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Arm Pain Versus Neck Pain: A Novel Ratio as a Predictor of Post-Operative Clinical Outcomes in Cervical Radiculopathy Patients

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ABSTRACT

Background: Informed patient selection and counseling is key in improving surgical outcomes. Understanding the impact that certain baseline variables can have on postoperative outcomes is essential in optimizing treatment for certain symptoms, such as radiculopathy from cervical spine pathologies. The aim was to identify baseline characteristics that were related to improved or worsened postoperative outcomes for patients undergoing surgery for cervical spine radiculopathic pain.

Methods: Retrospective review of prospectively collected data. Patient Sample: Surgical cervical spine patients with a diagnosis classification of "degenerative." Diagnoses included in the "degenerative" category were those that caused radiculopathy: cervical disc herniation, cervical stenosis, and cervical spondylosis without myelopathy. Baseline variables considered as predictors were: (1) age, (2) body mass index (BMI), (3) gender, (4) history of cervical spine surgery, (5) baseline Neck Disability Index (NDI) score, (6) baseline SF-36 Physical Component Summary (PCS) scores, (7) baseline SF-36 Mental Component Summary (MCS) scores, (8) Visual Analogue Scale (VAS) Arm score, and (9) VAS Neck. Outcome Measures: Improvement in NDI ($\geq$50%), VAS Arm/Neck ($\geq$50%), SF-36 PCS/MCS ($\geq$10%) scores at 2-years postoperative. An arm-to-neck ratio (ANR) was also generated from baseline VAS scores. Univariate and multivariate analyses evaluated predictors for 2-year postoperative outcome improvements, controlling for surgical complications and technique.

Results: Three hundred ninety-eight patients were included. Patients with ANR $\leq$ 1 (n = 214) were less likely to reach improvements in 2-year NDI (30.0% vs 39.2%, P = .050) and SF-36 PCS (42.4% vs 53.5%, P = .025). Multivariate analysis for neck disability revealed higher baseline SF-36 PCS (odds ratio [OR] 1.053) and MCS (OR 1.028) were associated with over 50% improvements. Higher baseline NDI were reduced odds of postoperative neck pain improvement (OR 0.958). Arm pain greater than neck pain at baseline was associated with both increased odds of postoperative arm pain improvement (OR 1.707) and SF36 PCS improvement (OR 1.495).

Conclusions: This study identified specific symptom locations and health-related quality of life (HRQL) scores, which were associated with postoperative pain and disability improvement. In particular, baseline arm pain greater than neck pain was determined to have the greatest impact on whether patients met at least 50% improvement in their upper body pain score. These findings are important for clinicians to optimize patient outcomes through effective preoperative counseling.

Article

Keywords: arm neck ratio, radiculopathy, cervical spine, neck pain, arm pain

INTRODUCTION

Patients presenting with cervical radiculopathy often present with concomitant axial neck pain.[1] Radiculopathy is characterized by a history marked by functional limitation and disability, with studies describing more than half of radiculopathic patients continuing to have a minor to moderate degree of morbidity at long-term follow-up.[2] Studies have also described generally favorable outcomes in regards to surgical intervention for radiculopathy.[3–6] Radiculopathy and axial neck pain are rarely mutually exclusive and highlight the broader spectrum of cervical degenerative disc degeneration,

which Rothman classically described as a "a chronic disease, productive of significant pain and incapacity over an extended period of time."[7]

Traditionally, operative management has been suggested to be reserved for patients with predominantly radicular symptoms and localized neurological findings while patients with mainly axial pain are conversely managed nonoperatively. Success rates are high for surgical decompression for radiculopathy, with reports of 80% to 90% of patients experiencing relief in arm pain.[3–6] With predominant axial neck pain complaints, however, outcomes have been less reliable, with satisfaction ranging from 60% to 80%.[8–11] While the cervical spine literature has largely focused on factors such as age, smoking history, comorbidities, and psychosocial factors as predictors of surgical outcomes, there is a paucity of literature extending beyond these factors. Health-related quality of life (HRQL) measures is one such proposed predictive factor with recent interest in utilizing HRQLs not only for measuring improvement, but also serving as preoperative predictors of outcomes.[12] Recent studies in the lumbar spine literature have shown a correlation between higher patient-reported numerical leg pain and better decompression surgery outcomes.[13,14]

