Sleep Disturbances in Cervical Spondylotic Myelopathy

Prevalence and Postoperative Outcomes—an Analysis From the Quality Outcomes Database

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Study Design: Prospective observational study, level of evidence 1 for prognostic investigations.

Objectives: To evaluate the prevalence of sleep impairment and predictors of improved sleep quality 24 months postoperatively in cervical spondylotic myelopathy (CSM) using the quality outcomes database.

Summary of Background Data: Sleep disturbances are a common yet understudied symptom in CSM.

Materials and Methods: The quality outcomes database was queried for patients with CSM, and sleep quality was assessed through the neck disability index sleep component at baseline and 24 months postoperatively. Multivariable logistic regressions were performed to identify risk factors of failure to improve sleep impairment and symptoms causing lingering sleep dysfunction 24 months after surgery.

Results: Among 1135 patients with CSM, 904 (79.5%) had some degree of sleep dysfunction at baseline. At 24 months postoperatively, 72.8% of the patients with baseline sleep symptoms experienced improvement, with 42.5% reporting complete resolution. Patients who did not improve were more like to be smokers [adjusted odds ratio (aOR): 1.85], have osteoarthritis (aOR: 1.72), report baseline radicular paresthesia (aOR: 1.51), and have neck pain of ≥4/10 on a numeric rating scale. Patients with improved sleep noted higher satisfaction with surgery (88.8% vs 72.9%, aOR: 1.66) independent of improvement in other functional areas. In a multivariable analysis including pain scores and several myelopathy-related symptoms, lingering sleep dysfunction at 24 months was associated with neck pain (aOR: 1.47) and upper (aOR: 1.45) and lower (aOR: 1.52) extremity paresthesias.

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Conclusion: The majority of patients presenting with CSM have associated sleep disturbances. Most patients experience sustained improvement after surgery, with almost half reporting complete resolution. Smoking, osteoarthritis, radicular paresthesia, and neck pain ≥4/10 numeric rating scale score are baseline risk factors of failure to improve sleep dysfunction. Improvement in sleep symptoms is a major driver of patient-reported satisfaction. Incomplete resolution of sleep impairment is likely due to neck pain and extremity paresthesia.

Key Words: cervical spondylotic myelopathy, sleep, neck disability index, quality outcomes database

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Sleep impairment is a common clinical symptom among patients with cervical spondylotic myelopathy (CSM), prevalent in an estimated 70% of patients at presentation.[1] Sleep dysfunction is attributed to the common spondylosis and myelopathy-related symptomatology—that is, neck pain, extremity paresthesias, and radiculopathy.[1] However, the pathophysiology of decreased sleep quality in CSM may be more complex than this, with ascending melatonin pathways potentially implicated in CSM sleep symptomatology.[1–3] The impact of sleep disturbance on a patient's overall health has been extensively studied and includes cognitive decline, mood disturbances, poor quality of life, and even medical complications, such as type II diabetes mellitus.[4–7] With the increasing prevalence of CSM due to the aging population, investigating CSM-related sleep disturbances is a timely and clinically important topic.

Yet, very little is known regarding the role of surgery in improving sleep-related symptoms in patients with CSM. The prognosis of sleep impairment is at large uninvestigated, limiting comprehensive patient consultation, and surgical decision-making. In this study, we utilized the CSM cohort of the quality outcomes database (QOD) to describe sleep-related outcomes after surgery and to identify potentially modifiable mediators of persistent sleep dysfunction.

MATERIALS AND METHODS

Data Source and Patient Cohort

The CSM cohort of the QOD includes 1141 patients who underwent cervical spine surgery for CSM across 14 high-enrolling sites of the original QOD.[8] Criteria for enrollment were a score of <17 in the modified Japanese Orthopedic Association (mJOA) questionnaire at baseline and myelopathy being the primary indication for surgery.[9] Patients were followed up via telephone or in-person for the completion of patient-reported questionnaires at the 3-month, 12-month, and 24-month follow-ups.[9] Due to the prospective nature of data collection and a follow-up rate exceeding 80%, the CSM database may be used to provide level-I evidence for prognostic studies.[10] Institutional Review Board approval was obtained by the participating sites during the development of the QOD registry. As this registry contains deidentified patient information, no additional IRB approval or consent was required.

