Image-guided navigation in spinal surgery from cervical to sacral spine— A comprehensive experience with accuracy results and lessons learned.

Doniel Drazin MD MA; Joseph Chia Yu Hsieh MD, MBA, MPH, MS; Robert S. Pashman MD; Terrence T. Kim MD; J. Patrick Johnson, MD MD

Departments of Neurosurgery and Orthopaedics, Cedars-Sinai Medical Center, Los Angeles; Department of Neurosurgery, UC Davis Medical Center, Sacramento, California; and University of Texas Medical School at Houston,

CEDARS-SINAI

Introduction

Advances in computer and computed-tomography (CT) imaging have accelerated the use of intra-operative navigation in spinal surgery. Several studies have confirmed that image-guided navigation (IGN) allows greater precision and improved accuracy of instrumentation placement. We present our single center experience and describe common modes of failure leading to less than exceptional (>90%) accuracy.

Methods

We retrospectively reviewed 140 consecutive adult patients undergoing posterior cervical, thoracic, lumbar and/or sacral spinal fusion with intraoperative CT-IGN from September 2009-August 2013 at Cedars-Sinai Medical Center. Two blinded surgeon-researchers evaluated all screws on intraoperative O-arm images and postoperative CT scans for assessment of screw accuracy. Bony pedicle and vertebral body breaches, and anatomical violations into the spinal canal, neural foramen, transverse foramen, or facets were recorded. Grade 1 breach was defined as < 2mm, Grade 2 as 2-4mm, Grade 3 as >4mm. Need for revision spine surgery or intraoperative screw revision was the primary outcome measure.

Results

Of 1185 pedicle screws placed, 1161 (98.05%) were in acceptable positions (good) without cortical wall or anterior vertebral body wall breach. Mean clinical follow-up period: 23 months (range 3–48). Pedicle screws placed in revision cases in the cervical (C1-2) and lumbo-sacral (L5-S1) spine represented most of the screws deemed to be fair or poorly placed (1.95%). No revision surgery was performed for symptomatic screw misplacement or neurological deterioration. Available overall clinical outcomes, measured using visual analog scale, were improved significantly postoperatively at 3 months compared with preoperatively ($p < 0.0001$).

Conclusions

CT-IGN surgery resulted in successfully placing 1161 pedicle screws (98.05% screw accuracy) in complex spine disorders from cervical spine to sacrum. High cervical and lumbosacral regions represented the most common technically difficult areas for instrumentation placement. Technical pearls are discussed to improve accuracy for the entire spinal axis.

References

1. Amiot LP, Lang K, Putzier M, Zippel H, Labelle H: Comparative results between conventional and computer-assisted pedicle screw installation in the thoracic, lumbar, and sacral spine. Spine (Phila Pa 1976) 25:606–614, 2000

2. Shin MH, Ryu KS, Park CK: Accuracy and safety in pedicle screw placement in the thoracic and lumbar spines: comparison study between conventional C-arm fluoroscopy and navigation coupled with O-arm® guided methods. J Korean Neurosurg Soc 52:204–209, 2012

3. Rajasekaran S, Vidyadhara S, Ramesh P, Shetty AP: Randomized clinical study to compare the accuracy of navigated and non-navigated thoracic pedicle screws in deformity correction surgeries. Spine (Phila Pa 1976) 32:E56–E64, 2007

4. Baaj AA, Beckman J, Smith DA: O-Arm-based image guidance in minimally invasive spine surgery: technical note. Clin Neurol Neurosurg 115:342–345, 2013

5. Mroz TE, Abdullah KG, Steinmetz MP, Klineberg EO, Lieberman IH: Radiation exposure to the surgeon during percutaneous pedicle screw placement. J Spinal Disord Tech 24: 264–267, 2011

Learning Objectives

1. Navigated spinal surgery has a high accuracy rate in complex spine disorders from cervical spine to sacrum.

2. High cervical and lumbosacral regions represented the most common technically difficult areas for instrumentation placement.

3. Specific technical pearls will be discussed to improve accuracy for the entire spinal axis.