The value and relationship of radicular arm pain to axial neck pain as a predictor of postoperative outcomes have yet to be elucidated.[12,15–17] The purpose of this study was therefore to use a multi-institutional database to quantify metrics for upper body pain and disability scores, and to determine whether baseline characteristics varied with pain location ratios. A secondary aim was to determine whether preoperative pain location ratios predicted surgical outcomes. Because clinical improvements in neck pain after cervical spine surgery is associated with improved patient satisfaction, consideration of relative arm pain and axial neck pain scores may assist in clinical decision-making and in establishing realistic patient expectations of surgery.[18]

MATERIALS AND METHODS

Data Source

This study was a retrospective review of the Prospective Spine Treatment Outcomes Study (PROSTOS) database. PROSTOS is a part of the Association for Collaborative Spinal Research (ACSR) and 2221 patients treated for spinal pathology collected at 14 nationwide surgical sites.

Institutional review board (IRB) approval was obtained from each contributing center prior to study initiation.

Inclusion Criteria

This study examined patients receiving surgical treatment for radiculopathic cervical spine complaints: cervical disc herniation, cervical stenosis, and cervical spondylosis without myelopathy. Patients without baseline and 2-year demographic and HRQL data were excluded.

Predictor Variables

We sought to examine outcomes according to predictor variables commonly used in clinical practice for cervical radiculopathy patients. Predictive variables selected included the following: age, body mass index (BMI), gender, history of previous cervical surgery, baseline neck disability index (NDI), baseline Short-Form 36 Physical Component Summary (PCS) score, and baseline Short-Form 36 Mental Component Summary (MCS) score, baseline visual analogue scale (VAS), and arm pain greater than neck pain. NDI, VAS, and SF-36 questionnaires have been validated and used in spine surgery. We created a ratio of arm pain to neck pain (arm pain–neck pain ratio [ANR]) to compare the 2 values. Values greater than 1 indicated arm pain greater than neck pain. All other values, including equal findings, were considered otherwise. This measure, and much of the analysis, was adapted from Cook et al,[19] which evaluated HRQL, pain, and disability outcomes in patients with leg pain greater than back pain after lumbar discectomy.

Outcome Measures

The NDI assesses neck pain and a higher score indicates more severe disability. A higher score on the VAS for neck and arm pain indicates worse pain. In the MCS and PCS, a lower score means more severe disability. The SF-36 MCS and PCS are created by finding the average of all of the emotionally or physically relevant questions of the questionnaire.

Change from baseline to 2-year VAS Arm, VAS Neck, NDI, SF-36 MCS, and SF-36 PCS was assessed by taking the difference, dividing by the baseline score, and multiplying by 100. Use of percentage change is recommended in the Initiative

on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) group to establish clinically meaningful outcome constructs.[20] Primary analysis utilized 4 different dichotomous, 2-year outcome measures: improvement in VAS Arm 50%, VAS Neck 50%, NDI 50%, SF-36 PCS 10% improvement, and SF-36 MCS 10% improvement. Percent changes were calculated from baseline to 2 years postoperative accordant to IMMPACT recommended pain and disability reduction threshold for success.

Statistical Analyses

Univariate analysis, including χ^2 tests for categorical variables and t tests on continuous variables, evaluated outcomes according to different predictor variables. Independent bivariate logistic regression models were then created to consider predictors from univariate analyses that yielded a P value < .05 for each of the dichotomous HRQL outcome measures. Control variables were used to control interactions within the modelling, isolating the effect of predictor variables. The presence or absence of complications, surgical approach utilized, and diagnosis were controlled. Presence of complications were assessed by identifying any form of complication during the time period studied. The effect of surgical approach (anterior, posterior, or anterior-posterior) on patient outcomes were controlled for utilizing these control variables. A P value of < .05 was considered statistically significant for all analyses; odds ratios (ORs) are reported as (OR [95% confidence interval (CI)], P value). Statistical analyses were performed using Statistical Package for the Social Sciences version 20.0 (SPSS Inc, Chicago, Illinois).