Our cohort included patients with available sleep assessments according to the neck disability index (NDI) questionnaire at baseline. The NDI is a questionnaire composed of 10 sections designed to evaluate the effect of neck pain on the patient's functionality.[11] In this registry, NDI percentage scores (ie, ranging from 0 to 100) are captured, with higher scores indicating greater disability. The sleep component of the NDI questionnaire (section 9) is an ordinal 6-level scale that evaluates the impact of neck pain on a patient's quality of sleep. In this section, 0 represents no trouble sleeping and 5 represents a complete disturbance in sleep (loss of 5–7 h of sleep) due to clinical symptoms (Table 1).

Baseline and Operative Variables

Patients with available data in the sleep section of the NDI were divided into 2 groups: (1) patients with unaffected sleep at baseline—defined as a sleep score of 0, that is, "No trouble sleeping" and (2) patients who had any sleep disturbance at baseline—defined as a score ≥1. Improvement in sleep was defined as a decrease in follow-up sleep scores for patients with impaired sleep at baseline. Similarly, an increase in NDI sleep score from baseline was defined as worsened sleep function. Demographic variables, comorbidities, clinical characteristics, and surgical variables were also included for each group. These variables included age, sex, self-reported race and ethnicity, socioeconomic status index, insurance payor, smoking status, medical comorbidities, American Society of Anesthesiologists grade, employment status, baseline symptoms, and symptom duration, and patient-reported scores (PROs), that is, mJOA, NDI, arm and neck pain numeric rating scale (NRS), and 5-dimensions Euro-QoL scores [measured in quality-adjusted life-years(QALY)]. Myelopathy severity, as per the mJOA score, was classified as mild (15–17), moderate (12–14), and severe (<12).[12]

Outcomes Of Interest

Our primary outcome of interest was the sleep score of the NDI questionnaire evaluated at baseline, 3 months, 12 months, and 24 months. Other outcomes of interest were changes in mJOA, patient satisfaction with surgery, NDI, neck and arm pain NRS, and QALY. Satisfaction

TABLE 1. The Sleep Impairment Component of the NDI Questionnaire

Score	Patient-selected option
0	I have no trouble sleeping
1	My sleep is slightly disturbed for <1 h
2	My sleep is mildly disturbed for up to 1–2 h
3	My sleep is moderately disturbed for up to 2–3 h
4	My sleep is greatly disturbed for up to 3–5 h
5	My sleep is completely disturbed for up to 5–7 h

NDI indicates neck disability index.

with surgery was measured based on the 4-point North American Spine Society scale; patients were considered satisfied if they had a North American Spine Society score of 1 or 2.[13] NRS pain scales ranged from 0 to 10, with higher scores signifying more intense pain. Outcomes were assessed as differences from baseline and as minimal clinically important differences (MCID). The MCID for mJOA was calculated based on the CSM severity at baseline, as described;[14] the MCIDs for NDI, neck NRS, arm NRS, and QALY were defined as a 30% decrease from baseline.[15] We also assessed estimated blood loss, length of stay, nonroutine discharge disposition (defined as discharge destination other than home), readmissions, and reoperations.

Statistical Analyses

Continuous variables were presented as means with SDs, and categorical variables were presented as frequencies with proportions. The 2-sample *t* test was used to compare groups on continuous variables and the χ^2 test was used for categorical variables. *P* values were 2-sided with a statistical significance set at $P<0.05$. Multiple-model imputation was performed to generate replacement values for missing data, and the final imputed data were used for our analysis.[16] Each variable class had its own imputation model: we used predictive mean matching for continuous data, logistic regression for binary data, and polytomous logistic regression for unordered categorical data. The number of imputations was set to 20 and the number of iterations was set to 30. The multivariable imputation by chained equations was done using the "mice" package.[17]

Multivariable logistic regression was performed to identify predictors of improvement in sleep symptomatology at 24 months after surgery for patients with impaired sleep function at baseline. All variables presented in Table 2 were included as covariates in this analysis. A separate multivariable analysis was also performed to identify predictors of satisfaction at 24 months among components of the NDI questionnaire. Finally, a multivariable logistic regression was also performed to identify symptoms associated with the persistence of any sleep impairment at 24 months after surgery. Covariates in this analysis were components of the PROs that could translate to patient-reported symptoms, such as the neck and arm pain NRS, and the components of the mJOA score (upper and lower extremity motor function; upper extremity, lower extremity, and trunk paresthesias, and bladder dysfunction). For the comparison of procedure allocation among patients with different baseline NDI sleep scores, ordinal logistic regressions were performed. The *R* software (version 4.2.1) was used for all statistical analyses.[18]

