of the patient's lowest rated response of the four items. Thus, the three outcomes appear as follows: 1) good: 76% to 100% relief in leg and back pain, return to previous work status, minimal or no restrictions of work activities, occasional mild or no analgesics; 2) fair: 26% to 75% relief of leg and back pain, return to lighter work, moderate restrictions of physical activities, regular use of non-narcotic analgesics; and 3) poor: 0% to 25% relief of leg and back pain, no return to work after surgery, severe restrictions of physical activities, occasional or regular use of narcotic analgesics.

Roland-Morris Disability Questionnaire (RDQ)

The RDQ [26,27] is an index of physical disability related to LBP and is composed of 24 dichotomous items. Higher scores indicate poorer functioning. This measure was found to be sensitive to functional improvement in LBP [28–30].

Short Form Health Survey-36 (SF-36)

The SF-36 [31,32] is a 36-item questionnaire designed to measure global quality of life. It assesses eight dimensions of health: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. The dimensions are aggregated into physical component summary (PCS) and mental health component summary (MCS) scores, which allow for analyses on two higher-order constructs without a substantial loss of information. Higher scores indicate better quality of life.

Statistical analysis

Multivariate analysis of variance (MANOVA) was used to compare the WCFU versus multispecialty clinic patients and respondents versus non-respondents on presurgical characteristics. Standardized mean difference effect sizes were calculated for comparison of ICLF outcomes with existing normative samples. A series of multiple regressions were performed with age at time of surgery, radiology severity rating, smoking status at time of surgery, presurgical depression diagnosis, and litigation at time of surgery as the predictors of disability status, RDQ, and SF-36 as the dependent variables. Discriminant function analysis was used to evaluate the ability of the five variable models to assign patients into SCI outcome classifications. All data were analyzed using the Statistical Packages for Social Sciences (SPSS) version 10 for Windows with an alpha level of .05 considered statistically significant.

Results

Presurgical patients and follow-up data

Of the 73 patients identified as having had ICLF, 56 (77%) agreed to complete all or part of the telephone outcome survey. Three (4%) patients declined to participate altogether, although the remaining 14 non-responders could not be located (18%) or were deceased (1%). The average time to outcome survey follow-up was 2.62 years (SD 0.77). The MANOVA comparison of the WCFU versus the multispecialty clinic patients was not statistically significant, indicating that the patients were not distinguishable on these variables (Table 1). The MANOVA comparison of respondents versus non-respondents was not statistically significant, and it was concluded that the results of the outcome survey were not differentially biased between the two groups because of presurgical characteristics.

Patient satisfaction

Responses to the patient satisfaction items are presented in Table 2. Almost 50% of the patients felt their pain improvement was either somewhat worse or much worse than what they had expected it to be at follow-up. Similarly, 38% of the patients indicated their quality of life had worsened as a result of the ICLF, whereas 57% felt their quality of life had improved. Approximately 44% of the patients indicated that if they had to spend the rest of their life with their back condition as it is currently, they would be dissatisfied. Finally, 64% of the patients indicated they would choose to have ICLF again.

Stauffer-Coventry Index

The SCI yielded the following aggregate patient outcomes: good, 5%; fair, 32%; and poor, 63% (Table 3). The overall classification is based on the lowest rating across the four subscales. If the modal rating were used as the criteria, the overall SCI rating becomes: good, 27%; fair, 41%; and poor, 32%.

Disability status and functional impairment

At follow-up, nearly 38% of the patients were considered totally disabled as a consequence of their back condition. According to responses on the RDQ, 47% of the patients scored at or above the recommended cut-off of 14 points [26,27]. The mean RDQ score for the patient sample was 12.47 (SD 7.44), although the modal and median scores were both 12.

Short-Form Health Survey-36

The eight SF-36 subscales and two summary scales were compared with existing norms [31,32], which included the general U.S. adult population (N 2,474) and adult patients reporting the comorbid conditions of back pain or sciatica