RESULTS

Patient Population

Of the 2221 patients in the database with radiculopathy, 631 patients underwent procedures for cervical disc herniation, cervical stenosis, or cervical spondylosis without myelopathy. One hundred three patients were missing demographic or operative data. One hundred thirty patients were missing 2-year follow-up. Therefore, 398 surgical patients with degenerative cervical spine diagnoses related to radiculopathy with complete 2-year follow-up data were included for analysis. The descriptive statistics for the total patient cohort

are presented in Table 1. On average, radiculopathy patients experienced symptoms 94 weeks (range: 6–572 weeks) prior to surgical treatment. The overall patient population was on 52.1 ± 10.5 years old (range: 21–84 years), presented with an average BMI of 28.7 ± 5.9 kg/m^2, and was 64.4% female. There were 55 patients (8.6%) who reported a prior cervical surgery, the most frequent treatment at C5-C6 (58.2%) and C6-C7 (52.7%).

Treatment Method

Preoperatively, patients were predominantly treated with the following conservative modalities physical therapy (33.3%), narcotics (32.3%), or nonsteroidal anti-inflammatory drugs (31.4%). Surgically, all patients underwent anterior cervical discectomy and fusion procedures, with some patients also undergoing a removal of the posterior longitudinal ligament. The most frequently operated levels were C5-C6 (39.7%), C6-C7 (24.9%), and C4-C5 (20.0%). Discectomies occurred most frequently anteriorly at the C5-C-6 level (54.3%), and decompression with lamino-foraminotomies and/or laminectomies were most prevalent at C5 (3.7%).

HRQL Metrics Change at 2 Years

For the NDI, patients who improved in neck pain from baseline to 2 years had an average improvement by 17.13 ± 8.05 and the average 2-year NDI score was 9.25 ± 8.57. The average 2-year VAS neck scores for patients who improved from baseline to 2 years was 1.71 ± 1.36 and 6.52 ± 1.88 for patients who did not improve in VAS neck.

The average SF-36 PCS score at 2 years for patients who improved in this metric was 45.35 ± 9.81, and the average for patients who did not improve was 32.01 ± 10.38. For the SF-36 MCS, the average 2-year score for those who improved was 46.41 ± 11.69 and 37.99 ± 13.71. Differences between improvement groups for every HRQL were statistically significant (all P < .001).

Arm-to-Neck Pain Ratio

Table 2 describes patients' improvement on NDI, SF-36 MCS, and SF-36 PCS in relation to their ANR. One hundred fifty-six patients (42.2%) had arm greater than neck pain preoperatively. Patients whose ANR was less than 1 were less likely to have greater change in baseline 2-year NDI (30.0% vs 39.2%, P = .050) and SF-36 PCS (42.4% vs 53.5%,

Table 1. Descriptive summary of the patient population in terms of outcome score group (NDI, VAS, arm/neck, SF-36 PCS/MCS).