RESULTS

Study Cohort

A total of 1135 patients with CSM who had baseline sleep scores were included in this analysis. The mean age was 60.5 ± 11.8 years old, and 47.2% of the cohort were females. The mean body mass index was 30.1 ± 6.4. At baseline, 38.5% had severe CSM, 39.4% had moderate CSM and 22.1% had mild CSM. Baseline characteristics are provided in Table 2. At baseline, 231 (20.4%) patients had no impairment in sleep (NDI sleep score: 0), whereas 904 (79.6%) patients had some degree of sleep dysfunction.

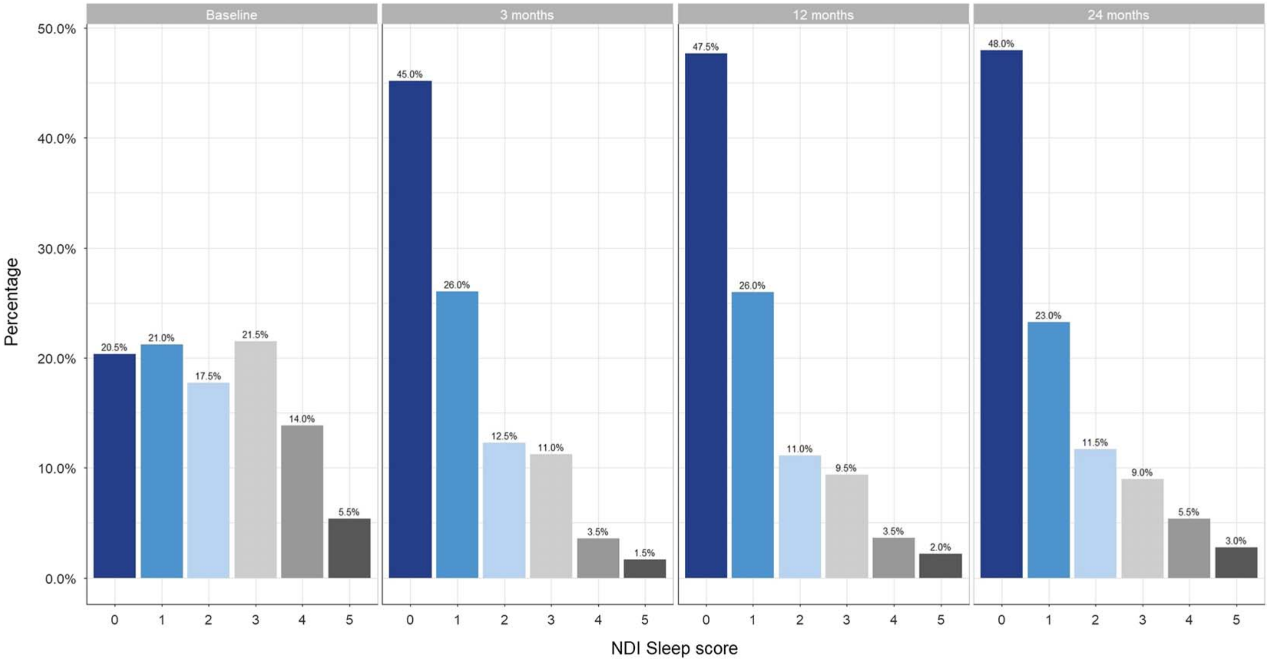

FIGURE 1. Distribution of sleep scores at baseline and at 3 months, 12 months, and 24 months postoperatively. full color online

