Pedicle Screw placement With Augmented Reality Surgical Navigation Using Intraoperative 3D Imaging

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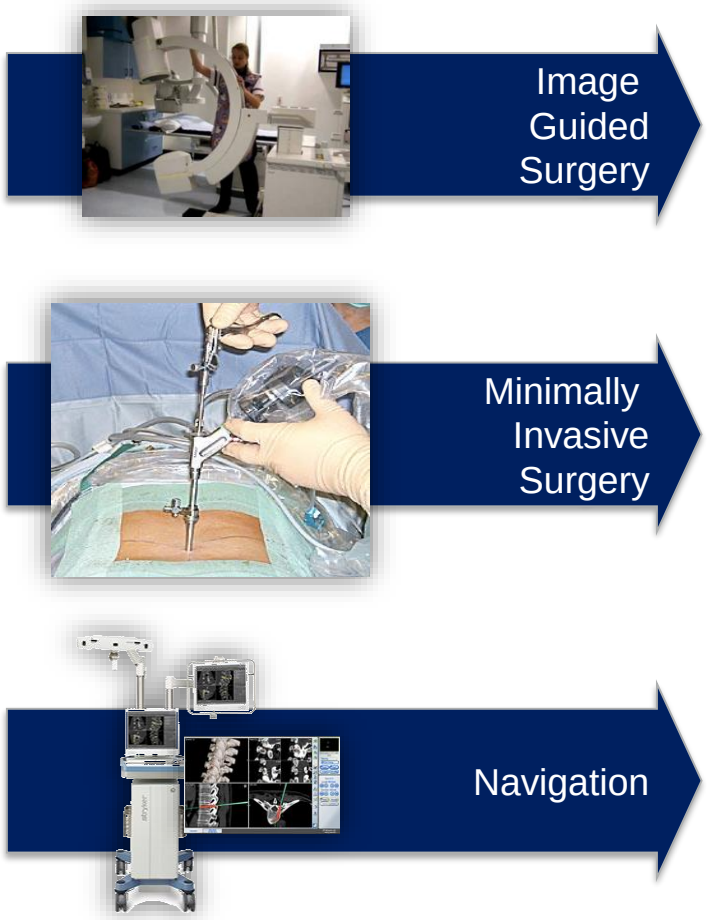
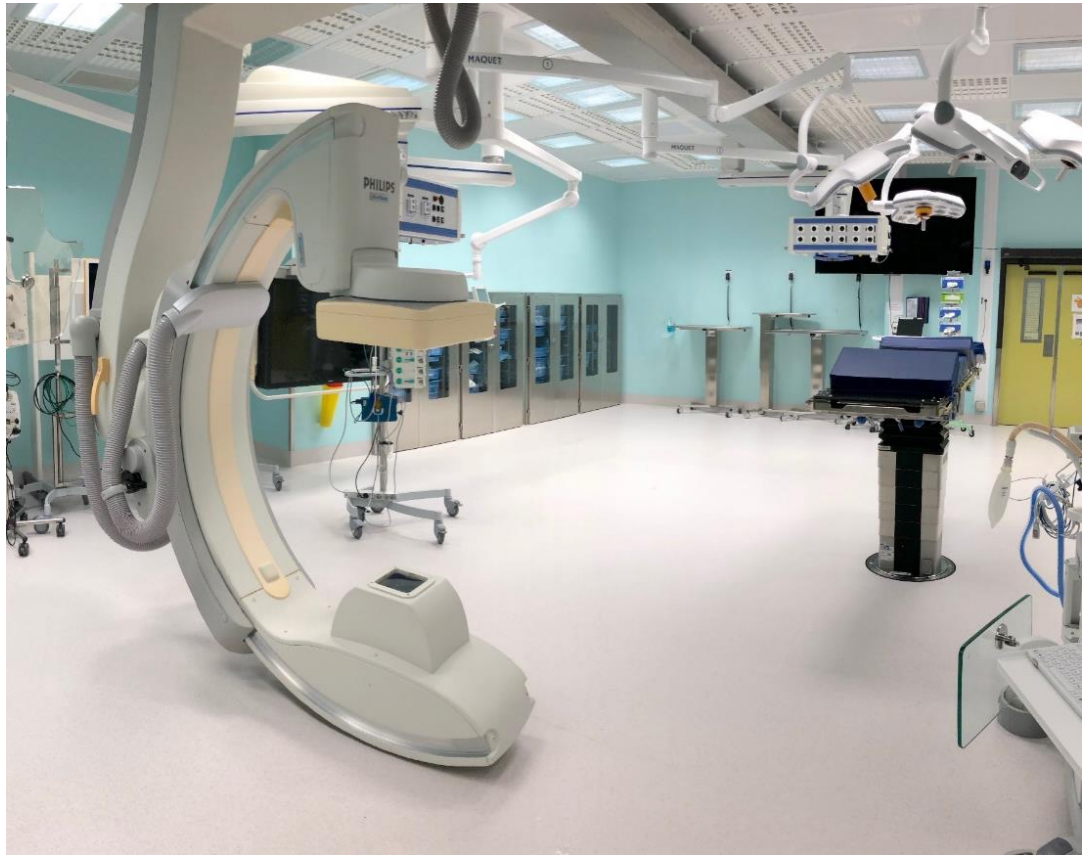
Background: Current trends in spine surgery





