ABSTRACT

Background: For cervical deformity (CD) surgery, goals include realignment, improved patient quality of life, and improved clinical outcomes. There is limited research identifying patients most likely to achieve all three.

Objective: The objective is to create a model predicting good 1-year postoperative realignment, quality of life, and clinical outcomes following CD surgery using baseline demographic, clinical, and radiographic factors.

Methods: Retrospective review of a multicenter CD database. CD patients were defined as having one of the following radiographic criteria: Cervical sagittal vertical axis (cSVA) >4 cm, cervical kyphosis/scoliosis >10° or chin-brow vertical angle >25°. The outcome assessed was whether a patient achieved both a good radiographic and clinical outcome. The primary analysis was stepwise regression models which generated a dataset-specific prediction model for achieving a good radiographic and clinical outcome. Model internal validation was achieved by bootstrapping and calculating the area under the curve (AUC) of the final model with 95% confidence intervals.

Results: Seventy-three CD patients were included (61.8 years, 58.9% F). The final model predicting the achievement of a good overall result (radiographic and clinical) yielded an AUC of 73.5% and included the following baseline demographic, clinical, and radiographic factors: mild-moderate myelopathy (Modified Japanese Orthopedic Association >12), no pedicle subtraction osteotomy, no prior cervical spine surgery, posterior lowest instrumented vertebra (LIV) at T1 or above, thoracic kyphosis >33°, T1 slope <16 and cSVA <20 mm.

Conclusions: Achievement of a positive outcome in radiographic and clinical outcomes following surgical correction of CD can be predicted with high accuracy using a combination of demographic, clinical, radiographic, and surgical factors, with the top factors being baseline cSVA <20 mm, no prior cervical surgery, and posterior LIV at T1 or above.

Keywords: Cervical deformity, clinical outcomes, predictive modeling, radiographic alignment, surgical correction
INTRODUCTION

Cervical deformity (CD) encompasses a complex group of disorders with a wide range of etiologies, including inflammatory arthropathy, spondylosis, trauma, and others. Although uncommon, CD can be debilitating and can result in severe disability and pain related to progressive neurologic impairment. Unlike for thoracolumbar deformities, there is less consensus and granularity for CD in regards to optimal treatment approaches, management, and outcome assessments. With recent advances in CD correction techniques and improvements in understanding of regional sagittal alignment in the cervical spine with respect to global alignment, a new classification system of CD was developed by Ames-ISSG to characterize the apex of the deformity as well as incorporate radiographic and outcome modifiers. This classification system characterized CD patients based on the apex of the deformity, as well as the severity of modifiers: Cervical sagittal vertical axis (cSVA), horizontal gaze, TS-CL, myelopathy (mJOA score), and SRS-Schwab modifiers.

Progressive cervical kyphosis leads to spinal cord compression and resulting neurologic impairment. As the spinal cord becomes tethered and bends around the kyphotic regions of the spine, it causes increased intramedullary pressure and neuronal loss and potential demyelination of the spinal cord. When the spinal cord experiences increased elongation because of dynamic motion including flexion of the spine and increased stretching because of the deformity, the strain is heightened and can lead to myelopathy. CD surgical correction has led to improvements in radiographic alignment and patient reported outcome metrics for pain, disability and neurologic and myelopathy improvement.

The use of predictive analytics in spine surgery outcomes allows surgeons to identify patient-specific predictors of the outcome of interest. As both surgeons and their patients are invested and interested in positive outcomes following surgery, isolating relevant factors that are predictive of a good outcome are of utmost importance. Recently, one study developed a statistical model to predict poor postoperative surgical outcomes following thoracolumbar deformity corrective surgery. This model included radiographic and surgical predictors of a poor outcome, but did not incorporate patient-reported outcome metrics in the model. Improvements in functional outcomes following CD surgery are understudied in the literature. With a recent definition of the minimum clinically important difference (MCID) for the mJOA in a cervical spondylotic myelopathy population, clinical assessments of patient-reported outcomes using mJOA improvements can be used in conjunction with the assessments of radiographic alignment improvements.

The aim of this study was to develop a predictive model of good radiographic and clinical outcomes following CD corrective surgery. Identifying factors that are predictive of a good outcome can aid in preoperative counseling and decision-making.

