

# **So Close Yet So Far: The Impact of cSVA Undercorrection during Adult Cervical Deformity Surgery - An Incremental Correction Analysis**

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## **INTRODUCTION:**

Surgeons recognize that a one-size-fits-all approach to achieving alignment goals in adult cervical deformity surgery is inadequate. Striking a precise balance in alignment targets is critical, as overcorrection can lead to potential complications, while undercorrection may compromise long-term outcomes. This study aims to investigate the optimal degrees of cervical sagittal vertical axis (cSVA) correction and to establish theoretical minimum and maximum thresholds that would maximize clinical benefits for ACD patients.

## **METHODS:**

We conducted a retrospective cohort study using a prospectively enrolled database, analyzing 657 operative adult cervical deformity (ACD) patients with complete baseline (BL) and two-year (2Y) radiographic and Health-Related Quality of Life (HRQL) data. Descriptive statistics and means comparison tests were utilized for initial analysis. Patients were categorized into two groups based on postoperative cSVA measurements: a corrected cohort (cSVA < 4 cm) and an undercorrected cohort (cSVA ≥ 4 cm). Chi-squared tests and regression analyses were employed to determine differences in cohort demographics, clinical characteristics, and outcomes.

## **RESULTS:**

In this study, 265 patients met inclusion criteria, with a mean age of 58.2±11.4 years, BMI of 28.9±7.5, and a Charlson Comorbidity Index (CCI) of 0.9±1.3. Surgically, the average operative time was 348.0±194.9 minutes, estimated blood loss (EBL) was 834.4±1180.3 mL, and length of stay (LOS) was 4.9±5.6 days. The mean number of anterior and posterior levels fused were 3.3±1.4 and 5.1±1.4, respectively. Baseline radiographic measurements included T1 slope (T1S) of 21.7±24.4°, cervical slope (C2S) of 30.9±20.2°, C2-C7 angle of -7.3±18.4°, T1 slope minus cervical lordosis (TS-CL) of 28.2±19.6°, and cSVA of 19.6±32.2 mm.

Only 11.2% of patients were undercorrected, while 88.8% were appropriately corrected. The undercorrected cohort had a significantly higher proportion of moderately to severely frail patients compared to the corrected group (91.3% vs. 71.4%, p=0.041) and experienced more radiographic complications (47.8% vs. 27.6%, p<0.046). This group also showed a significantly higher rate of severe 6-month distal junctional kyphosis (DJK) and 1-year DJK (54.5% vs. 45.5%, p<.001). Clinically, undercorrected patients demonstrated lesser improvements in hand clumsiness (22% vs. 80%, p=0.33) and bladder/bowel continence (33% vs. 66.7%, p=0.029). They also reported lower resolution of persistent symptoms compared to the corrected cohort (4.5% vs. 95.5%, p=0.026).

In terms of HRQL, the corrected group exhibited significantly higher Year 2 EQ5D-Health scores (76.9 vs. 46.7, p=0.012). Being undercorrected significantly predicted a moderate to high 1-year modified Japanese Orthopaedic Association (mJOA) score (OR 3.0, CI 95% 1.2-7.3, p=0.015). However, the risk for distal junctional failure (DJF) increased significantly when the cSVA correction exceeded 5 cm (p=0.026), highlighting the risks of overcorrection and emphasizing the narrow optimal range for correction.

## **DISCUSSION AND CONCLUSION:**

The findings from our study elucidate the nuanced relationship between surgical correction of ACD and patient outcomes, particularly highlighting the repercussions of undercorrection and overcorrection. The data demonstrate that patients who were undercorrected had significantly higher incidences of radiographic complications and postoperative degenerative changes, such as DJK, which were notably pronounced at 6 months and 1 year. These complications are clinically significant as they correlate with poorer functional recovery and satisfaction, evidenced by less improvement in symptoms like hand clumsiness and bladder/bowel continence among the undercorrected group.

Moreover, the significantly greater resolution of persistent symptoms in the adequately corrected cohort underscores the importance of achieving the surgical goals set during preoperative planning. This is further supported by the superior HRQL scores observed in this group at the 2-year follow-up. These outcomes collectively suggest that precise surgical planning and execution, aiming for an optimal correction, are crucial in maximizing postoperative recovery and enhancing long-term well-being.

However, our study also highlights the fine balance required in surgical corrections. The increased risk of DJF when corrections exceeded a cSVA of 5 cm illustrates the potential complications associated with overcorrection. This indicates a need for careful intraoperative assessment to ensure that while sufficient correction is achieved to alleviate symptoms and restore function, it does not surpass a threshold that predisposes patients to additional complications.

In conclusion, this study reinforces the critical role of strategic surgical planning and execution in the management of adult cervical deformity. Appropriate correction is paramount; undercorrection is associated with continued or exacerbated postoperative complications and poorer functional outcomes, while overcorrection poses risks for structural complications like DJF. These findings advocate for the development of more refined surgical guidelines that specify optimal correction ranges to enhance outcomes and minimize risks. Further research should focus on establishing these parameters more concretely, potentially through larger scale studies or advanced simulation models, to aid surgeons in achieving the best possible outcomes for their patients. Ultimately, personalized surgical approaches, tailored to the individual's specific anatomical and functional needs, will be essential in advancing the field and improving patient care in adult cervical deformity surgery.