Hybrid operating room: Integrated high-end 2D and 3D imaging in the Operating Room

Background: Current navigation technologies

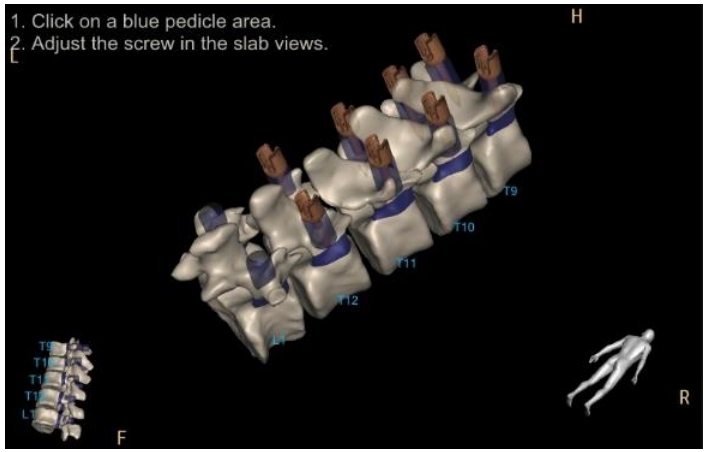
- Current accuracy rates for pedicle screw placement between 60-97% for lumbar and 27-96% for thoracic spine[1]
- Previous studies have shown superior pedicle screw placement using a combination of intraoperative CT images and navigation[2], while others have not shown a difference
- Our aim was to study if a new concept of surgical navigation with live integration of radiological and visual information would result in comparable or superior results than previous studies

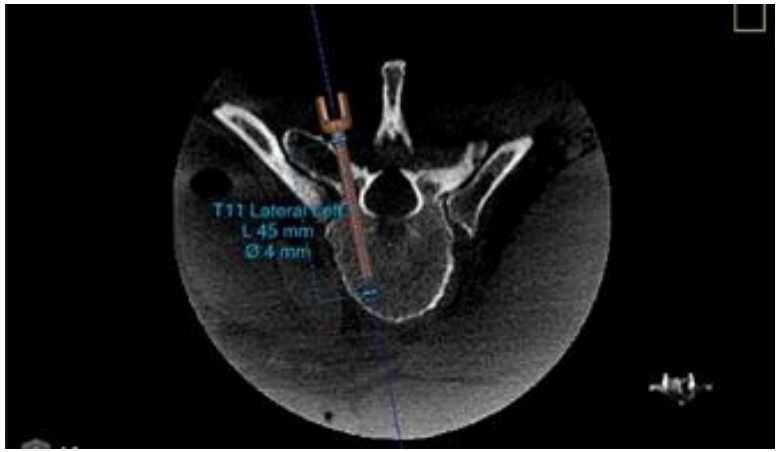
1. Kosmopulos V, and Schizas C. Pedicle screw placement accuracy: a meta-analysis. *Spine.* 2007
2. Du JP, Fan Y, Wu QN, et al. Accuracy of pedicle screw insertion among 4 image-guided navigation systems: systematic review and meta-analysis. *World Neurosurg*. 2018

