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Clinical Studies

Cognitive impairment is associated with greater preoperative symptoms, worse health-related quality of life, and reduced likelihood of recovery after cervical and lumbar spine surgery

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ABSTRACT

Background: Cognitive impairment (CI) is associated with prolonged hospital stays and increased complications; however, its role in symptom severity and health-related quality of life (HRQoL) among spine patients is unknown. We determined 1) prevalence of preoperative CI; 2) associations between CI and preoperative pain, disability, and HRQoL; and 3) association between CI and postoperative improvements in HRQoL.

Methods: This is a prospective cohort study of 453 consecutive adult spine surgery patients between October 2019 and March 2021. We compared pain (Numeric Rating Scale, NRS), pain-related disability (Oswestry/Neck Disability Index, O/NDI), and HRQoL (PROMIS-29 profile, version 2.0) among participants having severe (PROMIS-29 Cognitive Abilities score ≤30), moderate (31–35), or mild CI (36–40) or who were unimpaired (score >40), using analysis of variance. Likelihood of clinical improvement given the presence of any CI was estimated using logistic regression. All comparisons were adjusted for age, gender, comorbidity, and use of opioid medication during the last 30 days. Alpha=.05.

Results: Eighty-five respondents endorsed CI (38 mild; 27 moderate; 20 severe). Preoperatively, those with CI had more severe back pain (p=.005) and neck pain (p=.025) but no differences in leg or arm pain. Those with CI had greater disability on ODI (p<.001) and NDI (p<.001) and worse HRQoL in all domains (all, p<.001). At 6 and 12 months postoperatively, those with CI were less likely to experience clinical improvement in disability and HRQoL (anxiety, pain interference, physical function, and satisfaction with ability to participant in social roles) (all, p<.05).

Conclusions: CI was present in nearly 20% of spine patients before surgery and was independently associated with worse preoperative back and neck pain, disability, and HRQoL. Those with CI had approximately one-half the likelihood of achieving meaningful clinical improvement postoperatively. These results indicate a need to evaluate spine patients' cognitive impairment prior to surgery.

Level of Evidence: III

Background

Although patients undergoing surgical procedures to alleviate cervical and lumbar spine pain and restore function can experience major complications, the use of preoperative assessment and optimization tools has improved outcomes dramatically [1–3]. Cognitive impairment is a common, although underdiagnosed, condition in the United States and is not routinely included in preoperative screening or addressed as part of preoperative optimization [4–8]. However, cognitive function is one of the most important preoperative risk factors related to clinical outcomes, particularly in geriatric patients [9–11]. As the U.S. population ages, focus on the influence of cognitive impairment on postoperative outcomes after spine surgery has increased [12,13]. The reported prevalence of preoperative cognitive impairment in elderly patients undergoing spine surgery is up to 70% [4,5].

Preoperative cognitive impairment is the most important risk factor for the development of postoperative cognitive dysfunction, which affects nearly 1 in 4 patients who undergo spine surgery [5]. Furthermore, cognitive impairment has emerged as a risk factor for medical complications, prolonged hospital stay, and death [4,14,15]. Among patients undergoing adult spine deformity correction, those with cognitive impairment have been shown to have a higher incidence of postoperative complications (39%) compared to those without cognitive impairment (20%); the incidence of delirium was also higher in those with cogni-

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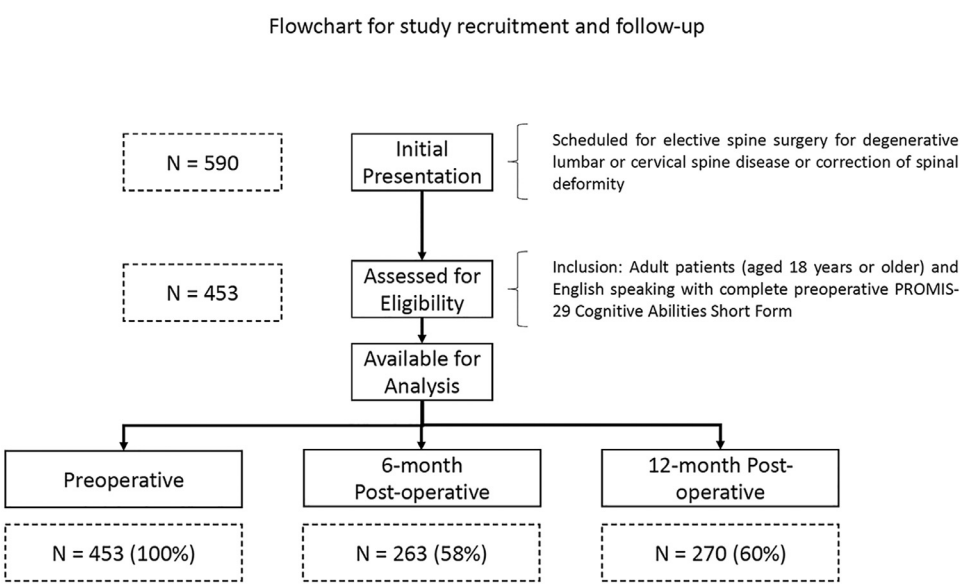