TABLE 2. Baseline Characteristics of Patients Undergoing Surgery for CSM

Patient characteristics	No impairment at baseline (N = 231); n (%)	Sleep impairment at baseline (N = 904); n (%)	*P*
Age, mean (SD)	65.2 (12.1)	59.3 (11.4)	**< 0.01**
Sex (F)	88 (38.1)	448 (49.6)	**< 0.01**
BMI, mean (SD)	29.5 (6.6)	30.3 (6.4)	0.10
Insurance payor			**< 0.01**
Medicaid	6 (2.6)	73 (8.1)	—
Medicare	119 (51.5)	318 (35.2)	—
Private	95 (41.1)	481 (53.2)	—
Uninsured	3 (1.3)	12 (1.3)	—
VA/government	8 (3.5)	20 (2.2)	—
Educational level			**< 0.01**
High school or lower	81 (35.1)	433 (47.9)	—
Graduate level	105 (45.5)	359 (39.7)	—
Postgraduate level	45 (19.5)	112 (12.4)	—
Preoperative employment status			0.26
Employed or on short-term leave	99 (42.9)	425 (47.0)	—
Unemployed	132 (57.1)	479 (53.0)	—
Smoking	28 (12.1)	173 (19.1)	**0.01**
Diabetes mellitus	49 (21.2)	192 (21.2)	0.99
Depression	41 (17.7)	209 (23.1)	0.08
Anxiety	43 (18.6)	167 (18.5)	0.96
Coronary artery disease	29 (12.6)	78 (8.6)	0.07
Osteoarthritis	74 (32.0)	249 (27.5)	0.18
Chronic obstructive pulmonary disease	11 (4.8)	70 (7.7)	0.12
Symptom duration			**< 0.01**
< 3 mo	40 (17.3)	121 (13.4)	—
3–12 mo	97 (42.0)	311 (34.4)	—
> 12 mo	94 (40.7)	472 (52.2)	—
Motor deficit	141 (61.0)	550 (60.8)	0.96
Paresthesia at baseline	112 (48.5)	559 (61.8)	**< 0.01**
No. levels treated, mean (SD)	2.6 (1.5)	2.6 (1.5)	0.97
No. levels treated			0.38
1	64 (27.7)	234 (25.9)	—
2	67 (29.0)	282 (31.2)	—
3	37 (16.0)	178 (19.7)	—
≥ 4	63 (27.3)	210 (23.2)	—
Surgical approach			**< 0.01**
Anterior	142 (61.5)	644 (71.2)	—
Posterior	89 (38.5)	260 (28.8)	—
mJOA score at baseline, mean (SD)	12.7 (2.9)	11.9 (2.8)	**< 0.01**
Myelopathy severity			**< 0.01**
Mild	67 (29.0)	184 (20.4)	—
Moderate	98 (42.4)	349 (38.6)	—
Severe	66 (28.6)	371 (41.0)	—
NDI score at baseline, mean (SD)	17.5 (15.1)	43.8 (18.5)	**< 0.01**
Arm pain (NRS) score at baseline, mean (SD)	2.4 (3.1)	5.5 (3.3)	**< 0.01**
Neck pain (NRS) score at baseline, mean (SD)	2.2 (2.7)	6.0 (2.9)	**< 0.01**
EQ-5D score (in QALY) at baseline, mean (SD)	0.646 (0.212)	0.540 (0.221)	**< 0.01**

Bold values indicates statistical significance at a level of $P < 0.05$.

BMI indicates body mass index; CSM, cervical spondylotic myelopathy; EQ-5D, 5-dimensions Euro-QoL; mJOA, modified Japanese Orthopedic Association; NDI, Neck Disability Index; NRS, numeric rating scale; QALY, quality-adjusted life-year; VA, Veterans Affairs.

The distribution of sleep scores at baseline, 3 months, 12 months, and 24 months is presented in Figure 1. Surgery through an anterior-only approach was elected for 786 (69.3%) patients and a posterior-only approach was elected for the rest. No difference in surgical approach across patients with different NDI scores was observed ($P = 0.51$). Among posterior procedures, motion-preserving surgery—that is, laminoplasty or laminectomy without fusion—was performed less commonly in patients with higher NDI sleep scores: 36.6% for scores 0–1, 31.7% for scores 2–3, and 20% for scores 4–5, $P = 0.03$.

Patients With and Without Sleep Disturbances at Baseline

On univariate analysis, patients with impaired sleep at baseline were more likely to be younger (59.3 vs 65.2; $P < 0.01$), females (49.6% vs 38.1%, $P < 0.01$), and have a high school as the highest level of education (47.9% vs 35.1%, $P < 0.01$). They were also significantly more likely to have clinical symptoms of radicular pain, paresthesia, neck pain and motor deficits, a longer symptom duration, and lower QALY at baseline. These characteristics are presented in Table 2.