METHODS

Data source

This study is a retrospective review of a prospectively-collected database of CD patients enrolled from 13 sites within the United States. Internal Review Board approval was obtained at each participating site prior to study initiation and informed consent was given by each included patient. Inclusion criteria for the database were patients ages ≥18 years, and radiographic evidence of CD at baseline assessment, defined as the presence of at least 1 of the following: cervical kyphosis (C2–C7 Cobb angle >10°), cervical scoliosis (C2–C7 coronal Cobb angle >10°), C2–C7 sagittal vertical axis (cSVA) >4 cm, or chin-brow vertical angle (CBVA) >25°. Patients with active tumors or infections were excluded from the study.

Data collection

Demographic and clinical data collected included patient age, sex, body mass index (BMI), prior cervical surgery, and Charlson comorbidity index (CCI). Surgical data collected included operative time, estimated blood loss, surgical approach, off-label use of bone morphogenetic protein 2, osteotomy use and number of osteotomies, levels fused, and instrumentation used. Patients were evaluated using full-length free-standing lateral spine radiographs (36° long-cassette) at baseline and 1 year postoperative follow-up visit. Radiographs were analyzed using dedicated and validated software (SpineView; ENSAM, Laboratory of Biomechanics, Paris, France) at a single center with standard techniques. Measured cervical spine parameters included cSVA (offset from the C2 plumbline and the posterosuperior corner of C7), C2–C7 lordosis (CL: Cobb angle between C2 inferior endplate and C7 inferior endplate), T1 slope minus CL (TS-CL: mismatch between T1 slope and cervical lordosis), and CBVA (angle subtended between the vertical line and the line from the brow to the chin). Measured spinopelvic parameters [Figure 1] included: sagittal vertical axis (SVA: C7 plumb line relative to the posterior-superior corner of S1), pelvic incidence minus lumbar lordosis (PI-LL: mismatch between pelvic incidence and lumbar lordosis), and pelvic tilt (PT: angle between the vertical and the line through the sacral midpoint to the center of the two femoral heads).
Achievement of “Good” radiographic and clinical outcomes

Patients were evaluated using the Ames-CD classification system’s radiographic modifiers (cSVA, CBVA, TS-CL, and SVA from the Schwab classification system). Alignment modifiers are graded from 0 (normal) to 2 (markedly abnormal/severe). A good radiographic outcome was achieved if patients did not have any “severe” Ames modifier grades at 1-year. We also assessed patients’ radiographic outcomes on the basis of having at least two non-“severe” radiographic Ames modifiers at 1-year. A positive improvement in patient-reported health-related quality of life outcome was achieved if (1) a patient improved in modified Japanese Orthopedic Association (mJOA) score or (2) a patient reached the MCID for the mJOA questionnaire at 1-year postoperative. The favorable outcome for the modeling was assessed by whether a patient achieved both a good radiographic and clinical outcome.

Statistical analysis

The characteristics of subjects including demographics were first summarized using descriptive statistics in mean ± standard deviation for continuous variables or % (counts) for categorical variables. In investigating an association of predictors with outcomes, the prediction model was fitted using a non-linear mixed model featuring a logistic model in which the subject was considered as a random factor to account for more than one outcome for the same patient. We first evaluated the association of the outcome with variables in a univariate manner. Then, all variables were evaluated in one multivariate model to control for confounding effects. All variables with \( P < 0.05 \) for the bivariate association with outcome were considered for initial inclusion in the multivariate model, but only those which remained significant to \( P < 0.05 \) were retained in the final model. To establish a final prediction model, a series of prediction models were built by sequentially adding predictors from the ranked list and a final model was chosen based on the model with the lowest Akaike information criterion. Internal validation of the prediction model was performed by calculating area under the curve (AUC) of the corresponding final prediction model by drawing the receiver operating characteristic. This process was repeated 1000 times and each time a resample of the validation data was used, and in this way, the distribution of the AUCs was obtained. The mean and 95% CI of the AUC was then estimated. Results are reported as coefficient with odds ratios with 95% confidence intervals. Two-sided \( P < 0.05 \) was considered statistically significant. All analyses were carried out using SPSS software (version 21.0, IBM, Armonk, New York). R statistical software package (R, version 2.12.2, R Development Core Team). Unless otherwise noted, analyses used mixed-effects models (package lme4: Bates, Maechler and Bolker 2011) in R 2.14.2 (R Development Core Team 2012).

RESULTS

Patient demographics

Seventy-three CD patients were included in the study. The most common diagnoses for these patients were degenerative kyphosis, iatrogenic kyphosis, and cervical stenosis. Demographic details are available in Table 1.