Fig. 1. Flowchart for study recruitment and follow-up

tive impairment (20%) than in those without (8%) [4]. However, the relationship between cognitive impairment and pain and functional outcomes after spine surgery is not well understood.

Our objectives were to determine 1) the prevalence of preoperative cognitive impairment among patients presenting for spine surgery, 2) the associations between cognitive impairment and preoperative pain, disability, and health-related quality of life (HRQoL), and 3) the association between preoperative cognitive impairment and postoperative improvements in HRQoL. We hypothesized that, compared with patients without cognitive impairment, those with cognitive impairment would have greater preoperative pain and disability and lower HRQoL and would experience less postoperative improvement in HRQoL.

Methods

Institutional review board approval was obtained for this study. Participants provided informed consent for the collection and use of these research data.

Study Design

This is a prospective cohort study of consecutive adults who presented for cervical or lumbar spine degeneration or deformity correction at our large U.S. academic hospital between October 2019 and March 2021.

Study Population

We included English-speaking patients aged 18 years or older who were scheduled for elective surgery for degenerative lumbar or cervical spine disease or for correction of spinal deformity. We report on the experience of 453 patients (50% women) with a mean age of 56 ± 19 years. Most were non-Hispanic white (83%). There were 20 (4%) patients undergoing discectomy surgery alone, 100 (22%) undergoing decompression alone, and 333 (74%) undergoing decompression with fusion. All participants were treated at the same center by 5 fellowship-trained, board-certified orthopedic spine surgeons with 6–26 years of practice experience.

Outcome Measures

After providing informed consent, all participants completed a preoperative assessment of sociodemographic and clinical information. The consent process and preoperative assessment were conducted remotely. Participant responses were input directly into the Research Electronic Data Capture (REDCap) electronic data capture system [16] through a link emailed to the participant or were collected over the phone and input by a study team member.

Sociodemographic information was age, sex, race/ethnicity, highest educational attainment (less than a 4-year college degree, a 4-year college degree, or a postgraduate degree), annual household income (<$30,000, $30,000–$80,000, or >$80,000), and relationship status (whether the participant lived alone or with a partner). Clinical information included the presence of comorbid conditions using the Charlson Comorbidity Index [17] and use of opioid medication within the past 30 days.

Participants completed assessments of pain intensity, pain-related disability, and HRQoL before and at 6 and 12 months after surgery. Postoperative assessments were completed by 263 participants (58%) at 6 months and 270 participants (60%) at 12 months after surgery (**Figure 1**). A comparison of sociodemographic and clinical characteristics between those who completed postoperative assessments and those who did not showed no significant differences. These assessments were the pain intensity Numeric Rating Scale (NRS) for back/leg and neck/arm pain, the Oswestry Disability Index (ODI) [18] or the Neck Disability Index (NDI) [19] for pain-related disability, and the Patient-Reported Outcome Measurement Information System (PROMIS-29 v2.0) health domains for HRQoL [20,21].

The pain intensity NRS asks participants to rate their level of pain from 0 (“no pain”) to 10 (“worst imaginable pain”). Pain-related disability was assessed using the ODI or NDI. The ODI and NDI each ask patients to rate their functional ability on 10 domains and scored on a 0–100 scale with higher scores reflecting greater disability. PROMIS-29 v2.0 was completed to assess health status for seven domains (physical function, fatigue, pain interference, depressive symptoms, anxiety, ability to participate in social roles, and sleep disturbance) using four items for each domain and a single-item pain intensity rating. Domain scores are expressed as T-scores with mean=50 and standard deviation (SD)=10. Higher scores indicate a greater presence of the quantity assessed.

Assessment of Cognitive Abilities

The PROMIS-29 Cognitive Abilities Short Form asks patients to rate the frequency of difficulty with cognitive function (e.g., “I have had difficulty switching back and forth between different activities that require

Table 1
Sociodemographic and clinical characteristics in 453 patients presenting for preoperative assessment of lumbar and cervical spine conditions stratified by preoperative cognitive impairment.