Table 1
Descriptive statistics of presurgical characteristics for patients

	Responders* (n 56)		Non-responders (n 17)		WCFU† (n 43)		NWCFU (n 30)	
Presurgical characteristics	M	SD	M	SD	M	SD	M	SD
Age (years)	44.39	11.07	42.05	9.42	43.90	8.92	43.76	12.99
Hollingshead index of social position	50.00	12.21	55.53	9.61	50.52	11.65	52.40	12.18
DSRI	9.09	5.02	9.12	3.00	9.67	4.69	8.27	4.45
Number of low back surgeries	0.95	1.00	0.82	0.95	1.09	0.95	0.67	0.99
Number of levels fused	1.38	0.49	1.53	0.51	1.44	0.50	1.37	0.49
Time delay (months)	32.51	25.08	33.75	24.98	36.58	23.63	27.39	26.03
Lawyer involvement (%)	33.9	—	29.4	—	37.2	—	26.7	—
Depression (%)	16.1	—	17.6	—	18.6	—	13.3	—
Smoking (%)	42.9	—	41.2	—	46.5	—	36.7	—

WCFU Workers Compensation Fund of Utah; NWCFU Non-Workers Compensation Fund of Utah; DSRI Diagnostic Severity Rating Index.
* ANOVA, Wilks λ 0.931; F .521;p .854.
† ANOVA, Wilks λ 0.880; F .955; p .486.

(within the past 6 months) and hypertension (N 481). As seen in Table 4, the subscale scores for the ICLF sample are considerably lower than the general population values. In fact, the standardized mean difference effect sizes range from 0.76 to 1.52, with 7 of 8 subscales considered large in magnitude. Although not displayed in the table, the subscale scores for the back pain or sciatica sample were also consistently higher than the scores of the patients undergoing ICLF with effect sizes ranging from 0.26 to 0.98 (7 of 8 were medium in magnitude).

Table 2
Patient satisfaction with outcomes of ICLF

Outcome category	Frequency (n 55)	Percentage
Back or leg pain		
Much better	12	21.8
Somewhat better	11	20.0
What expected	3	5.5
Somewhat worse	10	18.2
Much worse	17	30.9
No expectation	2	3.6
Quality of life		
Great improvement	14	25.5
Moderate improvement	11	20.0
A little improvement	6	10.9
No Change	3	5.5
A little worse	4	7.3
Moderately worse	10	18.2
Mush worse	7	12.7
Satisfaction with back condition		
Extremely satisfied	11	20.0
Very satisfied	8	14.5
Somewhat satisfied	9	16.4
Neutral	3	5.5
Somewhat dissatisfied	15	27.3
Very dissatisfied	4	7.3
Extremely dissatisfied	5	9.1
Retrospectively, would repeat surgery		
Yes	35	63.6
No	14	25.5
Undecided	6	10.9

Arthrodesis and patient outcomes

For the overall sample, arthrodesis was established in 82% of the cases with one individual not included because of in-hospital mortality. Of those participating in the outcome survey, 84% were documented to have achieved solid fusion. Arthrodesis was conceptualized as constituting an intermediate variable, and, as such, it was examined separately from the other proposed predictors of long-term outcomes. Achieving solid fusion was modestly related to total disability status (p .05, 0.26) at follow-up, indicating that arthrodesis was associated with a lower probability of receiving disability compensation. However, arthrodesis was not significantly correlated with any other patient outcomes.

Presurgical variables and prediction of patient outcomes

Because the SCI overall score grouped patients into one of three nominal groups, discriminant function analysis was used. Neither the first (Wilks λ .759, p .169) nor second (Wilks λ .939, p .520) discriminant function was statistically significant. Consequently, no further analyses were conducted with the SCI.

The second prediction analysis involved using logistic regression to assess the relationship between postsurgical disability status and the five presurgical variables. Three of the presurgical predictors were recoded from their original continuous values to an equal-interval continuous format to facilitate interpretation of results. Thus, age was recoded to 5-year intervals, the DSRI was reformatted to intervals of five units, and smoking was recoded from the number of packs smoked per day to equal-intervals of 1,825 packs, which is the equivalent of smoking one pack per day for 5 years. The overall logistic model was statistically significant (chi-square 24.27, p .001). As presented in Table 5, Wald values were statistically significant (p .05) for lawyer involvement and diagnostic severity rating, whereas depression approached significance (p .06). Examination of the Exp β for lawyer involvement revealed the odds of total

Table 3
Stauffer-Coventry Index outcomes

	Overall index rating*	Pain relief		Employment status†		Physical limitations		Medication usage	
Category	Frequency (%)	Improvement rating	Frequency (%)	Rating	Frequency (%)	Rating	Frequency (%)	Rating	Frequency (%)
Good	3 (5.4)	76%–100%	15 (26.8)	Return to previous work status	17 (30.4)	Minimal/no restrictions	8 (14.3)	Occasional/no use of mild analgesics	16 (28.6)
Fair	18 (32.1)	26%–75%	25 (44.6)	Return to lighter work	20 (35.7)	Moderate restrictions	28 (50.0)	Regular use on non-narcotic analgesics	12 (21.4)
Poor	35 (62.5)	0%–25%	16 (28.6)	No return to work	15 (26.8)	Severe restrictions	20 (35.7)	Occasional/regular use of narcotic analgesics	28 (50.0)