Surgical details

The average levels fused was 7.57 levels, with an estimated blood loss of 891 cc and average operative time of 361 min [Table 1]. The breakdown of surgical approaches was as follows: 17.8% anterior-only, 47.9% posterior-only, and 34.3% combined approach.

Preoperative and 1-year postoperative radiographic alignment

At baseline, the average cSVA was 46.2 mm, TS-CL was 36.7°, thoracic kyphosis was 40.2°, global SVA was 8.28 mm, and PI-LL was 1.33° [Table 2]. Broken down by Ames modifiers, 4.1% of patients had a cSVA modifier Grade 2 (“severe”), 27.1% had a severe horizontal gaze modifier, 83.6% had a severe TS-CL modifier, and 8.3% had a global SVA modifier [Table 3]. From baseline to 1-year postoperative, patients improved in all cervical parameters including, TS-CL, cervical lordosis, cSVA, C2–T3 angle, C2 slope, with the exception of C2–T3 SVA [Table 2].

Health-related quality of life scores

At baseline, the average Neck Disability Index score was 48.6
Predicting a good clinical and radiographic outcome

The following baseline demographic, clinical, and radiographic factors were included in initial models predicting a good overall outcome following CD surgery: gender, CCI, osteoporosis, Ames type driver, prior history of cervical spine surgery, pedicle subtraction osteotomy (PSO) osteotomy use, baseline mJOA score, baseline cSVA, T2–T12 kyphosis, T1 slope, C2 slope, maximum kyphosis value, T1SPl, C2SPl, baseline neurologic weakness, and presence of neurologic symptoms. In using a liberal definition of a good clinical and radiographic outcome, the highest AUC achieved was 0.848, however this model did not contain clinically relevant predictors. We sought to use more stringent definitions of a good overall outcome in combination with more clinically relevant parameters [Table 5]. The best overall outcome was predicted using Model 1 (no severe Ames radiographic modifiers and reaching 1Y MCID for mJOA). Model 2 was a slight variation on this first model that still required a patient to not have any severe radiographic alignment parameters but the clinical definition of a good outcome was loosened slightly so that a patient had to improve in mJOA from pre- to postoperative but did not necessarily need to meet MCID. Model 3 had a strict definition of the clinical outcome (must meet mJOA MCID) but a slightly more relaxed radiographic outcome and Model 4 had the most liberal definitions of the final models chosen, with patients still having one severe radiographic parameter and only improving but not reaching MCID for mJOA.

All four models had lack of PSO use and no prior cervical spine surgery as predictors of a good overall outcome. For both models that required patients to not have any severe radiographic parameters (Models 1 and 2), a mean baseline mJOA score >12, baseline T2-T12 thoracic kyphosis >32.6°, and baseline cSVA <20.2 mm predicted a good overall outcome. Both models where patients still had one severe radiographic parameter (Models 3 and 4) had the same T2-T12 thoracic kyphosis cutoffs and similar mJOA score cutoffs (>15 for Model 3 and >16 for Model 4). All models except Model 2 had a posterior lowest instrumented vertebra (LIV) at T1 or above as a significant predictor of a good outcome, whereas for Model 2 the cutoff was T2 or above for a good outcome. The cutoff for cSVA being predictive of a good

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**Table 1: Demographics and surgical details for cervical deformity patients**

| Demographic variable | Frequency or mean |
|----------------------|-------------------|
| Age (years)          | 61.81 ± 10.67     |
| BMI (kg/m²)          | 29.47 ± 8.13      |
| CCI                  | 0.63 ± 0.36       |
| Gender (female) (%)  | 43 (58.9)         |
| Prior cervical surgery (%) | 27 (38.0)     |
| History of smoking (%) | 20 (29.0)       |
| Ambulatory status (percentage walking without any aid) | 56 (76.7) |
| Diabetes (%)         | 12 (16.4)         |
| Osteoporosis (%)     | 8 (11.0)          |

**Surgical variables**

- Levels fused: 7.57 ± 3.62
- Estimated blood loss (cc): 891.59 ± 915.78
- Operative time (min): 361.29 ± 233.05
- BMP-2 use (%): 28 (38.9)
- Surgical approach (%): 13 (17.8)
- Anterior only: 35 (47.9)
  - Combined: 25 (34.3)
- Posterior LIV: T4
- Osteotomy use (%): 3 (5.0)
- Partial facet: 1 (1.7)
  - Complete facet: 1 (1.7)
- Smith-peterson osteotomy: 14 (19.2)
- Opening wedge: 1 (3.8)
- Closing wedge: 12 (16.4)
- Vertebral column resection: 3 (4.1)
- Transition rods (%): 18 (24.7)

