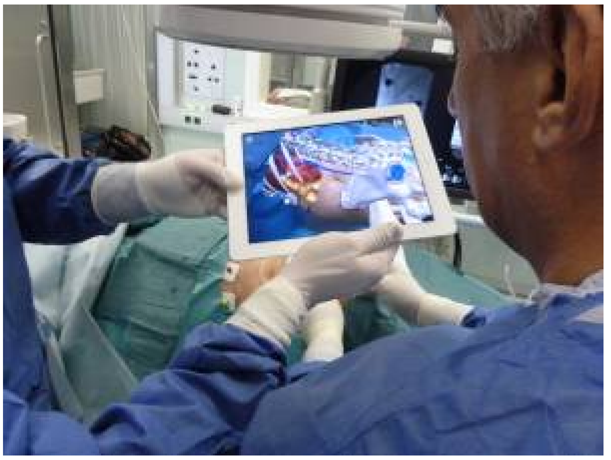
Augmented reality for pedicle screw insertion



Cadaveric studies have shown improved accuracy for pedicle screw placement in the thoracic spine using augmented reality with intraoperative 3D imaging, without the need for periprocedural x-ray. In this clinical study, Elmi-Terander et al., used the same system to place pedicle screws in the thoracic and lumbosacral spine of 20 patients.

The study was performed in a hybrid operating room with an integrated augmented reality system encompassing a surgical table, a motorized flat detector C-arm with intraoperative 2D/3D capabilities, integrated optical cameras for augmented reality navigation, and noninvasive patient motion tracking. Three independent reviewers assessed screw placement accuracy using the Gertzbein-Robbins classification on 3D scans obtained before wound closure. In addition, the navigation time per screw placement was measured.

One orthopedic spinal surgeon placed 253 lumbosacral and thoracic pedicle screws on 20 consenting patients scheduled for spinal fixation surgery. An overall accuracy of 94.1% of primarily thoracic pedicle screws was achieved. No screws were deemed severely misplaced (Gertzbein grade 3). Fifteen (5.9%) screws had 2 to 4 mm breach (Gertzbein grade 2), occurring in scoliosis patients only. Thirteen of those 15 screws were larger than the pedicle in which they were placed. Two medial breaches were observed and 13 were lateral. Thirteen of the grade 2 breaches were in the thoracic spine. The average screw placement time was 5.2 ± 4.1 minutes. During the study, no device-related adverse event occurred.

Augmented reality can be clinically used to place thoracic and lumbosacral pedicle screws with high accuracy and with acceptable navigation time. Consequently, the risk for revision surgery and complications could be minimized [1].

Molina et al., studied the use of an augmented reality head-mounted display (AR-HMD) in the placement of thoracolumbar pedicle screw spinal instrumentation in cadaver specimens. The AR-HMD system has the potential to reduce important limitations of conventional manual and robotic computer navigation for pedicle screw placement [2].

In 2017 Ma et al., presented a novel augmented reality (AR) surgical navigation system based on ultrasound-assisted registration for pedicle screw placement. This system provides the clinically desired targeting accuracy and reduces radiation exposure.

Ultrasound (US) is used to perform registration between preoperative computed tomography (CT) images and patient, and the registration is performed by least-squares fitting of these two three-dimensional (3D) point sets of anatomical landmarks taken from US and CT images. An integral videography overlay device is calibrated to accurately display naked-eye 3D images for surgical navigation. We use a 3.0-mm Kirschner wire (K-wire) instead of a pedicle screw in this study, and the K-wire is calibrated to obtain its orientation and tip location. Based on the above registration and calibration, naked-eye 3D images of the planning path and the spine are superimposed onto patient in situ using our AR navigation system. Simultaneously, a 3D image of the K-wire is overlaid accurately on the real one to guide the insertion procedure. The targeting accuracy is evaluated postoperatively by performing a CT scan.

An agar phantom experiment was performed. Eight K-wires were inserted successfully after US-assisted registration, and the mean targeting error and angle error were 3.35 mm and [Formula: see text], respectively. Furthermore, an additional sheep cadaver experiment was performed. Four K-wires were inserted successfully. The mean targeting error was 3.79 mm and the mean angle error was [Formula: see text], and US-assisted registration yielded better targeting results than skin markers-based registration (targeting errors: 2.41 vs. 5.18 mm, angle errors: [Formula: see text] vs. [Formula: see text].

Experimental outcomes demonstrated that the proposed navigation system has acceptable targeting accuracy. In particular, the proposed navigation method reduces repeated radiation exposure to the patient and surgeons. Therefore, it has promising prospects for clinical use [3].

References

1)

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2)

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3)

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