Prospective 3D Imaging Study of Screw Position Using Two Different Robotic Spinal Surgery Techniques

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INTRODUCTION: Robotic-navigated assisted (RNA) surgery with integrated navigation continues to expand its applications across orthopaedic surgery – particularly in pedicle screw insertion during spinal surgery. Despite the assistance of the robotic arm-guide and navigated instruments, there is still potential for screw deviation from planned trajectories due to several factors including soft tissue pressure on the instruments. First generation anti-skive instruments include an anti-skive cannula (ASC), which is a spiked second cannula attached to bone through the drill guide involving four total components. In this study we examined a new workflow utilizing a navigated, high-speed drill (HSD) to create a pilot-hole to streamline the RNA workflow and further prevent instrument skive.

METHODS:

Data was gathered prospectively on 120 patients (57 consecutive ASC patients, 63 consecutive HSD patients) over a three year period (2019-2022) that underwent robotic-navigated posterior spinal fusion by a single surgeon. Demographic data as well as positioning, registration, and screw insertion times were recorded. Planned screw trajectory from software based on preoperative CT was compared with final intraoperative 3D fluoroscopic images to grade screw position in sagittal and axial planes. Standard and 3D fluoroscopic time and dosage were also recorded.

RESULTS:

A total of 602 instrumented pedicles were planned robotically between each group (311 ASC, 291 HSD). 277 (98.5%) of the HSD screws were inserted robotically; 13 screws were converted to freehand (4.5%) and 1 screw was planned freehand. No screws were inserted over a k-wire. In the ASC group, 259 (83.3%) of the screws were inserted robotically; 8 (2,6%) were converted to freehand, 10 (3.2%) were converted to freehand over a k-wire, and 34 (10.9%) were planned freehand. 100% of the robotically inserted HSD screws were Liebermann Grade A versus 94.2% of the ASC screws (the remainder were Grade B). 4 skive events (3 superior, 1 inferior skives) were recorded using the HSD workflow versus 15 (11 superior, 4 inferior skives) in the ASC workflow ($p < 0.05$). Comparison of the intraoperative 3D fluoroscopic images versus the preoperative plan for the HSD workflow in the axial plane showed mean lateral deviation of 0.5 ± 0.6mm (SD), medial deviation of 0.7 ± 0.6mm, and 4 accurate screws without deviation; in the sagittal plane, mean deviation was 0.7 ± 0.7mm and 0.6 ± 0.5mm with cranial and caudal directionality, respectively. Two screws were accurate. For the ASC workflow in the axial plane, mean lateral deviation was 1.0 ± 1.1mm, medial deviation 1.2 ± 1.1mm, and 18 were determined to be accurate; in the sagittal plane mean cranial deviation was 0.7 ± 0.7mm and caudal 1 ± 0.6mm, and 12 accurate. The average time per screw (TPS) was significantly lower in the HSD group versus ASC (2.03 ± 1.05 mins vs 3.42 ± 2.22 mins, ($p < 0.001$)). Lastly, screws placed using the HSD workflow were closer to their preoperative planned trajectory in all directions except cranial deviation where no significant difference was found ($p > 0.05$). No adverse clinical sequelae occurred from the implantation of any screw.

DISCUSSION AND CONCLUSION: The implementation of the HSD workflow has significantly reduced both the rate of instrumentation skive (likewise overall screw accuracy) and time per screw. The HSD workflow shows an improvement in rate of skive and screw accuracy because the side-cutting tip ignores variable contact with the surface anatomy and allows some redirection within the length of the pedicle. Time per screw is significantly reduced by eliminating the number of passed instruments and increased first-pass accuracy.