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Risk Factors for Failure to Improve in Sleep

Of the 743 patients who had sleep disturbances at baseline and available 24-month follow-up, 541 (72.8%) reported improvement in sleep at 24 months, whereas 202 patients (27.2%) did not. Characteristics of the patients in these 2 groups are comparatively reported in Table 3. On univariate analysis, individuals who experienced no improvement in sleep at 24 months were more likely to be smokers (22.8% vs 14.8%, $P < 0.01$), and have comorbid osteoarthritis (38.1% vs 25.5%) and radicular paresthesia (68.8% vs 59.1%, $P = 0.02$) at baseline.

In the multivariable model to identify risk factors of failure to improve from baseline in sleep symptomatology at 24 months after surgery for patients with impaired sleep function at baseline, all covariates presented in Table 1 were included. Patients who did not improve at 24 months were more like to be smokers at baseline [odds ratio (OR): 1.85; 95% CI: 1.17–2.94], have arthritis (OR: 1.72; 95% CI: 1.17–2.54), report radicular paresthesia at baseline (OR: 1.51; 95% CI: 1.02–2.24), and report a higher neck pain NRS score. Also, patients with more severe impairment at baseline were more likely to experience any

TABLE 3. Baseline Characteristics of Patients That Did and Patients That Did Not Experience an Improvement in Preoperative Sleep Disturbances by 24 Months After Surgery

Patient characteristics	Improved sleep symptoms (N = 541); n (%)	No improvement or worse (N = 202); n (%)	*P*
Age, mean (SD)	60.2 (11.0)	58.7 (11.7)	0.09
Sex (F)	272 (50.3)	108 (53.5)	0.44
BMI, mean (SD)	30.0 (5.9)	30.9 (6.9)	0.09
Insurance payor			0.62
Medicaid	39 (7.2)	18 (8.9)	—
Medicare	200 (37.0)	71 (35.1)	—
Private	289 (53.4)	109 (54.0)	—
Uninsured	2 (0.4)	2 (1.0)	—
VA/Government	11 (2.0)	2 (1.0)	—
Educational level			0.64
High school or lower	256 (47.3)	89 (44.1)	—
Graduate level	215 (39.7)	88 (43.6)	—
Postgraduate level	70 (12.9)	25 (12.4)	—
Preoperative employment status			0.57
Employed or on short-term leave	259 (47.9)	92 (45.5)	—
Unemployed	282 (52.1)	110 (54.5)	—
Smoking	80 (14.8)	46 (22.8)	**< 0.01**
Diabetes mellitus	116 (21.4)	41 (20.3)	0.73
Depression	122 (22.6)	50 (24.8)	0.53
Anxiety	106 (19.6)	39 (19.3)	0.93
Coronary artery disease	52 (9.6)	16 (7.9)	0.48
Osteoarthritis	138 (25.5)	77 (38.1)	**< 0.01**
Chronic obstructive pulmonary disease	36 (6.7)	18 (8.9)	0.29
Symptom duration			0.61
< 3 mo	76 (14.0)	26 (12.9)	—
3–12 mo	198 (36.6)	68 (33.7)	—
> 12 mo	267 (49.4)	108 (53.5)	—
Radicular motor deficit	181 (33.5)	68 (33.7)	0.96
Paresthesia at baseline	320 (59.1)	139 (68.8)	**0.02**
No. levels treated, mean (SD)	2.7 (1.5)	2.6 (1.5)	0.50
No. levels treated			0.59
1	130 (24.0)	55 (27.2)	—
2	169 (31.2)	60 (29.7)	—
3	112 (20.7)	46 (22.8)	—
≥ 4	130 (24.0)	41 (20.3)	—
Surgical approach			0.22
Anterior	377 (69.7)	150 (74.3)	—
Posterior	164 (30.3)	52 (25.7)	—
mJOA score at baseline, mean (SD)	12.0 (2.8)	11.8 (2.8)	0.36
Myelopathy severity			0.35
Mild	120 (22.2)	35 (17.3)	—
Moderate	208 (38.4)	83 (41.1)	—
Severe	213 (39.4)	84 (41.6)	—
NDI score at baseline, mean (SD)	43.3 (18.9)	43.2 (18.4)	0.91
Arm pain (NRS) score at baseline, mean (SD)	5.4 (3.3)	5.4 (3.1)	0.76
Neck pain (NRS) score at baseline, mean (SD)	5.8 (3.0)	6.2 (2.7)	0.14
EQ-5D score (in QALY) at baseline, mean (SD)	0.546 (0.219)	0.544 (0.222)	0.92

Bold values indicates statistical significance at a level of $P < 0.05$.