Percentages are based on follow-up; n 56 patients.
* Final classification is based on lowest-rated single category.
† Four patients (5.5%) were retired or not working before surgery and were not factored into employment status.

disability was 9.1 times greater with the presence of an attorney, assuming all the other variables in the model remained constant. Similarly, the odds of being disabled at follow-up was 7.7 times greater with a depression diagnoses, whereas each five-unit DSRI increase was associated with 2.5 times greater risk of disability.

With the use of simultaneous-entry multiple linear regression analysis to predict the RDQ score, the five-variable model was statistically significant (F 6.60, p .001) with a R^2 of .412. Two of the predictor variables (smoking, presurgical depression, and lawyer involvement) were statistically significant (Table 6). With the use of simultaneous-entry multiple regression analysis to predict the SF-36 PCS score, the five-variable model was statistically significant (F 7.46, p .001) with a R^2 of .442. As seen in Table 7, presurgical depression, smoking, and lawyer involvement were statistically significant (p .01) predictors of the variance. The simultaneous-entry multiple regression analysis predicting the SF-36 MCS score was also statistically significant (F 2.54, p .041). The five-variable model yielded a R^2 of .213. Smoking at the time of surgery was the only statistically significant predictor, although a trend toward significance (p .10) was seen with presurgical depression (Table 8).

Discussion

The purposes of this study were to examine ICLF outcomes across several qualitatively different variables and to investigate a multivariate predictive model of presurgical biopsychosocial predictors. In the current study, 84% of the participating patients had established a solid bony fusion after their ICLF surgery, which is generally commensurate or moderately more favorable than those reported elsewhere in the literature for non-ICLF techniques [5,6]. However, this rate did not match the impressive percentages reported by the developers of the ICLF. For instance, Ray [13] declared that arthrodesis, at 2 years after surgery, was present in 96%

Table 4
SF-36 multidimensional health outcomes

	ICLF sample*			General population sample*†			Back pain or sciatica sample‡			
Scale	M	SD	T§	M	SD	T	M	SD	T§	ES‖
Physical functioning (PF)	48.87	30.57	34.4	84.15	23.28	50	66.32	28.60	42.0	1.52
Role-physical (RP)	36.32	38.16	36.7	80.96	34.00	50	46.71	40.51	39.8	1.31
Bodily pain (BP)	40.92	22.31	35.3	75.15	23.69	50	59.34	24.63	43.1	1.44
General health (GH)	51.94	23.39	39.9	71.95	20.34	50	58.45	21.63	43.2	0.98
Vitality (VT)	40.28	24.46	40.0	60.86	20.96	50	52.29	22.74	45.8	0.98
Social functioning (SF)	57.56	30.65	38.4	83.28	22.69	50	81.48	24.38	49.1	1.13
Role-emotional (RE)	54.09	40.42	41.8	81.26	33.04	50	70.90	38.97	46.9	0.80
Mental health (MH)	61.06	25.31	42.3	74.46	18.05	50	74.93	18.62	50.0	0.76
Physical component summary (PCS)	—	—	34.6	—	—	50	—	—	39.6	—
Mental component summary (MCS)	—	—	44.1	—	—	50	—	—	51.3	—

* Observed range of all scores is 0-100; higher scores indicate better quality of life.
† General U.S. adult population [31]; n 2,474.
‡ Norms for comorbid condition: back pain or sciatica (in past 6 months) with hypertension [31]; n 481.
§ Patient sample scale scores transformed to T scores (M 50; SD 10) to facilitate comparisons with PCS and MCS scores.
‖ Standardized mean difference effect size ICLF sample and general population norms.

Table 5
Logistic regression equation predicting disability status

Variable	β	Wald	P	Exp (B)	95% CI
Age*	0.235	1.334	.25	1.265	0.85–1.89
DSRI†	0.947	3.780	.05	2.578	0.99–6.69
Smoking‡	0.275	1.966	.16	1.317	0.90–1.93
Depression	2.041	3.532	.06	7.701	0.92–64.73
Lawyer involvement	2.214	6.770	.01	9.148	1.73–48.48
Constant	3.658	4.796	—	0.26	—

* Age recoded to 5-year intervals.
† DSRI recoded to 5-unit intervals.
‡ Smoking (packs × years) recoded to intervals of 1,825 packs (5 years of 1 pack per day).

