Impact of Cervical Decompression on Balance and PROMs in Cervical Myelopathy: A Prospective Analysis Using Cone of Economy Metrics

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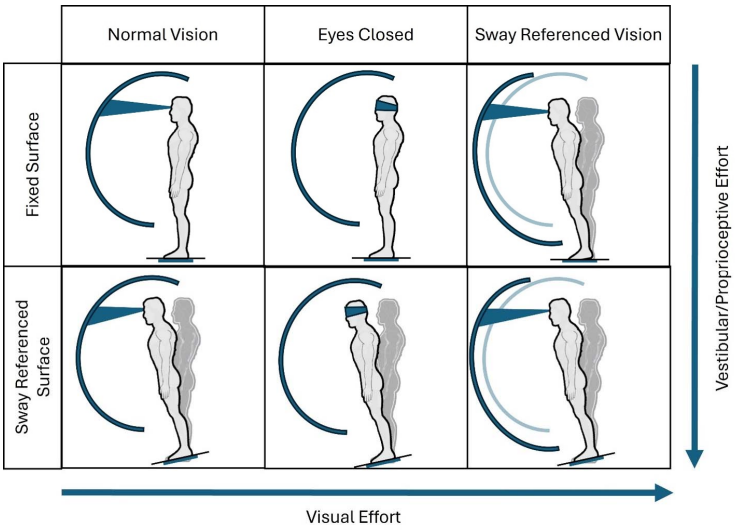
INTRODUCTION: Patients with cervical spondylotic myelopathy (CSM) experience progressive functional decline and increased dependency as their symptoms advance. Impairments in balance and proprioception contribute not only to physical disability but also to psychological effects, including reduced confidence in standing and ambulation safety. Altered postural stability—encompassing spinal alignment, sensory integration, muscle conditioning, and neuromuscular responses—is a hallmark of CSM. Emerging evidence challenges the notion of CSM as a predominantly irreversible condition, highlighting potential for functional recovery. Computerized Dynamic Posturography (CDP) offers a robust method to elucidate the underlying etiology of balance disorders by assessing patient performance under stable and experimentally destabilized conditions. This study aims to quantitatively evaluate changes in postural sway within the Cone of Economy (CoE) in CSM patients before and three months after surgical intervention, alongside standard patient-reported outcome measures (PROMs).

METHODS: In a prospective, single-center, concurrent cohort study, 21 CSM patients and 30 healthy controls (H) were included in this study. Each patient was tested approximately one week before and 3 months after surgery. Patients completed fall risk assessment, including the Sensory Organization Tests (SOT), which include normal and perturbed stability, both with and without visual cues using CDP (Figure 1). As the patient performs this test, the CDP measures whether the patient is using their ankles or hips to stay balanced, as well as whether their center of gravity is correct. In addition, patients were also fitted with a set of external reflective markers, which measure traditional CoE using human motion capture. All tests are performed with a harness attached to the machine to ensure safety, so that it is impossible to fall. Outcome measures included CoE, Center of Pressure (CoP), and Patient-Reported Outcomes Measurement Information System (PROMIS). A repeated measurement analysis of variance was used to determine differences in the balance effort and CoE dimensions in LD patients before and after surgical intervention.

RESULTS: Surgical decompression in patients with CSM significantly reduces fall risk, as evidenced by decreased balance effort and reduced center of excursion (CoE) and center of pressure (CoP) dimensions three months postoperatively. Head range of sway (RoS) was significantly reduced following surgery in multiple Sensory Organization Test (SOT) conditions: Eyes Open with Fixed Support (Pre: 30.1 cm vs. Post: 20.3 cm, $p = 0.045$), Eyes Closed with Fixed Support (Pre: 37.3 cm vs. Post: 21.2 cm, $p = 0.040$), and Eyes Open with Sway Surround and Sway Support (Pre: 83.6 cm vs. Post: 51.3 cm, $p = 0.015$; Table 1). Significant reductions in CoP RoS were observed across all six SOT conditions ($p < 0.044$). Compared to healthy controls, CSM patients exhibited significantly larger CoE dimensions across all SOT conditions preoperatively (e.g., Eyes Open with Fixed Support: CSM Pre: 33.5 cm vs. Controls: 15.8 cm, $p = 0.001$), with persistent but improved differences noted postoperatively (e.g., Eyes Closed with Fixed Support: Pre: 27.3 cm vs. Post: 18.1 cm, $p = 0.001$; Table 1). Similar improvements and residual differences were observed in CoP and CoE RoS metrics ($p < 0.041$). Although lumbar decompression led to measurable improvements in postural stability, select CoE and CoP parameters remained significantly elevated relative to healthy controls at three months post-surgery.

DISCUSSION AND CONCLUSION:

Surgical intervention for symptomatic CSM led to significant improvements in multiple objective measures of functional balance. However, balance profiles remained partially impaired at three months postoperatively, indicating incomplete normalization. These results highlight the importance of surgical decompression in mitigating disease progression and enhancing balance function. Although the advanced assessment tools employed in this study are not yet routinely available in clinical settings, ongoing technological innovation and decreasing costs are expected to support broader implementation, enabling more precise evaluation and management of balance dysfunction in CSM patients.


Normal Vision
Eyes Closed
Sway Referenced Vision
Fixed Surface
Sway Referenced Surface
Vestibular/Proprioceptive Effort
Visual Effort