BMI - Body mass index; CCI - Charlson comorbidity index; BMP-2 - Bone morphogenetic protein 2; LIV - Lowest instrumented vertebra

**Table 2: Baseline and 1-year postoperative radiographic measurements**

| Radiographic parameter | Baseline | Postoperative | P     |
|------------------------|----------|---------------|-------|
| PT (°)                 | 19.39 ± 11.06 | 18.21 ± 10.32 | 0.118 |
| PI-LL (°)              | 1.33 ± 16.29 | 1.31 ± 15.33 | 0.987 |
| C7-S1 SVA (mm)         | 8.28 ± 75.34 | 26.33 ± 63.9 | 0.002* |
| C2-S1 SVA (mm)         | 48.98 ± 82.37 | 64.01 ± 72.93 | 0.022* |
| T4-T12 TK (°)          | 40.21 ± 16.39 | 44.17 ± 15.59 | 0.001* |
| T1PA (°)               | 13.87 ± 11.65 | 14.68 ± 10.26 | 0.199 |
| CTPA (°)               | 4.83 ± 2.7 | 4.38 ± 1.87 | 0.024* |
| T1 slope (°)           | 31.77 ± 17.48 | 37.17 ± 14.23 | <0.001* |
| TS-CL (°)              | 36.74 ± 19.36 | 27.42 ± 13.18 | <0.001* |
| C2-C7 CL (°)           | -6.32 ± 21.35 | 8.28 ± 16.14 | <0.001* |
| C2-C7 SVA (mm)         | 46.21 ± 23.91 | 41.34 ± 16.51 | 0.018* |
| C2-T3 (°)              | -16.03 ± 20.4 | 0.07 ± 16.43 | <0.001* |
| C2-T3 SVA (mm)         | 78.82 ± 39.45 | 77.73 ± 27.17 | 0.663 |
| C2 slope (°)           | 38.71 ± 19.62 | 28.36 ± 13.47 | <0.001* |
| C1 slope (°)           | 1.92 ± 18.21 | -7.09 ± 13.42 | <0.001* |
| C0 slope (°)           | -1.27 ± 14.37 | -7.23 ± 9.88 | 0.002* |
| C0-C2 angle (°)        | 33.49 ± 12.05 | 28.34 ± 11.12 | 0.001* |

* C7-S1 SVA (mm) 8.28 ± 75.34 26.33 ± 63.9 0.002. PT - Pelvic tilt; PI-LL - Pelvic incidence minus lumbar lordosis; SVA - Sagittal vertical axis; TX - Thoracic kyphosis; T1PA - T1 pelvic angle; CTPA - Cervical-thoracic pelvic angle; TS-CL - T1 slope minus cervical lordosis

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[Table 4] out of 100, EQ-5D was 0.73, and mJOA was 13.6. Using the Ames mJOA modifier grade, 10.6% of patients had no myelopathy (mJOA score of 18), 27.3% of patients had mild myelopathy (mJOA score 15–17), 40.9% of patients had moderate myelopathy (mJOA score 12–14), and 21.2% had severe myelopathy. 35.6% of patients improved in mJOA, with 20.5% of patients reaching mJOA MCID.
outcome was the same for Models 1, 2, and 4 (<20.2 mm) and for Model 3 it was 23.9 mm.

**Case examples**

Figure 2 presents a case of a 53-year-old female patient with a BMI of 21.9 kg/m² who underwent CD surgery from C2–T2 with no pedicle subtraction osteotomy performed. At baseline, cSVA was 27.7 mm, TS-CL was 30.5°, and horizontal gaze was 3.3°. 1-year postoperatively, cSVA was 20.2 mm, TS-CL was 20.4°, and horizontal gaze was 3.4°. This patient had a baseline mJOA score of 12 and postoperative score of 15, thus meeting 1-year MCID for mJOA. This patient achieved a good overall outcome as defined by the most strict definition of Model 1.