Characteristic	N (%)				p[a]
	No Cognitive Impairment (n = 368)	Mild Cognitive Impairment (n = 38)	Moderate Cognitive Impairment (n = 27)	Severe Cognitive Impairment (n = 20)	
Age, years	56 ± 19[b]	54 ± 18[b]	54 ± 14[b]	58 ± 16[b]	.824
Female gender	177 (48)	23 (59)	16 (59)	11 (55)	.417
Race/ethnicity					
Non-Hispanic white	289 (82)	36 (95)	19 (76)	15 (75)	.015
Non-Hispanic Black	47 (13)	1 (2.5)	5 (20)	1 (5)	
Hispanic	16 (5)	1 (2.6)	1 (4)	4 (20)	
Lives alone					
No	256 (70)	29 (74)	21 (78)	12 (60)	.553
Yes	111 (30)	10 (26)	6 (22)	8 (40)	
Education					
< College degree	150 (41)	17 (44)	14 (51)	9 (45)	.930
Bachelor's degree	111 (30)	11 (28)	8 (30)	6 (30)	
Postgraduate degree	106 (29)	11 (28)	5 (19)	5 (25)	
Household income, $					
<30,000	48 (17)	8 (22)	4 (19)	6 (33)	.200
30,000–80,000	71 (25)	4 (11)	5 (24)	6 (33)	
>80,000	169 (58)	24 (67)	12 (57)	6 (33)	
Opioid use in past 30 days					
None	260 (67)	24 (59)	19 (59)	13 (62)	.819
Some (not daily)	61 (18)	6 (15)	6 (19)	3 (24)	
Daily	69 (16)	11 (27)	7 (22)	5 (14)	
Surgical procedure					
Discectomy alone	17 (5)	1 (3)	2 (7)	0 (0)	.517
Decompression alone	86 (24)	8 (20)	4 (15)	2 (10)	
Decompression with fusion	263 (71)	31 (77)	21 (78)	18 (90)	
PROMIS Cognitive Abilities	52 ± 7.9[b]	38 ± 1.1[b]	34 ± 1.3[b]	26 ± 1.9[b]	<.001

[a] From analysis of variance for continuous variables and chi-squared test for categorical variables.
[b] Data represent mean ± standard deviation.

thinking") that they have experienced over the last 7 days. The form is a reliable and valid assessment of subjective cognitive function [22]; however, it has not previously been used to assess cognitive function among spine surgery patients. The instrument has been used to assess subjective cognitive function in healthy adults [22], patients with cancer [23], and those living with multiple sclerosis [24]. Clinically relevant severity thresholds were developed to characterize severity as none, mild, moderate, or severe based on patient and clinician consensus [25].

Statistical Analysis

Using preoperative PROMIS-29 Cognitive Abilities Short Form scores, we grouped participants for comparisons using published cut-off values based on clinician consensus [25]: those with severe preoperative impairment (score ≤30; herein, "severe group"), moderate preoperative cognitive impairment (score 31–35; herein, "moderate group"), mild cognitive impairment (score 36–40; herein, "mild group"), or no cognitive impairment (score >40; herein, "unimpaired group").

We compared the observed prevalence of preoperative cognitive impairment with the age- and gender-adjusted population rate using a 1-sample Z proportion test. We compared pain intensity and pain-related disability and HRQoL among the groups using analysis of variance (ANOVA). Linear-regression models were used to adjust for differences among the groups by age, gender, comorbid conditions, and opioid use during the past 30 days. The likelihood of achieving minimal clinically important improvements given the presence of any cognitive impairment (mild, moderate, or severe) was estimated using logistic regression adjusting for age, gender, comorbid conditions, opioid use during the past 30 days, and baseline patient-reported outcome score. Odds ratios (ORs) and 95% confidence intervals (CIs) are reported.

Analyses were conducted using Stata BE, version 17.0 (StataCorp, College Station, TX). Significance was set as P<0.05.

Results

Prevalence of Cognitive Impairment

Preoperative cognitive impairment was endorsed by 85 participants (19%): it was mild in 38 (8%), moderate in 27 (6%), and severe in 20 (4%) (**Table 1**). These rates were not greater than age- and gender-adjusted rates in the general U.S. population (p>.05).

Preoperative Assessment

All comparisons are to participants with no cognitive impairment. Scores are reported as means and standard deviations.

