Preventing Distal Junctional Kyphosis: Choosing a Stable End for the Lowest-Instrumented Vertebra is Protective Following Adult Cervical Deformity Surgery

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INTRODUCTION: The stable sagittal vertebra (SSV) is a commonly used anatomical landmark for guiding the placement of the lowest instrumented vertebra (LIV) in adolescent idiopathic scoliosis. However, the concept and implications of a stable end vertebra (SEV) in adult cervical deformity have not been thoroughly investigated, particularly in relation to preventing structural complications. This study aims to investigate whether placing the LIV at a stable end vertebra provides protective effects against distal junctional kyphosis (DJK).

METHODS:

Cervical deformity (CD) patients with available baseline and 2-year (2Y) follow-up data were included in the study. High-risk patients needing severe (SEV) intervention were defined by increasing baseline deformity and frailty, worsening osteoporosis despite medical optimization, or existing distal junctional kyphosis (DJK) requiring reoperation. SEV components included: LIV inclination angle above -10°, LIV at or distal to the stable sagittal vertebra (SSV), and LIV greater than 210 Hounsfield units (HUs).

Patients were stratified into those meeting SEV criteria and those not meeting SEV criteria. The primary outcome measure was DJK, defined radiographically as a ≥10° angle between the superior endplate of the LIV and the inferior endplate of the vertebra two levels below on a standing lateral radiograph. A means comparison test assessed differences in outcomes based on the presence of SEV. SEV patients were further compared to those fused past the thoracic apex (T10). Multivariate regression, controlling for age and baseline deformity, determined the odds ratios for developing DJK by the 2-year follow-up.

RESULTS: A total of 120 cervical deformity (CD) patients were included (mean age: 58.5 ± 10 years, 60% female, mean BMI: 28.2 ± 6.6 kg/m², mean Charlson Comorbidity Index [CCI]: 0.93). The mean Hounsfield units (HU) were as follows: LIV: 272 ± 79, LIV+1: 252 ± 71, C3: 338 ± 109, and C7: 294 ± 97. By two years, 20.6% of patients developed distal junctional kyphosis (DJK) and 6.3% developed distal junctional failure (DJF). A total of 41 patients met the severe (SEV) criteria. Patients meeting SEV criteria had an average Neck Disability Index (NDI) improvement of 1-19, compared to 4.5 for those not meeting SEV ($p < 0.05$). SEV patients had a significantly lower likelihood of developing DJK (0% vs. 40%, $p < 0.05$) and lower overall complication rates (16.7% vs. 40%, $p < 0.001$). Patients fused past T10 had higher complication rates over two years compared to SEV patients (25% vs. 16.7%, $p = 0.045$). Multivariate regression showed that SEV patients had a 72% lower likelihood of developing DJK within two years (OR: 0.28, 95% CI [0.96, 1.02], $p < 0.05$) and a 97% lower likelihood of developing DJF (OR: 0.03, 95% CI [1.00, 1.06], $p = 0.018$). SEV patients were also 98% less likely to undergo reoperation within two years (OR: 0.016, 95% CI [0.99, 1.04], $p < 0.001$). Patients fused past T10 had twice the risk of DJK occurrence (OR: 2.43, 95% CI [0.76, 1.88], $p < 0.05$) and a 23% higher likelihood of reoperation compared to SEV patients (OR: 1.23, 95% CI [1.45, 1.98], $p = 0.022$).

DISCUSSION AND CONCLUSION: Discussion: In this study, we delve into the clinical implications of Stable End Vertebrae (SEV) in patients undergoing cervical spine surgery. Our findings underscore the significance of SEV in mitigating the risk of Degenerative Joint Kyphosis (DJK) and Degenerative Junctional Failure (DJF). Patients exhibiting SEV demonstrated a markedly lower incidence of DJK and DJF compared to those without SEV. Moreover, the overall complication rates were substantially reduced in SEV patients, with a notable decrease in the need for reoperation. Conversely, patients with fusion extending beyond T10 faced elevated complication rates and a higher likelihood of DJK occurrence and reoperation compared to SEV patients. These results suggest that preserving SEV during cervical spine surgery could offer a protective effect against the development of adjacent segment pathology.

Conclusion:The presence of Stable End Vertebrae (SEV) appears to be a crucial factor in reducing the risk of complications following cervical spine surgery. SEV may serve as a safeguard against the development of DJK and DJF, leading to improved patient outcomes and a decreased need for reoperation. Surgeons should carefully consider the preservation of SEV when planning cervical spine procedures to optimize long-term results. Future research could further explore the biomechanical and clinical implications of SEV to refine surgical strategies and enhance patient care.