| Variable | NDI 50% Improvement from Baseline | | VAS Neck 50% Improvement from Baseline | | VAS Arm 50% Improvement from Baseline | | SF-36 PCS 10% Improvement from Baseline | | SF-36 MCS 10% Improvement from Baseline | |
	Met 50% Improvement (N = 121)	Did Not Meet 50% Improvement (N = 246)	Met 50% Improvement (N = 167)	Did Not Meet 50% Improvement (N = 213)	Met 50% Improvement (N = 183)	Did Not Meet 50% Improvement (N = 181)	Met 10% Improvement (N = 183)	Did Not Meet 10% Improvement (N = 215)	Met 10% Improvement (N = 174)	Did Not Meet 10% Improvement (N = 224)
Age	11.71%	9.88%	10.53%	10.46%	10.15%	10.58%	11.18%	10.34%	10.64%	10.74%
BMI	5.29%	6.44%	5.60%	6.51%	5.22%	7.03%	6.04%	6.10%	5.80%	6.35%
Gender (% female)	59.5%	69.5%	65.9%	67.1%	66.1%	68.5%	65.0%	67.4%	68.4%	64.7%
Previous cervical surgical history	11.9%	22.3%	14.7%	21.1%	15.8%	20.7%	14.4%	20.6%	21.6%	14.3%
Baseline NDI	8.94%	8.74%	8.77%	8.06%	8.67%	7.97%	9.00	9.34	8.88%	9.34%
Baseline SF 36 PCS	8.18%	8.04%	8.64%	8.11%	8.29%	8.31%	8.24	9.11	7.27%	9.61%
Baseline SF 36 MCS	12.32%	12.17%	12.85%	11.83%	12.42%	11.97%	12.35	12.34	10.91%	12.34%
Arm pain greater than neck pain?	33.1%	24.0%	27.5%	24.9%	33.3%	22.7%	30.1%	22.3%	23.6%	27.7%

Abbreviations: BMI, body mass index; NDI, neck disability index; SF-36 MCS, Short-Form 36 Mental Component Summary; SF-36 PCS, Short-Form 36 Physical Component Summary; VAS, visual analog scale.

Table 2. Distribution of patients meeting 2-year NDI, SF-36 PCS/MCS improvement based on ANRs at baseline.

	Arm < Neck (n = 99)	Arm > Neck (n = 156)	P^a
NDI 2-yr 50% improvement	30.0%	39.2%	**.050**
SF-36 PCS 2-yr 10% improvement	42.4%	53.5%	**.025**
SF-36 MCS 2-yr 10% improvement	46.9%	37.0%	**.041**

Abbreviations: ANR, arm-to-neck pain ratio; NDI, neck disability index; SF-36 MCS, Short-Form 36 Mental Component Summary; SF-36 PCS, Short-Form 36 Physical Component Summary.
[a]Difference between arm ≤ neck and arm > neck. Bold indicates significant values.

$P = .025$). These patients conversely were more likely to meet 10% SF-36 MCS improvement from baseline (46.9% vs 37.0%, $P = .041$).

Postoperative Disability

30.4% (n = 121) of patients met at least 50% improvement in NDI score 2 years postoperative, while 61.8% (n = 246) did not. Table 3 displays differences between cervical radiculopathy patients who did and did not improve in NDI score. There were fewer females in the group that met 50% postoperative NDI improvement (59.5% vs 69.5%, $P = .037$), and fewer prior cervical spine surgeries (11.9% vs 22.3%, $P = .039$). The improved NDI group presented with higher SF-36 PCS, MCS, and NDI scores at baseline compared to patients who did not improve in 2-year NDI score. At baseline, 50% NDI improvement patients also reported significantly elevated rates of greater arm pain than neck pain (33.1% vs 24.0%, $P = .044$). Increased SF-36 PCS (1.053 [1.016–1.091], $P = .005$) and SF-36 MCS (1.028 [1.003–1.054], $P = .028$) independently increased the likelihood of improving by 50% for NDI from baseline to 2 years (Table 5).

Postoperative Neck and Arm Pain

At 2-year follow up, 167 patients (43.9%) reached at least 50% improvement in VAS Neck score from baseline, and 183 (50.3%) reached at least 50% improvement in VAS Arm scores. Differences in considered variables are presented in Table 3. Patients meeting 50% VAS Neck improvement displayed better HRQL scores at baseline: NDI was lower (22.62 vs 28.96, $P < .001$), while PCS (36.50 vs 32.94, $P < .001$) and MCS (41.54 vs 35.92, $P < .001$) were higher. On multivariate analyses (Table 4) only a statistically elevated baseline NDI score decreased the OR of 50% VAS Neck improvement (0.958 [0.919–1.151], $P = .045$). Patients who improved 50% in VAS Arm 2-year

Table 3. Univariate analyses for 50% improvements at 2-year post-operative for NDI, VAS Neck/Arm, and SF-36 PCS/MCS scores.[a]