BMI indicates body mass index; EQ-5D, 5-dimensions Euro-QoL; mJOA, modified Japanese Orthopedic Association; NDI, neck disability index; NRS, numeric rating scale; QALY, quality-adjusted life-year; VA, Veterans Affairs.

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improvement during follow-up, contrary to patients with slight impairment, which was more likely to persist. The findings of this analysis are presented in Figure 2, where only predictors associated with the outcome at a statistical significance level of $P < 0.2$ are illustrated, even though the model did include all available variables.

Patient-reported Outcomes

At baseline, no significant difference was seen for arm and neck pain NRS between the patients who reported improvement in sleep at 24 months and those who did not improve. In addition, no significant difference was seen for the class of mJOA score at baseline ($P = 0.33$). Table 4 compares PROs of patients with baseline impairment with or without improvement at 24 months. At 24 months, patients with improvement were more likely to achieve MCID in all patient-reported outcomes, that is, mJOA, NDI, arm pain NRS, neck pain NRS, and QALY. In addition, patients who had improved sleep were more likely to be satisfied with surgery at 24 months (88.8% vs 72.9%, $P < 0.01$). Finally, they more commonly achieved MCID for QALY (51.3% vs 33.5%, $P < 0.01$). The univariate analysis of PROs is presented in Table 4.

On a multivariable analysis that included all components of the NDI questionnaire—namely, sleep, driving, lifting weights, headache, concentration, personal care, reading, pain intensity, work, and recreation—achieving improvement in sleep at 24 months was found to be an independent predictor of satisfaction from surgery at 24 months postoperatively (OR: 1.66; 95% CI: 1.03–2.67; $P = 0.04$).

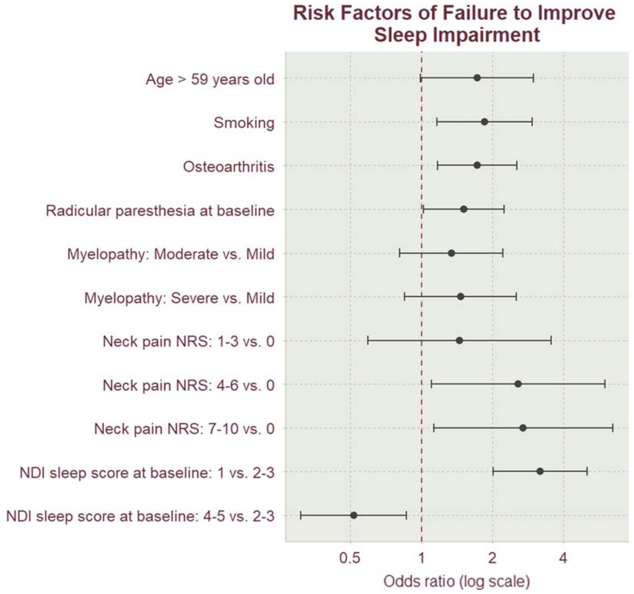

FIGURE 2. Forest plot illustrating the results of the multivariable logistic regression on baseline predictors of improvement in sleep dysfunction at 24 months from surgery. Odds ratios and CIs are demonstrated for those covariates associated with the outcome at $P < 0.2$ in the multivariable analysis for the conciseness of the figure. NDI indicates neck disability index; NRS, numeric rating scale. full color online

Complete Resolution Versus Lingering Symptoms

Of the total 753 patients with sleep impairment at baseline, 316 (42.5%) experienced complete resolution of their sleep impairment, having no symptoms at 24 months after surgery. On the contrary, 427 patients (57.5%) had at least some symptoms at the 24-month follow-up. In a multivariable analysis to describe the symptoms associated with lingering sleep impairment at 24 months, neck pain (OR: 1.47), paresthesia down arms (OR: 1.45), and legs (OR: 1.52) were found to be independently associated with sleep impairment, whereas arm pain, bladder function, and motor symptoms were not associated with the existence of persistent symptoms at a statistically significant level (Fig. 3).