Table 7
Linear multiple regression model predicting the SF-36 physical component summary score*

	Coefficients			
	Unstandardized		Standardized	
Variable	β	SE	β	P
Age	0.171	0.120	0.179	.16
DSRI	0.423	0.292	0.198	.15
Smoking	0.001	0.000	0.359	.01
Depression	11.447	3.300	0.399	.01
Lawyer involvement	7.788	2.551	0.342	.01
Constant	64.672	6.267		

* Model summary: p .01; R .655 R^2 .442.

of the patients undergoing ICLF. Notably, two independent studies [19,33] examining ICLF with sufficient follow-up periods did not replicate the high rates of arthrodesis reported elsewhere [11–13]. The differences in rates appear likely attributable to carefully selected patients in the clinical trials. That is, the studies with rates approaching 100% [11–13] either excluded or minimally included patients with psychiatric history, pending litigation, secondary gain issues, or smoking cigarettes at the time of intervention. The more moderate ICLF fusion rate observed in the present study is likely more reflective of typical back pain patients with multiple medical and psychosocial comorbidities.

In terms of patient functioning at follow-up after ICLF, the current study found poorer outcomes than anticipated. For instance, 38% of the patients were considered totally disabled as a consequence of their back condition at follow-up, whereas 47% scored in the quite painful [26,27] range for the RDQ. Similarly, the patients with ICLF reported considerably poorer quality of life than the general population and nonsurgical back pain or sciatica norms. Substantial rates of patient dissatisfaction with ICLF were also observed, although the proportions between satisfaction and dissatisfaction tended to be evenly divided. Interestingly, despite the rates of dissatisfaction, nearly two thirds of the patients stated they would, in retrospect, choose the spinal fusion again, whereas only a quarter of the sample would not. As a potential hypothesis for explanation of these data, it appears that some patients could have gone into the ICLF procedure with somewhat inflated expectations about the potential for pain relief and improvement in functioning. Despite disconfirmation of these beliefs for some individuals, it appears as though they could be experiencing such dissatisfying presurgical levels of pain and impairment that, by comparison, their surgical outcome was better than the alternative. It could also be that these patients experienced some degree of cognitive dissonance after the spinal fusion. That is, patients undergoing this procedure endured considerable financial, social, and personal stakes and could experience intrapsychic distress and conflict at the notion that ICLF was a poor choice for them. Consequently, patients in these circumstances could assert that they would indeed retrospectively repeat the spinal surgery.

Perhaps more striking than the patient satisfaction and functional outcomes was the finding that biopsychosocial presurgical data predicted several patient outcomes, whereas arthrodesis failed to predict nearly all outcomes. Disability status, RDQ total score, and the SF-36 summary component scores had significant levels of variance accounted for by the five-variable regression model, and three of the five presurgical variables (presurgical depression, smoking, lawyer involvement) in the model consistently accounted for the most variance across the regression equations. These findings are consistent with reports in the chronic pain literature and nonfusion spinal surgical studies [7,8,18,20–24] in which psychological distress or depression, tobacco use or poor health behaviors, and litigation are associated with

Table 6
Linear multiple regression model predicting the RDQ score*

	Coefficients			
	Unstandardized		Standardized	
Variable	β	SE	β	P
Age	0.150	0.085	0.229	.08
DSRI	0.005	0.205	0.004	.98
Smoking	0.000	0.000	0.342	.01
Depression	6.281	2.317	0.320	.01
Lawyer involvement	4.243	1.791	0.273	.02
Constant	8.771	4.400		

* Model summary: p .01; R .642; R^2 .412.

Table 8
Linear multiple regression model predicting the SF-36 mental component summary score*

	Coefficients			
	Unstandardized		Standardized	
Variable	β	SE	β	P
Age	0.170	0.161	0.159	.29
DSRI	0.006	0.390	0.003	.99
Smoking	0.001	0.000	0.340	.02
Depression	7.407	4.408	0.230	.10
Lawyer involvement	1.704	3.407	0.067	.62
Constant	65.175	8.370		

* Model summary: p .04; R .461 R^2 .213.

worse patient outcomes. The results of the current study are also generally consistent with the findings of DeBerard et al. [8], with the exception that they failed to find an association between smoking and poorer patient outcomes. An important distinction between the two studies was that the current study assessed tobacco use with regard to a dose-response relationship between consumption and outcomes. Our findings are consistent with an attempt at assessing a dose-response relationship by Andersen et al. [15] in which they found that smoking more than 10 cigarettes per day was associated with worse non-ICLF spinal fusion outcomes.