Variable	NDI P Value	VAS Neck P Value	VAS Arm P Value	SF-36 PCS P Value	SF-36 MCS P Value
Age	.940	.434	.756	.782	.108
BMI	.056	.720	.387	.992	.649
Gender	**.037**	.440	.354	.344	.255
Previous cervical surgical history	**.039**	.144	.236	.146	.100
Baseline NDI	**<.001**	**<.001**			**<.001**
Baseline SF 36 PCS	**<.001**	**<.001**	**<.001**	.224	**.012**
Baseline SF 36 MCS	**.001**	**<.001**	**<.001**	**<.001**	**<.001**
Arm pain greater than neck pain	**.044**	.319	**.016**	**.050**	.208

Abbreviations: BMI, body mass index; NDI, neck disability index; SF-36 MCS, Short-Form 36 Mental Component Summary; SF-36 PCS, Short-Form 36 Physical Component Summary; VAS, visual analog scale.
[a]Bold indicates significant values.

scores from baseline had better preoperative NDI scores (23.25 vs 27.63, $P < .001$), SF-36 PCS scores (36.25 vs 32.49, $P < 0.001$), and SF-36 MCS scores (41.40 vs 34.82, $P < .001$). Improved VAS Arm cohort also comprised a higher prevalence of patients reporting arm pain greater than neck pain at baseline (33.3% vs 22.7%, $P = .002$). On multivariate analysis (Table 5) significant baseline factors that increased the odds of reaching 50% VAS Arm improvement at 2-year postoperative included the following: arm pain greater than neck pain (1.707 [1.073–2.716], $P = .024$), SF-36 PCS score (1.046 [1.005–1.089], $P = .028$), and SF-36 MCS score (1.038 [1.014–1.063], $P = .002$).

Postoperative Physical and Mental Outcomes

One hundred eighty-three (46.0%) patients met 10% SF-36 PCS baseline 2-year improvement, and 174 (43.7%) did so for SF-36 MCS. The cohort that met 10% SF-36 PCS improvement had greater SF-36 MCS scores at baseline (42.26 vs 35.67, $P < .001$), and had more patients who reported greater arm than neck pain preoperatively (30.1% vs 22.3%, $P = .050$). Both baseline SF-36 MCS (1.044 [1.026–1.062], $P < .001$) and arm greater than neck pain (1.495 [0.953–2.346], $P = .024$) were associated with greater odds of meeting 10% SF-36

2-year improvement. Patients who met 10% SF-36 MCS 2-year improvement had better NDI (25.98 vs 23.74, $P = .019$), better SF-36 PCS (35.33 vs 36.07, $P = .012$) score at baseline, but worse SF-36 MCS (32.98 vs 43.14, $P < .001$). Multivariate analysis showed that baseline SF-36 PCS (1.069 [1.016–1.125], $P = .010$) increased the OR of SF-36 MCS improvement while preoperative SF-36 MCS (0.929 [0.899–0.959], $P < .001$) decreased the OR (Table 6).

DISCUSSION

Spine surgery has historically been associated with more variability in indications and outcomes than other surgical procedures.[21–23] Although the cause for this variability is multifactorial, accurately diagnosing a specific pain generator to select an appropriate treatment is difficult, yet necessary given surgical results for chronic benign pain syndromes without a reversible anatomic cause are generally poor.[24–26] Given the ubiquitous nature of cervical degenerative disc disease in the adult population, the clinical presentation of cervical radiculopathy is varied with up to 80% of patients having concomitant neck pain associated with radicular pain and neurological symptoms.[27] Multiple studies suggest that cervical discs and facet joints can generate pain with the prevalence rates ranging from 36% to 60%.[25,28–30] Identification of factors that may help predict surgical outcomes has been a driving force in the spine literature since pain relief and improvements in functional disability have been shown to correlate to postoperative patient satisfaction in cervical spine surgery.[9,18,31] In our study, we aimed to predict postoperative outcomes given preoperative arm and neck pain scores and to determine whether baseline characteristics varied with the ratio of those pain scores.