DISCUSSION

In this study, we found that the majority of patients presenting with CSM have associated sleep disturbances. The quality of sleep was significantly improved postoperatively and maintained at 24 months, and patients with more severe sleep disturbances were less likely to undergo motion-preserving surgery. We were also able to identify predictors of postoperative sleep quality through an analysis adjusted for baseline sleep disturbances: smoking, osteoarthritis, radicular numbness, and neck pain ≥ 4 out of 10 were independent risk factors of poor outcomes. Finally, we documented that lingering sleep disturbances are associated with neck pain and extremity paresthesias.

The prevalence of sleep impairment in our cohort was 79.6%. This rate is higher than the 71.4% estimated in a prior cross-sectional study on 203 patients.[1] The discrepancy might be attributed to the fact that our cohort was comprised of patients undergoing surgery for CSM, whereas the prior study included patients with a CSM diagnosis not necessarily managed surgically. Therefore, higher disease severity was expected in our cohort, which was evident in the mean mJOA scores of the 2 studies: 12.1 in our analysis versus 13 in the referenced study.[1]

Kim and colleagues performed a similar prospective cohort study comparing the effect of surgical versus conservative treatment of CSM on sleep improvement. In their analysis, they found that sleep quality was more commonly improved in the surgical arm (26 out of the 31 patients) than in the conservative arm (27 out of 100 patients).[19] The limitations of this analysis were the small sample size preventing high-confidence estimates and the short follow-up window. Our study fills both gaps, confirming the beneficial role of surgery in improving CSM-associated sleep disturbance in a cohort of 1135 patients and demonstrating sustained results until the 2-year follow-up.

Our study was also able to yield risk factors for failure to improve sleep symptoms. These included smoking,

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TABLE 4. Univariate Analysis of Satisfaction From Surgery and MCID Achievement in NDI, mJOA, Arm and Neck Pain NRS, and QALY at 3 and 24 Months Postoperatively Among Patients That Did and Did Not Experience an Improvement in Sleep Symptoms 24 Months After Surgery

Outcomes	Improved sleep symptoms (N = 541); n (%)	No improvement or worse (N = 202); n (%)	*P*
Satisfaction at 3 mo	413 (87.5)	149 (86.6)	0.77
Not available	69	30	—
Satisfaction at 24 mo	476 (88.8)	145 (72.9)	**< 0.01**
Not available	5	3	—
MCID in mJOA at 3 mo	276 (59.5)	93 (54.4)	0.25
Not available	77	31	—
MCID in at mJOA 24 mo	294 (66.4)	75 (46.9)	**< 0.01**
Not available	98	42	—
MCID in NDI at 3 mo	333 (69.4)	86 (49.4)	**< 0.01**
Not available	61	28	—
MCID in NDI at 24 mo	437 (80.8)	62 (30.7)	**< 0.01**
Not available	0	0	—
MCID in arm pain (NRS) at 3 mo	299 (63.5)	100 (58.1)	0.22
Not available	70	30	—
MCID in arm pain (NRS) at 24 mo	340 (66.0)	95 (49.2)	**< 0.01**
Not available	26	9	—
MCID in neck pain (NRS) at 3 mo	317 (67.0)	98 (56.6)	**0.01**
Not available	68	29	—
MCID in neck pain (NRS) at 24 mo	375 (72.3)	87 (44.6)	**< 0.01**
Not available	22	7	—
MCID in EQ-5D (QALY) at 3 mo	219 (48.0)	68 (40.7)	0.11
Not available	85	35	—
MCID in EQ-5D (QALY) at 24 mo	264 (51.3)	64 (33.5)	**< 0.01**
Not available	26	11	—

Bold values indicates statistical significance at a level of $P < 0.05$.

