Thoracic Inlet Angle as a Predictor of Recovery in Cervical Spine Surgery: A Cluster Analysis of Demographic Interactions on Radiographic and Functional Outcomes

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INTRODUCTION: Thoracic Inlet Angle (TIA) is a critical factor in understanding cervical alignment and predicting recovery outcomes following cervical spine surgery. We analyzed correlations between TIA and T1Slope, CL, and cSVA at multiple time points, perform cluster analysis based on PreopΔ, and assess how demographic interactions impact outcomes within each cluster.

METHODS: In this multi center study of 157 cervical spine surgery patients, correlations between TIA and T1Slope, CL, and cSVA were evaluated preoperatively and at 1 month, 1 year, and 2 years postop. Clusters based on PreopΔ divided patients into Cluster 0 (high PreopΔ), Cluster 1 (moderate PreopΔ), and Cluster 2 (low PreopΔ).

RESULTS: TIA showed strong correlations with T1Slope ($r = 0.76$, $p < 0.001$) and CL ($r = 0.63$, $p < 0.001$), confirming TIA's alignment impact. While Cluster 0, with the highest PreopΔ, experienced persistent alignment challenges, Cluster 2—despite lower PreopΔ—exhibited delayed functional recovery and significantly higher ODI scores at 2 years, particularly among smokers ($p < 0.001$). This finding diverges from expectations, suggesting that lower preoperative misalignment alone does not ensure better outcomes. Cluster 1 outcomes were heavily influenced by BMI and age, with older and high-BMI patients showing worse TIA and CL recovery. The interaction effects reveal that demographic factors like smoking, age, and BMI may sometimes outweigh alignment severity in determining functional recovery.

DISCUSSION AND CONCLUSION:

High PreopΔ was linked to alignment difficulties, as expected, but functional recovery was notably poorer in Cluster 2 smokers, showing that demographic risks can heavily influence outcomes. Cluster 1 patients with high BMI and age showed exacerbated alignment and pain, suggesting these patients require weight management and targeted postoperative alignment support.