Optical Topographic Imaging for Spinal Intra-Operative Three-Dimensional Navigation in Minimally-Invasive Approaches: Initial Pre-Clinical and Clinical Feasibility

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Introduction

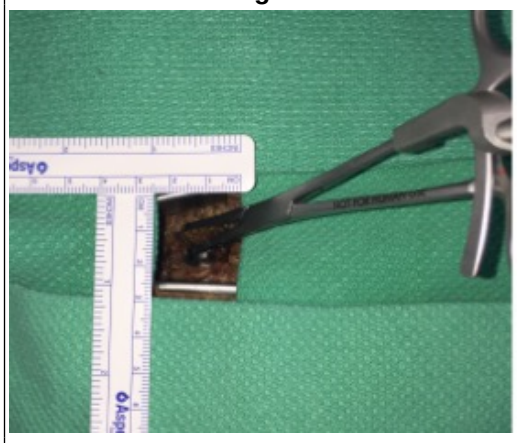
Computer-assisted three-dimensional navigation may guide spinal instrumentation. A novel optical topographic imaging (OTI) system for spinal navigation has been developed, and described separately. While it offers comparable accuracy and significantly faster registration relative to current navigation systems, OTI to date has been applied only to open posterior exposures. Here, we explore the utility of OTI in minimally-invasive (MIS) approaches.

Methods

Mini-open midline posterior exposures were performed in four human cadavers. Square exposures of size 25, 30, 35, and 40mm2 were registered to a preoperative CT scan. Screw tracts were fashioned using a tracked awl and probe, and instrumentation placed. Navigation data were compared to screw positions on postoperative CT imaging, and absolute translational and angular deviations computed.

In-vivo validation was performed in three patients, with mini-open thoracolumbar exposures and percutaneous placement of navigated instrumentation.

Fig. 1



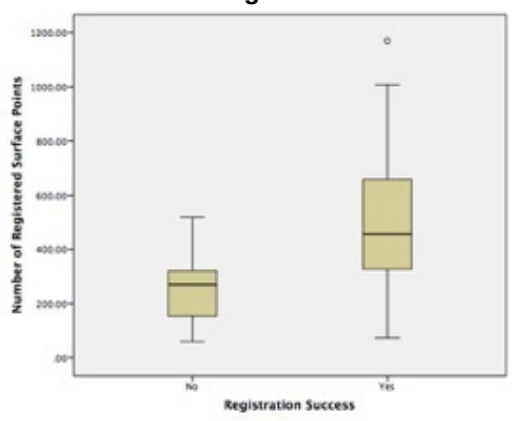
Representative mini-open midline cadaveric exposure, with clamped reference frame

Results

For 37 cadaveric screws, absolute translational errors were (1.79±1.43mm) and (1.81±1.51mm) in the axial and sagittal planes, respectively; absolute angular deviations were (3.81±2.91) and (3.45±2.82), respectively (mean±SD). Errors were similar across levels and screw types. The number of surface points registered by the navigation system, but not exposure size, correlated positively with the likelihood of successful registration (OR=1.02, 95%-CI 1.009 -1.024, p<0.0001).

24 in-vivo thoracolumbar pedicle screws were analyzed. Overall (mean±SD) axial and sagittal translational errors were (1.86±1.82 mm) and (3.29±2.81 mm), while axial and sagittal angular errors

Fig. 2



Standard boxplot showing number of optically-acquired surface points in successful vs. unsuccessful registrations.

Conclusions

Optical machine-vision is a novel navigation technique previously validated for open posterior exposures. OTI has comparable accuracy for mini-open MIS exposures. The likelihood of successful registration is affected more by the geometry of the exposure than its size.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe the utility of intra-operative navigation in minimally-invasive spinal procedures

2) Describe the application of optical topographic imaging to spinal intra-operative navigation

3) Describe techniques of quantitation of absolute navigation accuracy

4) Describe variables influencing registration accuracy in minimally-invasive spinal approaches

References

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