

Deviation of Spinous Processes in the Adult Cervical Spine

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INTRODUCTION: The cervical spinous processes (SPs) are ubiquitously encountered in various spinal procedures, including laminectomy and disc arthroplasty. During arthroplasties, where midline placement of the artificial disc is crucial for proper biomechanics, some surgeons may use the SPs as directly visualized intraoperative guides or as confirmation for accurate midline disc placement through fluoroscopy. However, previous studies and clinical practice have shown that the SPs of the cervical spine can have varying degrees of offset from true midline, although none have directly evaluated this in detail. As such, this study aims to investigate the lateral and angular deviation of cervical SPs to determine their utility as midline markers in spine surgery.

METHODS: Adult patients who visited a university-affiliated academic medical center between December 2020 and February 2024 were included if they had available preoperative CT scans of the cervical spine prior to disc surgery with hardware placement. Patients were excluded if they had previous hardware, underwent prior surgery that involved trauma to or removal of any SP, or had CT evidence of ossification of the posterior longitudinal ligament. The angle of SP deviation was measured by determining the angle between an anteroposteriorly drawn midline through the vertebral body and a line drawn from the anterior canal to the tip of the SP. In cases of bifid SPs, the middle of the two cusps served as the tip (Figure 1). For lateral deviation, the distance between the vertebral midline and a parallel line connected to the SP tip was measured. The uncinate processes were used to adjust for any rotation in the image. Means are shown in bar graphs with error bars representing standard deviation. The two-sample t-test was used to compare results between relevant demographic groups. This study was approved by an institutional review board (HS-23-00758).

RESULTS: Of 62 patients who met inclusion criteria, the average age was 60.7 years, with 64.5% males. The average angular deviation off midline for each cervical level was 2.94° for C3, 3.52° for C4, 3.50° for C5, 4.31° for C6, and 3.53° for C7 (Figure 2). The average lateral deviation off midline for each level was 1.38 mm for C3, 1.56 mm for C4, 1.67 mm for C5, 2.37 mm for C6, and 2.51 mm for C7 (Figure 3). C7 was found to have the largest variation between individuals both for angular deviation (SD = 2.86°) and for lateral deviation (SD = 2.52 mm), and C3 showed the smallest variation in both angular deviation (SD = 2.06°) and in lateral deviation (SD = 1.03 mm). There were no significant differences at any level for angular deviation or lateral deviation when results were compared between sexes ($p > 0.05$ for all).

DISCUSSION: These results reveal that in adults, there is marked variability in the orientation and position of the cervical SPs between individuals, with C3 having the smallest variability and C7 having the greatest variability. Additionally, the degrees of offset are similar in both males and females. These results support the idea that the cervical SPs, especially C6 and C7, are not reliable indicators of vertebral midline since they commonly deviate from midline in individual patients, and the actual degree of deviation varies noticeably between different patients. As such, in spine procedures such as disc arthroplasty, the SPs should not be considered as reliable indicators of vertebral midline when gauging proper artificial disc placement and positioning. One current limitation of this study is the relatively small sample size, which may limit power to detect further significant differences, if present, between subgroups and between vertebral levels. Additionally, other demographic and radiographical categories, such as ethnicity and spinal canal diameter, are still in the process of being collected and so are currently not included in this analysis.

SIGNIFICANCE/CLINICAL RELEVANCE: During cervical disc arthroplasty, there is a need for accurate intraoperative assessment of vertebral midline to ensure proper placement of an artificial disc. While the spinous processes may be quickly used to gauge a general midline, their markedly variable degrees of deviation between levels and between patients make them less helpful landmarks when accuracy is critical for better patient outcomes.

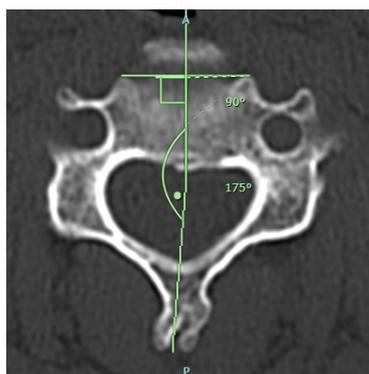


Figure 1. Angular deviation measurement method

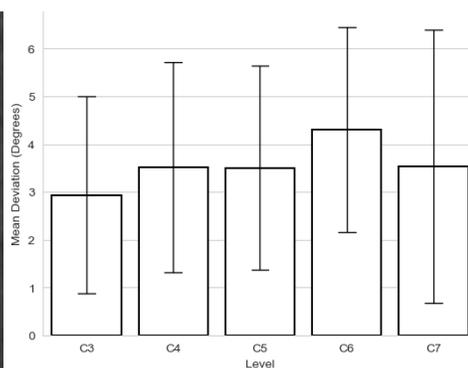


Figure 2. SP angular deviation by level

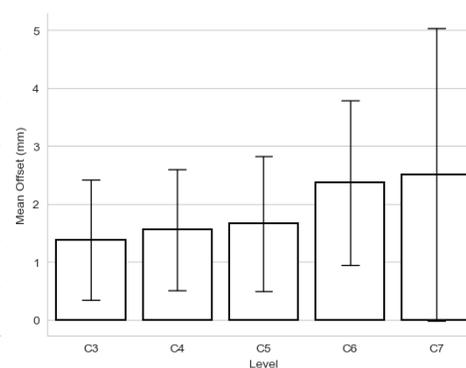


Figure 3. SP lateral deviation by level