Table 4. Multivariate analysis for 50% improvements at 2-year postoperative for NDI score.[a]

Variable	Odds Ratio (95% CI)	P Value
Gender (% female)	0.899 (0.495–1.631)	.725
Previous cervical surgical history	0.556 (0.247–1.250)	.155
Baseline NDI	1.011 (0.958–1.068)	.684
Baseline SF-36 PCS	1.053 (1.016–1.091)	**.005**
Baseline SF-36 MCS	1.028 (1.003–1.054)	**.028**
Arm pain greater than neck pain	1.319 (0.683–2.546)	.410

Abbreviations: NDI, neck disability index; SF-36 MCS, Short-Form 36 Mental Component Summary; SF-36 PCS, Short-Form 36 Physical Component Summary.
[a]Bold indicates significant values.

Table 5. Multivariate analysis for 50% improvements at 2-year postoperative for VAS neck and arm scores.[a]

Variable	VAS Neck		VAS Arm	
	Odds Ratio (95% CI)	P Value	Odds Ratio (95% CI)	P Value
Baseline NDI	0.958 (0.919–1.151)	**.045**	0.994 (0.952–1.038)	.788
Baseline SF 36 PCS	1.020 (0.981–1.060)	.323	1.046 (1.005–1.089)	**.028**
Baseline SF 36 MCS	1.021 (0.998–1.044)	.079	1.038 (1.014–1.063)	**.002**
Arm pain greater than neck pain	NS	NS	1.707 (1.073–2.716)	**.024**

Abbreviations: NDI, neck disability index; SF-36 MCS, Short-Form 36 Mental Component Summary; SF-36 PCS, Short-Form 36 Physical Component Summary; VAS, visual analog scale.
[a]Bold indicates significant values.

Traditionally, neck pain has been considered a poor prognostic indicator for surgical intervention.[10,11] Williams et al[11] reported on the outcomes of 99 patients following anterior cervical discectomy and fusion (ACDF) for cervical disc degeneration with less than 10-year follow-up and found that 73% of patients with radicular symptoms had good to excellent results compared to 26% with nonradicular symptoms. Similarly, DePalma and Rothman[10] described approximately 70% of patients with chronic axial dominant neck pain, who were treated nonoperatively, had partial to no relief in their symptoms, while surgically treated patients had little functional benefit 5 years postoperatively. Other studies have highlighted the predominance of qualitative radicular symptoms in the context of superior outcomes.[4,32–34] While these studies have shown that axial versus radicular pain symptoms may guide surgical treatment, none of these studies quantified region specific pain ratios as a prognostic value.

In contrast, early results of ACDF published by Smith and Robinson[35] showed 73% good to excellent results for patients with predominant axial symptoms. However, interpretation of the authors' findings is limited by subjective, nonstandardized clinician evaluation of the subjects.[35] More recent studies have shown surgical treatment for axial neck pain with minimal radicular complaints can have positive surgical outcomes with improvements in disability ranging from 32.3% to 51.9%, improvement in patient reported pain ranging from 50% to 60%, and patient satisfaction ranging from 56% to 79%.[9,36,37] Nevertheless, interpretation of these results is limited given lack of level I to III evidence and absence of reporting of clinically meaningful improvement in pain and function. Our study utilized NDI, SF-36 MCS/PCS, and VAS scores for neck and arm as baseline measures of health status given their high level of reliability, validity, and responsiveness as outcome measures.[38–40]

Recent research into cervical surgical procedures for radiculopathy has focused on patient-reported outcome measures like the VAS as not only measurements of improvement, but also as preoperative predictors for surgical success.[21–23] Via the use of established criteria for improvement for our outcome measures,[19,41,42] our results show associations between ANR greater than or equal to 1 correlated with statistically significant improvements in NDI and SF-36 PCS 2 years after surgery. Baseline arm pain greater than neck pain similarly increased the odds of achieving improvement in SF-36 PCS and VAS Arm scores following surgery. This is intuitive, given a patient with predominant radicular symptoms is more likely to have relief of the arm pain symptoms after adequate decompression of the affected nerve root.