Preoperatively, participants with cognitive impairment reported more severe back (p=.005) and neck (p=.025) pain intensity on the NRS but no differences in leg or arm pain (**Table 2**). They also reported greater pain-related disability on the ODI and NDI (both, p<.001). Additionally, participants with cognitive impairment reported worse HRQoL in all PROMIS-29 domains: Anxiety, Depression, Fatigue, Pain Interference, Physical Function, Sleep Disturbance, and Satisfaction with Ability to Perform Social Roles (herein, "Social Roles") (all, p<.001).

Postoperative Assessment

At 6 months after surgery, cognitive impairment was associated with lower odds of achieving clinical improvement in neck pain (OR 0.49, 95% CI 0.26–0.90), pain-related disability on the ODI (OR 0.59, 95% CI 0.41–0.85), and lower odds of achieving improvement in HRQoL on PROMIS-29 domains (Anxiety: OR 0.62, 95% CI 0.40–0.91; Fatigue: OR 0.68, 95% CI 0.48–0.97; Pain Interference: OR 0.54, 95% CI 0.39–0.76; Physical Function: OR 0.72, 95% CI 0.52–0.98; and Social Roles: OR 0.53, 95% CI 0.38–0.75) (**Figure 2A**).

Table 2
Patient-reported outcome measures of pain, pain-related disability, and health-related quality of life in 453 patients presenting for preoperative assessment of lumbar and cervical spine conditions, stratified by preoperative cognitive impairment.

PRO[a]	Mean ± Standard Deviation Score				p[b]
	No Cognitive Impairment (n = 368)	Mild Cognitive Impairment (n = 38)	Moderate Cognitive Impairment (n = 27)	Severe Cognitive Impairment (n = 20)	
Pain NRS					
Arm[c]	5.2 ± 3.5	5.5 ± 3.2	5.7 ± 3.0	5.3 ± 2.8	.627
Back[d]	7.3 ± 2.7	8.3 ± 2.0	8.2 ± 2.4	8.9 ± 1.2	.005
Leg[c]	5.9 ± 3.4	6.4 ± 3.5	6.4 ± 3.8	6.6 ± 3.7	.470
Neck[d]	6.1 ± 3.0	6.9 ± 2.9	6.1 ± 3.8	8.9 ± 1.6	.025
Disability					
NDI[c]	36 ± 17	44 ± 13	52 ± 14	61 ± 9.7	<.001
ODI[d]	42 ± 17	51 ± 15	57 ± 11	59 ± 11	<.001
PROMIS-29					
Anxiety	51 ± 9.2	57 ± 10	57 ± 10	59 ± 16	<.001
Depression	49 ± 8.6	56 ± 8.6	56 ± 8.9	60 ± 7.0	<.001
Fatigue	53 ± 9.2	61 ± 6.9	60 ± 7.9	64 ± 9.5	<.001
Pain interference	64 ± 7.4	67 ± 5.1	68 ± 5.9	71 ± 4.5	<.001
Physical function	37 ± 6.8	35 ± 6.0	33 ± 5.8	32 ± 4.6	<.001
Sleep disturbance	55 ± 8.1	59 ± 8.9	62 ± 7.0	62 ± 9.8	<.001
Social roles	43 ± 8.3	39 ± 5.0	39 ± 7.9	34 ± 5.0	<.001

NDI, Neck Disability Index; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; PRO, patient-reported outcomes; PROMIS, Patient-Reported Outcome Measurement Information System.

[a] PRO scores reflect amount of domain measured, with higher scores indicating more of that domain. For example, higher NDI values reflect more disability.

[b] Multivariable regression adjusted for age, gender, comorbid conditions, living alone, and opioid use during the past 30 days.

[c] Available for 157 patients seen for a condition of the cervical spine.

[d] Available for 334 patients seen for a condition of the lumbar spine.

Table 3
Incidence of achieving minimal clinically important difference at 6 and 12 months after lumbar and cervical spine surgery in 484 patients, stratified by presence of cognitive impairment.