Figure 3 presents a case of a 52-year-old female patient with a BMI of 24.3 kg/m² who underwent CD surgery from C2 to T2 with no pedicle subtraction osteotomy performed. At baseline, cSVA was 2.7 mm, TS-CL was 15.6°, and horizontal gaze was 2.9°. One-year postoperatively, cSVA was 18.9 mm, TS-CL was 31.3°, and horizontal gaze was 8.9°. This patient had a baseline mJOA score of 12 and postoperative score of 13, thus slightly improving in mJOA but not reaching MCID. This patient achieved a good overall outcome as defined by the more loosely defined definition of Model 4.

**DISCUSSION**

As the field of CD corrective surgery continues to progress, the importance of being able to identify patient factors that are predictive of a good outcome in terms of radiographic alignment and clinical improvements is heightened. In this study, we created four predictive models with variations in the definition of a good clinical and radiographic outcome that used baseline clinical, demographic, and surgical factors to predict this good overall outcome.

As both surgeons and their patients are invested and interested in positive outcomes following surgery, isolating relevant factors that are predictive of a good outcome are
of utmost importance. Predictive analytics in spine surgery outcomes allows surgeons to identify patient-specific predictors of the outcome of interest. Recent work has looked at predicting outcomes in spine surgery and specifically

Table 5: Description of the four Models utilized to assess postoperative outcomes

| Significant predictor | Model 1 No severe radiographic modifiers and met mJOA MCID | Model 2 No severe radiographic modifiers and improved in mJOA | Model 3 At least two nonsevere radiographic modifiers and met mJOA MCID | Model 4 At least two nonsevere radiographic modifiers and improved in mJOA |
|-----------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|
| 1. PSO use            | 0.372 (0.073-1.906)/0.236                                 | 0.555 (0.170-1.817)/0.331                                 | 1.066 (0.442-2.566)/0.887                                 | 1.107 (0.460-2.663)/0.821                                 |
| 2. Baseline mJOA score| 0.870 (0.718-1.054)/0.155                                 | 0.883 (0.758-1.029)/0.111                                 | 1.004 (0.884-1.141)/0.948                                 | 0.985 (0.867-1.120)/0.819                                 |
| 3. Posterior LIV      | 0.924 (0.778-1.096)/0.363                                 | 0.982 (0.868-1.112)/0.779                                 | 1.042 (0.946-1.149)/0.405                                 | 1.063 (0.962-1.174)/0.229                                 |
| 4. Prior history of cervical spine surgery | 0.480 (0.145-1.583)/0.228 | 0.711 (0.295-1.715)/0.448 | 0.864 (0.435-1.716)/0.676 | 0.956 (0.485-1.882)/0.895 |
| 5. Baseline T2-T12 kyphosis | 1.047 (1.017-1.078)/0.002 | 1.028 (1.005-1.051)/0.015 | 1.020 (1.002-1.039)/0.029 | 1.017 (1.000-1.035)/0.054 |
| 6. Baseline T1 slope  | 0.953 (0.921-0.986)/0.005                                 | 0.970 (0.946-0.995)/0.017                                 | 0.972 (0.952-0.992)/0.007                                 | 0.975 (0.955-0.994)/0.012                                 |
| 7. Baseline cSVA      | 0.938 (0.933-0.983)/0.001                                 | 0.974 (0.954-0.996)/0.018                                 | 0.977 (0.958-0.995)/0.014                                 | 0.981 (0.963-1.000)/0.047                                 |
|                      | 0.735 (0.498-0.7649)                                      | 0.706 (0.498-0.7516)                                      | 0.678 (0.465-0.7254)                                      | 0.694 (0.510-0.7463)                                      |

(a) Significant predictors of the final outcome for all four final models included in the analysis

(b) Cutoff values at which each variable is a significant predictor of the outcome predicted by each of the four models

1. PSO use            | No                                                      | No                                                      | No                                                      | No                                                      |
2. Baseline mJOA score| >12                                                     | >12                                                     | >15                                                     | >16                                                     |
3. Posterior LIV      | T1 or above                                             | T2 or above                                             | T1 or above                                             | T1 or above                                             |
4. Prior history of cervical spine surgery | No                                                      | No                                                      | No                                                      | No                                                      |
5. Baseline T2-T12 kyphosis (°) | >32.6                                                  | >32.6                                                  | >33.1                                                   | >33.1                                                   |
6. Baseline T1 slope  | <16.0                                                   | <21.3                                                   | <22.2                                                   | <20.2                                                   |
7. Baseline cSVA      | <20.2                                                   | <20.2                                                   | <23.9                                                   | <20.2                                                   |