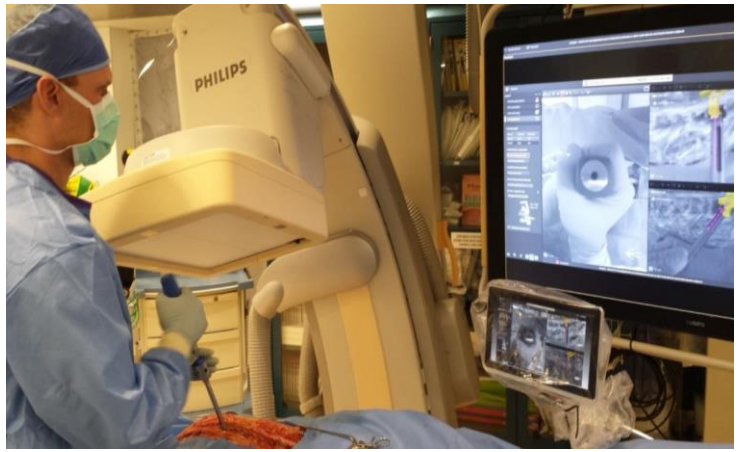
Background: A new concept using augmented reality based on intraoperative CBCT (I/II)

- Optical video cameras are integrated in the flat detector of the Philips Allura C-arm
- Flat adhesive surface markers are placed on the skin for patient position tracking
- An intraoperative 3D Cone Beam CT (CBCT) with a high spatial and contrast resolution is acquired

Background: A new concept using augmented reality based on intraoperative CBCT (II/II)







The navigation software performs an automatic 3D spine segmentation and corresponding pedicle assessment and suggests an optimal screw path

The surgeon optimizes and confirms a virtual screw path as clinically desired

The C-arm is automatically aligned with the virtual path to position the video cameras for live augmented reality (AR) navigation[1]

1. Elmi Terander A et al. Surgical Navigation Technology Based on Augmented Reality and Integrated 3D Intraoperative Imaging: A Spine Cadaveric Feasibility and Accuracy Study, *Spine*, 2016

Method: 20 patients enrolled in a prospective study

20 consecutive patients enrolled

Consecutive enrollment resulting in inclusion of 20 patients - 14 deformity cases, 3 spondylolisthesis and 5 other clinical indications

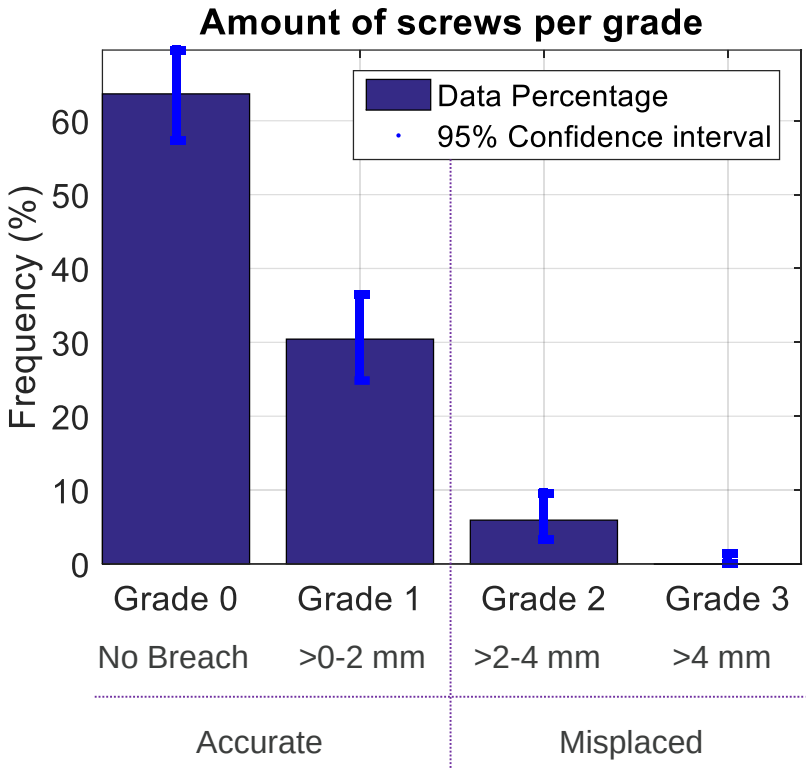
Clinical accuracy assessed by independent reviewers