EQ-5D indicates 5-dimensions Euro-QoL; MCID, minimal clinically important difference; mJOA, modified Japanese Orthopedic Association; NDI, neck disability index; NRS, numeric rating scale; QALY, quality-adjusted life-year.

osteoarthritis, baseline numbness, and neck pain. Even though all factors were studied at baseline, one could assume that perioperative smoking cessation or optimization of medical and behavioral management of osteoarthritis—might improve the patient's odds of experiencing an improvement in sleep quality. Indeed, both of these factors are independently associated with sleep disturbance: smoking is associated with obstructive sleep apnea[20] and sleep disturbances due to the neurophysiologic effects of nicotine,[21] whereas osteoarthritis is associated with chronic joint pain that interferes with sleep quality.[22] Our study was not able to investigate whether the impact of smoking and osteoarthritis on sleep symptoms was additive to that of CSM or synergistic. Nevertheless, addressing risk factors such as smoking and osteoarthritis could potentially increase surgical success rates and patient satisfaction, which was demonstrated to be independently associated with sleep improvement in this study.

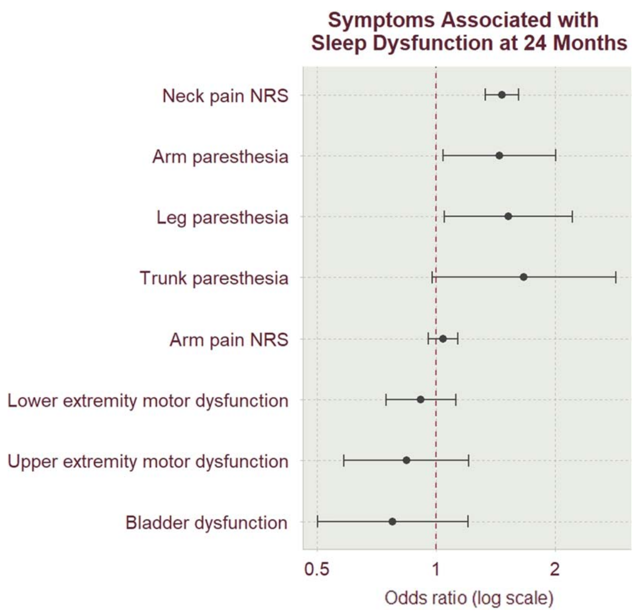

FIGURE 3. Forest plot illustrating the multivariable association of neck pain NRS, arm pain NRS, and mJOA components with the persistence of any sleep impairment at 24 months after surgery. mJOA indicates modified Japanese Orthopedic Association; NRS, numeric rating scale. full color online

Sleep disorders are common among patients with cervical spinal cord injury, including insomnia, sleep-disordered breathing, circadian rhythm disorders, and others.[23] Studies have hypothesized the potential for the endogenous secretion of melatonin in cervical spinal cord injury to be associated with such sleep dysfunctions.[24,25] Due to the anatomic relevance of CSM with cervical spinal cord injury, the potential association of CSM with the ascending melatonin pathways contributing to the regulation of the circadian rhythm necessitates further investigation. Such a hypothesis remains to be documented in patients with CSM, but if confirmed, it would add a new dimension to the evaluation of patients with CSM and the role of decompressive surgery in their management.

There are some limitations to this study. For the assessment of sleep impairment, we used the respective component of the NDI score, an ordinal 6-item scale. This scale may be susceptible to the ceiling/floor effect, potentially translating to substantially higher proportions of individuals with either maximum or minimum scores. Moreover, the sleep component of the NDI is not the most exhaustive questionnaire for the investigation of the patient's quality of sleep. A validated sleep-exclusive tool could shed more light on the symptoms impacting sleep function and the sleep characteristics that patients fail to improve. Also, this study did not compare sleep outcomes between different procedures and approaches, as group allocation was influenced by selection bias and tailored decision-making.

CONCLUSION

Most patients presenting with CSM have associated sleep disturbances of varying severity. Our analysis documented that over 70% of these patients experience an improvement in their sleep impairment, with slightly under half reporting complete resolution. Lingering sleep symptomatology seems to be attributed to neck pain and extremity paresthesia. These findings may be used in patient consultation in the preoperative setting by providing reliable estimates of postoperative outcomes and adjusting patient expectations. Independent risk factors for failure to improve sleep quality include smoking, osteoarthritis, baseline arm numbness, and neck pain. Therefore, smoking cessation and optimization of osteoarthritis management could potentially increase the patient's odds of experiencing an improvement and, hence, their likelihood of reporting satisfaction from surgery.

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