Accuracy of Augmented Reality Navigation Versus Freehand Pedicle Screw Placement

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INTRODUCTION:
Accurate pedicle screw placement is essential in spinal fusion surgery to ensure optimal stability and avoid complications. Augmented Reality (AR) navigation has emerged as a novel radiation-sparing alternative to conventional freehand (FH) techniques in pedicle screw placement, with potential benefits including improved accuracy, workflow efficiency, and surgical ergonomics. This study aims to compare the accuracy of AR-guided versus conventional FH techniques in lumbosacral pedicle screw placement.
METHODS: This single-center retrospective cohort study included 202 patients who underwent pedicle screw placement from L1 to S1 between 2016 and 2024 using either AR navigation or conventional FH technique. The primary outcome was screw placement accuracy, assessed postoperatively via CT imaging and graded using the Gertzbein-Robbins Scale (GRS). Secondary outcomes included demographic and surgical variables associated with screw accuracy. Patient demographics and surgical characteristics were compared between the AR and FH cohorts.
RESULTS: A total of 202 patients were analyzed, comprising 1109 pedicle screws placed (AR: n = 548; FH: n = 561). The proportion of clinically acceptable screws (GRS Grade A or B) was significantly higher in the AR group compared to the FH group (99.3% vs. 96.4%; p = 0.013). The rate of clinically unacceptable breaches (GRS Grade C-E) was lower in the AR group than in the FH group (0.7% vs. 3.6%; p = 0.013). Level-specific directional analysis showed that the highest number of breaches in the AR group occurred at L4, predominantly lateral (n = 24), while in the FH group, breaches were most common at L5 and primarily medial (n = 22). No screw-related adverse events or revision surgeries were observed in either group. Demographic and surgical characteristics demonstrated no significant differences between the cohorts.
DISCUSSION AND CONCLUSION: AR-guided navigation was associated with significantly improved pedicle screw placement accuracy compared to the conventional FH technique. These results indicate that AR may provide more consistent accuracy in screw placement, though further prospective studies are needed to assess its long-term clinical impact.