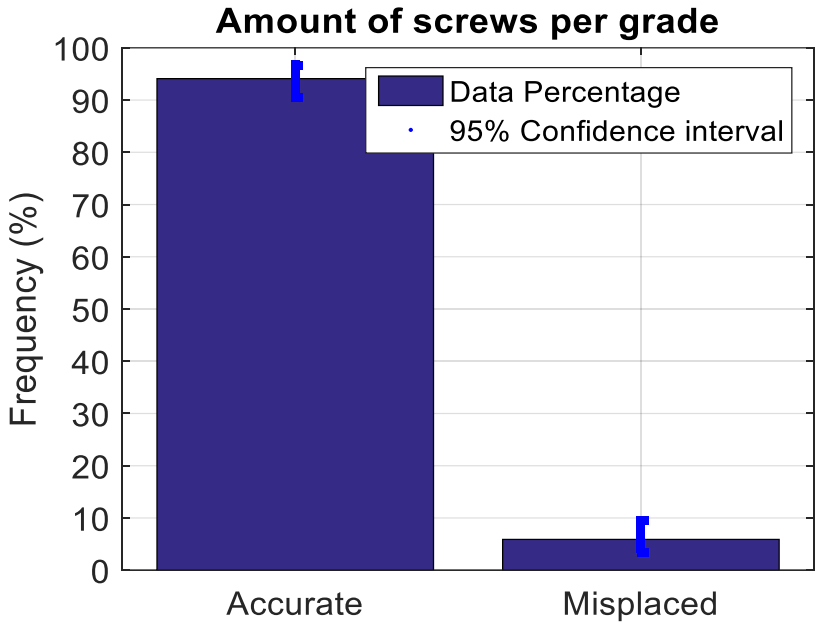
Three independent neuroradiologist reviewers rated clinical accuracy according to Gertzbein.

Radiation dose evaluated

Staff and patient dose measured consecutively throughout study.

