

**The Accuracy of Pedicle Screw Placement Using Intraoperative Image Guidance: A Meta Analysis** Alexander Mason MD; Rene Paulsen PhD; Jason Babuska BS; Sharad Rajpal MD; Lee Nelson MD; Sigita Burneikiene MD;

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### Introduction

Several retrospective studies have demonstrated higher accuracy rates and increased safety for navigated pedicle screw placement compared to free-hand techniques; however, the accuracy differences between navigation systems has not been extensively studied. In some instances, three-dimensional (3D) fluoroscopic navigation methods have been reported to not be more accurate than two-dimensional (2D) navigation for pedicle screw placement. A systematic review was conducted to examine pedicle screw insertion accuracy using conventional fluoroscopy, 2D or 3D fluoroscopic image guidance systems.

#### Methods

A PubMed and Medline database search was conducted to review published literature that focused on the accuracy of pedicle screw placement using intraoperative, realtime fluoroscopic image guidance in spine fusion surgeries. Descriptive statistics were employed to compare the pedicle screw insertion accuracy rate differences between the navigation methods.

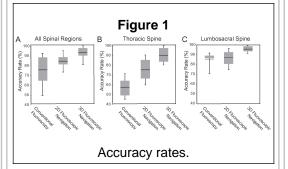
#### Results

The database search and review of references yielded a total of 30 studies to be included in our analysis. The data was abstracted and analyzed for the following groups: 12 datasets that utilized conventional fluoroscopy, 8 datasets that utilized 2D fluoroscopic navigation, and 20 datasets that utilized 3D fluoroscopic navigation. The conventional fluoroscopy group contained studies that used real-time fluoroscopy images without the use of computer-aided navigation. The 2D navigation group included studies that utilized virtual fluoroscopy, and the 3D navigation group included studies that implemented Iso-C fluoroscopy, Oarm fluoroscopy, or a combination of these two techniques. These studies included 1,973 patients in which 9,310 pedicle screws were inserted in total. Analyzing the quality of the published studies, we identified only one randomized, controlled clinical trial. The rest of the studies we either Level IV (observational studies) or Level III (observational studies with controls).

# Accuracy

With conventional fluoroscopy, a total of 2,532 screws out of 3,719 screws were inserted accurately (68.1% accurate). The percentage of misplaced screws ranged from 8.3 – 50.3% with a mean of 23.6%. Considering the individual spinal levels, 188 out of 271 cervical pedicle screws, 628 out of 1,223 thoracic pedicle screws, and 1,544 out of 2,035 lumbosacral screws were placed accurately (69.4%, 51.7%, and 75.9% accuracy rates, respectively).

**Comparison of Conventional, 2D and 3D Fluoroscopic Methods** Both 2D and 3D fluoroscopic navigation had significantly greater pedicle screw placement accuracy(2D Nav:  $p = 4.00 \times 10-30$  and 3D Nav:  $p = 1.26 \times 10-264$ ) (Figure 1).



Both methods of navigation also resulted in significantly higher accuracy rates for the individual thoracic (2D Nav:  $p = 7.74 \times 10-19$ and 3D Nav:  $p = 1.68 \times 10-106$ ) and lumbosacral (2D Nav:  $p = 1.75 \times 10-9$ and 3D Nav:  $p = 2.57 \times 10-128$ ) spinal regions compared to conventional fluoroscopy.

Additionally, 3D fluoroscopic navigation lead to significantly higher pedicle screw placement accuracy in the cervical spine (3D Nav: p =9.64×10-15); however, the difference between the placement accuracies of 2D fluoroscopic navigation and conventional fluoroscopy was not found to be statistically significant due to the low number of cervical pedicle screws that had been reported to be placed using 2D navigation (2D Nav: p = 0.834).

Three-dimensional fluoroscopic navigation was also found to be significantly more accurate for pedicle screw placement than 2D fluoroscopic navigation ( $p = 2.77 \times 10-35$ ). The differences in pedicle screw placement accuracy between 2D and 3D fluoroscopic navigation methods were also statistically significant for the individual spinal levels. With 3D navigation, 9.7% of cervical pedicle screws were incorrectly placed compared to the 26.7% that were misplaced using 2D navigation (p = $8.29 \times 10-3$ ). In the thoracic spine, 4.96% of pedicle screws were misplaced using 3D navigation compared to the 21.6% misplaced with 2D navigation ( $p = 4.33 \times 10-15$ ), and in the lumbosacral spine, 1.2% and 13.2% pedicle screws were incorrectly placed using 3D and 2D fluoroscopic navigation techniques, respectively (p  $= 7.37 \times 10-40$ ).

### Conclusions

Three-dimensional fluoroscopic image guidance systems demonstrated a significantly higher pedicle screw placement accuracy than conventional fluoroscopy or 2D fluoroscopic image guidance methods.

# Learning Objectives

1.Demonstrate improved pedicle screw placement accuracy using 3D navigation

2.Demonstrate pedicle screw placement accuracy at different levels of the spine.