Assessment of Proximal Facet Joint Violations in Robotic and Augmented Reality-Assisted Pedicle Screw Placement

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INTRODUCTION:
Navigation technologies have revolutionized spine surgery, yet comparative data on proximal facet joint violation (FJV) rates between robotic-assisted navigation (RAN) and augmented reality (AR) guidance remains limited. The primary objective was to evaluate the incidence of proximal FJV in lumbar and sacral pedicle screw placement, comparing RAN versus AR guidance systems. Secondary objectives examined risk factor assessment across demographic characteristics, surgical variables, and analysis of vertebral level-specific violation patterns.
METHODS: A single-center retrospective cohort study included 175 adult patients who underwent lumbar and sacral pedicle screw placement between 2020 and 2023, with 95 patients in the robot-assisted navigation (RAN) group and 80 in the augmented reality group. The primary outcome was the presence and grade of proximal facet joint violation (FJV), assessed using the modified Park and Shah classifications. Secondary outcomes included demographic and surgical variables associated with FJV occurrence. Postoperative imaging was analyzed for FJV, and comparisons of patient demographics, surgical characteristics, and FJV rates were made between the two groups.
RESULTS:
Among 175 patients, a total of 350 proximal facet joints were evaluated, with an FJV rate of 5.8% (n = 11) in the RAN group and 9.4% (n = 15) in the AR group. The highest violation rates occurred at L5 (RAN: 13.2%, n=5; AR: 35.3%, n=12), without reaching statistical significance. Most violations were modified Park Grade I (RAN: 6.3%, n=9; AR: 4.4%, n=7) or Grade II (RAN: 1.6%, n=2; AR: 5.6%, n=8), with no Grade III violations observed. Demographic factors showed no significant association with FJV rates. No revision surgeries were required for screw malposition or FJV.
DISCUSSION AND CONCLUSION: RAN demonstrated lower proximal FJV rates compared to AR guidance in lumbar and sacral pedicle screw placement, particularly at L5, however, this difference was not statistically significant. While demographic factors showed no significant association with FJV occurrence, the absence of severe violations in both cohorts demonstrates the overall safety profile of these navigation systems. Nevertheless, RAN may provide potential advantages in minimizing FJV risk, particularly at the lower lumbar levels.