MCID - Minimum clinically important difference; mJOA - Modified Japanese Orthopedic Association; LIV - Lowest instrumented vertebra; cSVA - C2-C7 sagittal vertical axis; CI - Confidence interval; LCI - Lower confidence interval; UPI - Upper confidence interval, PSO - : Pedicle subtraction osteotomy

Figure 2: Lateral cervical radiographs of pre- and 1-year postoperative for a case example of a cervical deformity patient who achieved a good overall outcome as defined by Model 1. This patient is a 53-year-old female with a body mass index of 21.9 kg/m² who underwent cervical deformity corrective surgery from C2 to T2 with no pedicle subtraction osteotomy performed. At baseline, cSVA was 27.7 mm, TS-CL was 30.5°, and horizontal gaze was 3.2°. 1-year postoperatively, cSVA was 20.2 mm, TS-CL was 20.4°, and horizontal gaze was 3.4°. This patient had a baseline mJOA score of 12 and postoperative score of 15, thus meeting 1-year minimum clinically important difference for mJOA. cSVA - Cervical sagittal vertical axis

Figure 3: Lateral cervical radiographs of pre- and 1-year postoperative for a case example of a patient who achieved a good overall outcome as defined by Model 4. This patient is a 52-year-old female with a body mass index of 24.3 kg/m² who underwent cervical deformity corrective surgery from C2 to T2 with no pedicle subtraction osteotomy performed. At baseline, cSVA was 2.7 mm, TS-CL was 15.6°, and horizontal gaze was 2.9°. 1-year postoperatively, cSVA was 18.9 mm, TS-CL was 33.3°, and horizontal gaze was 8.9°. This patient had a baseline mJOA score of 12 and postoperative score of 13, thus slightly improving in mJOA but not reaching minimum clinically important difference. cSVA - Cervical sagittal vertical axis
The fact that we were unable to achieve an AUC greater than 85% even when utilizing a liberal definition of a good outcome and incorporating factors that were not as clinically relevant speaks to the fact that radiographic and clinical outcomes do not display a linear relationship and that a much more complex interaction of these factors is at play. Previous studies of CD patients mirror this concept, with low correlations seen between radiographic and clinical outcomes.\textsuperscript{11,16} Previous reports have shown that baseline mJOA score is predictive of postoperative outcomes in cervical spondylotic myelopathy patients, and similar results have also been shown in a recent study looking at predicting outcomes after CD surgery.\textsuperscript{11,19} Few studies have reported the relationship between radiographic parameters in the cervical spine and health-related quality of life metrics.\textsuperscript{20,21} One study reported no significant relationship between segmental kyphosis and clinical outcomes and another found that overall cervical alignment did not correlate with outcomes despite correlated segmental changes.\textsuperscript{21,22} This speaks to the fact that varied combinations of clinical and radiographic good outcomes needs to be used to assess CD patients.

We sought to use more stringent definitions of a good overall outcome in combination with more clinically relevant parameters to assess these CD patients. As previously noted, radiographic and clinical outcomes following CD surgery are not linearly correlated and thus we aimed to test variations on a good outcome to find the best fit for this population.\textsuperscript{18} The MCID for mJOA in a CD-specific population has yet to be developed, but related literature for other cervical spine pathologies were used in this study, given that many deformity patients in this study also presented with cervical myelopathy.\textsuperscript{23} The best overall outcome was Model 1, where a patient had no severe radiographic modifiers at 1-year and reached MCID for mJOA and milder baseline deformity and more severe myelopathy predicted this good outcome. When we combine these outcomes into one model, where we are predicting both a good radiographic and clinical outcome, we found that milder baseline deformity and severe myelopathy treated with fusions not extending beyond T1 or T2 were predictive of the best overall outcome.

Achievement of a positive outcome in radiographic and clinical outcomes following surgical correction of CD can be predicted with high accuracy using a combination of demographic, clinical, radiographic, and surgical factors, with the top factors being baseline cSVA < 20 mm, no prior cervical surgery, and posterior LIV at T1 or above. With the combination of factors, we found that milder CD also presenting with more severe baseline myelopathy is the most ideal combination to predict a good outcome. Further study is needed however to identify predictors of a good overall outcome in a more severely deformed population. Preoperative assessment of patients’ overall characteristics can help counsel patients and increase the chance of the
patient improving in radiographic and clinical factors and achieving a good outcome after surgery.

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Conflicts of interest
There are no conflicts of interest.

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