Several hypotheses have been suggested to explain the association between these constructs and poorer outcomes. Habitual nicotine use and cigarette smoking, for example, are thought to decrease revascularization of bone graft, slow rates of healing and bone metabolism, and increase the risk of pseudarthrosis [15,17]. Smoking is also thought to be a marker for a constellation of negative lifestyle choices (eg, improper nutrition and exercise, drug and alcohol use) that might have deleterious effects on postoperative rehabilitation efforts. Although such lifestyle habits were not assessed in the current study, other researchers [34,35] noted that individuals who smoke are disposed to poorer self-care habits, fewer social supports, lower levels of education, and employment in physically strenuous jobs.

Presurgical depression was also a strong and significant predictor of ICLF outcomes, and several possibilities exist as to why this relationship occurred. It has been suggested that negative emotion, such as depression, can result in patients experiencing a heightened somatic sensitivity or hypervigilance, which in turn increases or maintains sensitivity to chronic pain [7,10,36]. Moreover, hypersensitivity to pain could increase the likelihood of restricting activities and bringing about physical deconditioning, which can produce a cascading detrimental effect on functioning, further exacerbating pain and poorer response to treatment [22,24,37]. Increased risk of poor spinal fusion outcome in patients who are depressed could also be linked to other mediators such as lower levels of social support, increased stress and loss of control, decreased immune system functioning and prolonged postsurgery healing, and poorer adherence to rehabilitation [8,36,38].

In terms of litigation, previous LBP studies found associations with poorer outcomes, such as delays in returning to work, increased rates of disability, and greater levels of posttreatment pain [8,18,39–41]. It may be tempting to conclude that patients involved in litigation are malingering or exaggerating symptoms and impairments to increase financial settlements or to extend absences from work. In fact, evidence exists in the literature that attorneys may advise their clients how to respond on psychological tests as well as what to emphasize or omit with examining psychologists [42,43]. However, it is important to note that the presence of secondary gain issues does not necessarily mean that patients with lumbar fusion are fabricating their symptoms or impairments. Regardless of potential incentives, before performing spinal fusion procedures surgeons require evidence of a spinal pathophysiology through routine radiographs [44,45]. The findings with ICLF could imply, as suggested elsewhere [7,10,38], that litigious patients also experience an increased somatic sensitivity to pain as a consequence of financial incentives and social-contextual variables.

The findings from this study have several implications. Lumbar fusion studies have typically emphasized biomedical outcomes and technical success and have given considerably less attention to quality-of-life and functional outcomes. We believe future studies should place an increased emphasis on the latter outcomes, which are likely to be of most interest to patients. Few patients are likely to be satisfied with arthrodesis but continuing pain and dysfunction. Another implication involves providing additional support for the biopsychosocial model. For instance, the presurgical variables that emphasized psychosocial factors consistently predicted long-term patient outcomes, whereas the biological variables accounted for much less variance. This finding is not surprising, given that biological factors appear to be more instrumental in the initiation of pain, whereas psychosocial factors play a greater role in the exacerbation and maintenance of chronic pain [37,46]. A related implication of this study is the potential utility of presurgical variables in assisting with identification of patients likely to have a poor response to spinal fusion procedures. In particular, recognition of patients experiencing presurgical depression or using tobacco or both could signal the need to implement interventions designed to reduce these risk factors. For instance, behavioral and cognitive-behavioral treatments focusing on depression, beliefs about pain, coping strategies, behavioral disengagement, and social influences have been effective for improving functioning levels in patients with chronic pain [22,47]. Recommendations for such interventions could be made and used more often before and after surgery than what appears to be the current practice [48]. Similarly, smoking cessation interventions tailored toward patients awaiting spinal fusion could be more beneficial than the typical practice of physician advice.

Although the current investigation is the only known study having used a multivariable model to predict ICLF outcomes, limitations exist with the use of a retrospective-cohort design and presurgical medical records. Presurgical depression (based on a documented diagnosis in the medical record) likely underestimated the actual rate of depression in patients and hindered its predictive efficacy. The current findings, therefore, need to be validated with larger sample sizes, a prospective design, and randomized controlled trials.

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