PRO	6 Months After Surgery (n = 263)					12 Months After Surgery (n = 269)				
	No N (%)	Mild N (%)	Moderate N (%)	Severe N (%)	p[a]	No N (%)	Mild N (%)	Moderate N (%)	Severe N (%)	p[a]
Pain NRS										
Arm[b]	39 (56)	9 (64)	5 (63)	2 (67)	.298	40 (55)	9 (69)	4 (67)	1 (25)	.580
Back[c]	110 (66)	9 (69)	8 (57)	9 (75)	.299	114 (67)	8 (73)	9 (64)	7 (64)	.112
Leg[b]	103 (62)	9 (69)	8 (57)	6 (50)	.006	95 (57)	6 (55)	9 (64)	7 (64)	.659
Neck[c]	41 (59)	8 (57)	2 (25)	2 (67)	.043	48 (66)	9 (64)	2 (33)	2 (50)	.011
Disability										
NDI[b]	31 (45)	7 (50)	4 (57)	2 (67)	.201	34 (47)	9 (69)	2 (33)	2 (50)	.078
ODI[c]	79 (48)	7 (54)	6 (43)	4 (33)	.005	88 (52)	6 (55)	7 (50)	3 (27)	.002
PROMIS-29										
Anxiety	78 (37)	6 (26)	3 (19)	6 (46)	.008	66 (31)	7 (32)	6 (26)	4 (31)	.049
Depression	43 (20)	6 (26)	4 (25)	2 (15)	.036	47 (22)	7 (32)	5 (26)	5 (38)	.338
Fatigue	95 (45)	13 (57)	6 (38)	5 (38)	.012	92 (43)	12 (55)	8 (42)	3 (23)	.001
Pain interference	125 (60)	12 (52)	8 (50)	4 (31)	<.001	129 (60)	13 (59)	11 (58	6 (46)	.004
Physical function	101 (48)	10 (43)	8 (50)	3 (23)	.036	112 (52)	10 (45)	9 (47)	3 (23)	.010
Sleep disturbance	95 (45)	11 (48)	7 (44)	5 (38)	.177	84 (39)	8 (36)	9 (47)	6 (46)	.345
Social roles	116 (55)	12 (52)	6 (38)	3 (23)	<.001	111 (52)	14 (64)	8 (42)	4 (31)	.005

NA, not applicable; NDI, Neck Disability Index; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; PRO, patient-reported outcomes; PROMIS, Patient-Reported Outcome Measurement Information System.

[a] Multivariable logistic regression adjusted for age, gender, comorbid conditions, living alone, opioid use during the past 30 days, and preoperative PRO score.

[b] Available for patients seen for a condition of the cervical spine (n = 95 at 6 months and n = 96 at 12 months).

[c] Available for patients seen for a condition of the lumbar spine (n = 206 at 6 months and n = 204 at 12 months).

At 12 months after surgery, patients with cognitive impairment had lower odds of clinical improvement in neck pain (OR 0.45, 95% CI 0.24–0.82) and pain-related disability on the ODI (OR 0.57, 95% CI 0.39–0.84), and lower odds of achieving improvement in HRQoL (Fatigue: OR 0.54, 95% CI 0.38–0.78; Pain Interference: OR 0.59, 95% CI 0.42–0.82; Physical Function: OR 0.67, 95% CI 0.39–0.92; and Social Roles: OR 0.62, 95% CI 0.44–0.86) (Table 3) (Figure 2B).

Discussion

Cognitive impairment is associated with postoperative medical complications; however, its effects on pain and functional outcomes are unknown. Our aim was to determine the pervasiveness of cognitive impairment among spine surgery patients, as well as the associations between cognitive impairment and preoperative and postoperative pain

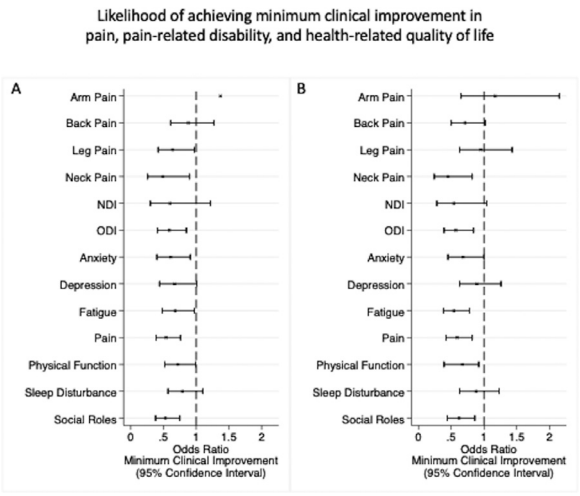

Fig. 2. Likelihood of achieving minimal clinical improvement in pain, pain-related disability, and health-related quality of life at (A) 6 months and (B) 12 months after lumbar and cervical spine surgery among those with preoperative cognitive impairment

and HRQoL. We found that participants with cognitive impairment had greater preoperative symptom burden and experienced less postoperative improvement in pain, pain-related disability, and HRQoL compared with those without cognitive impairment. These disparities increased with increasing severity of cognitive impairment.

