A novel approach to navigated implantation of thoracic and lumbosacral pedicle screws using inertial measurement units

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Introduction: A novel method of intraoperative navigation with inertial measurement units was developed to implant pedicle screws in the thoracic and lumbosacral human spine. This was compared with a freehand technique. IMUs house accelerometers and gyroscopes to measure acceleration and angular rotation. Among the many applications, IMUs control and detect motion and orientation of tablet computers and smartphones. Material and Methods: The study was done on 9 human cadavers. A preoperative CT was performed to measure the axial and sagittal tilt angles of the pedicle screw trajectories from T1 to S1. After defining the entry points on the exposed spine, the IMU-equipped pedicle finder and screwdriver were used to reproduce these tilt angles and implant one half of the screws. The other half was implanted with a freehand technique. Fluoroscopy was not used in any of the procedures. In addition to adhering to anatomic landmarks, the entry points of the last 216 screws of the study were found by intraoperatively reproducing the distance between the left and right pedicle with a divider. The screw trajectories were analyzed and compared on postoperative CTs. Results: 162 screws were implanted with use of the IMUs and 162 screws were implanted with a freehand technique. In relation to the preoperatively planned trajectories, the IMU-guided technique performed significantly better than the freehand technique (axial tilt p?=?0.000001, sagittal tilt p?=?0.0000000003): With the IMU-guided technique, the mean offsets between the planned and postoperatively measured tilt angles of the screws were for the axial plane 3.3?ř?ś3.5ř (median 2ř, range 0ř - 23ř) and for the sagittal plane 3.4?ř?ś3ř (median 3ř, range 0ř - 13ř). For the freehand techniques the mean offsets between the planned and postoperatively measured tilt angles of the screws were for the axial plane 5.6ř ś4.5ř (median 5ř, range 0ř - 31ř) and for the sagittal plane 6.7ř ś5.4ř (median 6ř, range 0ř - 33ř). Evaluation of the overall screw position showed that the IMU-guided technique in combination with the divider scored significantly better than the freehand technique plus divider (p?=?0.006). Conclusion: Inertial measurement unit?based intraoperative navigation may provide a more reliable implantation of pedicle screws in the thoracic and lumbosacral spine than a freehand technique. Furthermore, adding a divider to intraoperatively reproduce the interpedicular distance of a given level may further improve this novel technique. Translating this rather low-cost technology from consumer electronics to a clinical spine scenario may assist implanting thoracic and lumbar pedicle screws with minimal to no fluoroscopic guidance, yet at no loss of precision.
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