The present study indicates that in patients with cervical radiculopathy due to degenerative disc disease, preoperative demographic and symptomatic factors may predict postoperative improvements in HRQL at 2-year follow-up. Furthermore, the

Table 6. Multivariate analysis for 50% improvements at 2-year postoperative for SF-36 PCS and MCS scores.[a]

Variable	SF-36 PCS		SF-36 MCS	
	Odds Ratio (95% CI)	P Value	Odds Ratio (95% CI)	P Value
Previous cervical surgical history	NS	NS	0.642 (0.290–1.420)	.274
Baseline NDI	NS	NS	1.035 (0.982–1.091)	.194
Baseline SF 36 PCS	NS	NS	1.069 (1.016–1.125)	**.010**
Baseline SF 36 MCS	1.044 (1.026–1.062)	**<.001**	0.929 (0.899–0.959)	**<.001**
Arm pain greater than neck pain	1.495 (1.053–2.346)	**.024**	NS	NS

Abbreviations: NDI, neck disability index; SF-36 MCS, Short-Form 36 Mental Component Summary; SF-36 PCS, Short-Form 36 Physical Component Summary.
[a]Bold indicates significant values.

present findings build on prior reports considering outcome scores in isolation by quantifying the ANR and utilizing this ratio as a predictor of outcomes in cervical spine surgery. By utilizing this novel ratio, we found that patients with higher neck than arm pain were less likely to improve in overall disability, physical and mental health postoperatively.

The present findings support the notion that patients with predominant axial neck symptoms are less likely to benefit from surgical intervention than those with predominant arm pain. Our findings are analogous to literature related to low back pain and leg pain in the context of lumbar spine surgery. Kleinstuck et al[43] found that quantified low back pain and leg pain scores in patients presenting with spinal stenosis was the strongest predictor of 12-month outcomes. Similarly, using the Spine Patient Outcomes Research Trial (SPORT) data, Pearson et al[41] found patients with degenerative spondylolisthesis and spinal stenosis who had predominant leg pain improved significantly more with surgery than patients with predominant back pain. Our results also show that a lower baseline NDI and higher SF-36 PCS and MCS scores have an impact on improvements in postoperative neck and arm pain. This is consistent with published data, which has shown that patients with lower preoperative disability and pain have better outcomes.[15,44]

Limitations of this study include the retrospective nature, as well as the inherent flaws of large database studies such as coding errors and variable response rates. Additionally, conclusions in the group studied may not be generalizable to the population as a whole. Although we are utilizing accepted minimal clinically important differences (MCID) for our outcome measures, the use of VAS scores has not been shown to have the same reliability, validity, and responsiveness as the NDI and SF-36 measures.[45] Additionally, our study is limited by 2-year follow-up, which may obscure clinically important changes that may occur in the immediate perioperative and short-term postoperative periods, as well as by current procedural terminology coding used for surgical procedures. This prospective cervical database was designed to study in an a priori manner predictors of the included patient derived outcomes; therefore, the performance of an actual ANR was not inherent to the design of the study. Radiographic variables were not included in the statistical model, hence, determination of successful fusion for ACDF surgeries

was unable to be evaluated. Another limitation is that the ANR was developed by assessing the data retrospectively; however, we believe that a prospectively collected ANR would be a powerful surgical planning tool and should be incorporated into future prospective studies. In spite of these limitations, our study utilized a large number of patients with long-term follow-up.

CONCLUSIONS

Patient-reported outcome measures not only give quantitative data regarding general health quality, function, and pain, but also may predict long-term outcomes. Additionally, patient-reported arm-pain greater than neck-pain scores may predict positive long-term physical outcomes. This retrospective analysis of a spine registry data identified baseline factors that may be predictive of patient-reported outcomes subsequent to cervical spine surgery in patients with cervical radiculopathy, as well as analyzed the utility of a novel ratio, the ANR. By utilizing this novel ratio, the present study found that patients with higher neck than arm pain were less likely to improve in overall disability, physical and mental health postoperatively. While this may suggest a clinical utility for the use of the ANR, further studies are required to establish more evidence of these predictive measures.

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