To our knowledge, no published studies have evaluated the relationship between cognitive impairment and functional recovery after spine surgery. Several studies in the orthopedic trauma literature have analyzed the relationship between cognitive function and functional outcomes after surgical treatment of hip fracture. Delgado et al. [26] showed that patients with cognitive impairment have lower preinjury ambulatory function compared with those without cognitive impairment, which parallels our finding of greater preoperative symptom burden in patients with cognitive impairment. Morghen et al. [27] found that patients with cognitive impairment were significantly less likely to be able to walk independently at up to 12 months after completion of rehabilitation therapy compared with patients without cognitive impairment.

Among patients admitted for inpatient rehabilitation after hip fracture, those with cognitive impairment were less likely to have autonomy in activities of daily living or to walk independently upon discharge from inpatient rehabilitation compared with those without cognitive impairment (50% vs. 74%) [28]. Similarly, a systematic review of 33 studies with more than 9,500 patients demonstrated that cognitive impairment was associated with poor recovery after hip fracture surgery [29]. Postoperatively, patients with cognitive impairment are less likely to ambulate and they show less improvement in ambulatory status compared with those without cognitive impairment [30,31]. Liang et al. [32] showed that cognitive impairment is associated with deterioration in the ability to perform activities of daily living after hip fracture surgery. Finally, Wantonoro et al. [33] showed that severity of cognitive impairment was correlated with lower HRQoL after hospital discharge. These postoperative outcomes are analogous to our findings of less improvement in pain, disability, and HRQoL in patients with cognitive impairment after spine surgery compared with those without cognitive impairment.

The American College of Surgeons' preoperative assessment guidelines recommend preoperative screening for cognitive impairment given its associations with postoperative delirium, medical complications, prolonged hospital stay, hospital readmission, and death [13]. However, spine surgery patients are not routinely screened for cognitive impairment. The findings of our study indicate that preoperative screening for patients undergoing spine surgery should include an assessment of cognitive impairment. Susano et al. [13] showed that using brief cognitive questionnaires during the preoperative assessment can help stratify older adults by their risk for postoperative delirium and other adverse events. Improved recognition of preoperative cognitive impairment may help in the development of interventions to prevent postoperative complications and improve postoperative pain, disability, and HRQoL in those with cognitive impairment.

Our study has several limitations. First, it is a single-center study conducted at a large academic tertiary care hospital. The results may not be generalizable to other care settings, such as community practices; however, the characteristics of the patients reported here are similar to those of published populations of spine surgery patients [34]. Second, this study analyzed the association between preoperative cognitive impairment and postoperative recovery with incomplete responses to the 6-month (58%) and 12-month (59%) assessments and may be biased by the response rate. However, we found no significant differences on preoperative sociodemographic or clinical characteristics between those who completed postoperative assessments and those who did not. Third, our preoperative analysis of the association between cognitive impairment and severity of spine disease cannot establish a causal relationship.

Fourth, our study uses self-report measures to assess both cognitive impairment and pain, disability, and HRQoL. There is the possibility that the presence of cognitive impairment may influence how an individual responds to the self-report measures of pain, disability, and HRQoL. While this has not been studied in spine surgery patients, studies have demonstrated that mild cognitive impairment does not affect the ability to complete self-report measures of HRQoL in patients with multiple sclerosis [35] or cancer [36], or in older adults [37]. We can reasonably assume that assessments of pain, disability, and HRQoL are reliable and valid in those with and without cognitive impairment; however, more research may be needed.

Despite these limitations, we found that, compared with those without cognitive impairment, patients with cognitive impairment had significantly greater preoperative pain intensity and pain-related disability and lower HRQoL, and their likelihood of clinical improvement after surgery was significantly lower.

Conclusions

Nearly 1 in 5 spine surgery patients endorsed some form of preoperative cognitive impairment, and 1 in 10 endorsed moderate or severe cognitive impairment. Preoperative cognitive impairment was independently associated with worse preoperative pain intensity, pain-related disability, and HRQoL. In addition, those with mild cognitive impairment had approximately one-half the odds of achieving meaningful postoperative improvements in pain intensity, pain-related disability, and HRQoL. These results highlight the importance of evaluating patients' cognitive impairment before and after surgery.

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Summary sentence

Cognitive impairment occurs in 20% of spine patients and is independently associated with worse pain and quality of life before surgery and with greater risk of persistent impairment after surgery.

Conflict of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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