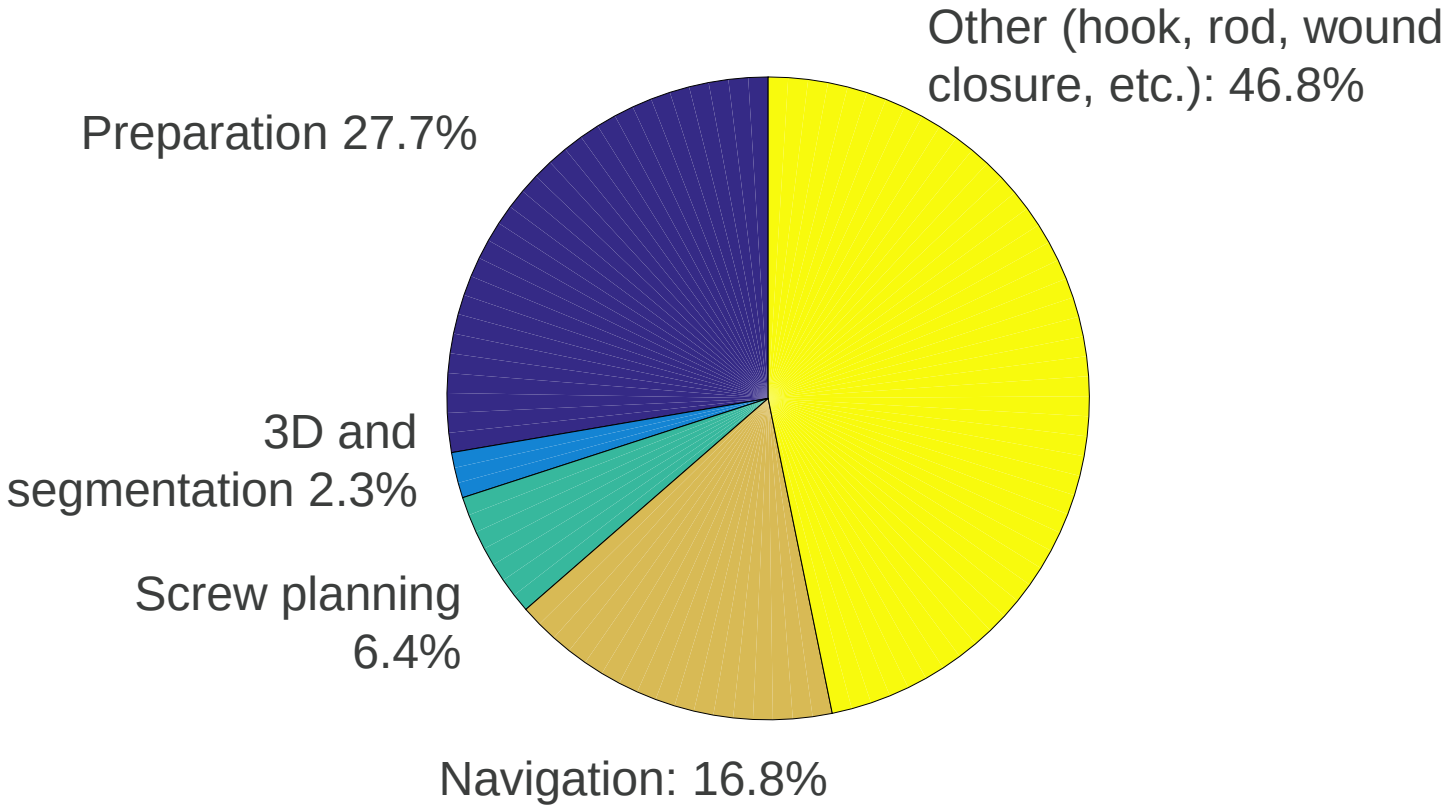
Results: Clinical accuracy of 94%





13/15 of the grade 2 screws had a diameter larger than the pedicle isthmus size where they were placed (automatically graded as Gertzbein grade 2)

Results: Procedure time disposition



- **¼ of the time** is preparation (skin incision, spine exposure, etc..)
- **¼ of the time** is usage of navigation (3D imaging, segmentation, path planning, navigation)
- **½ of the time** is manual placement of implants, rod placement, wound closure.

Results and Conclusion (I/II)

94% clinical accuracy

Surgical navigation using AR with intraoperative CBCT demonstrated a clinical accuracy of 94% for pedicle screw placement in a sample of primarily thoracic screws. There were no device-related clinical complications.

4 min median navigation time

The median required time of navigation per screw was 4 min (mean 5.2 min). The use of navigation accounted for 17% of the total procedure time.

Results and Conclusion (II/II)

0.8 µSv staff radiation dose

The CBCT intraoperative imaging available on the AR-based navigation system demonstrated a mean of 0.8±1.1 and a median of 0.3 [0-3.2] µSv cumulative staff dose to an average of 3 staff members.

3.3 mSv patient dose per CBCT

Mean effective patient dose per procedure was 12.7±5.1 mSv. The dose area product ranged from 14.1 to 51.4 Gy·cm^2. This included a CBCT that also served as a post-operative CT confirmation of surgical results.

Disclosures

- The authors have no personal financial relationships with any commercial interests related to the content of this project

- Rami Nachabe is employed by Philips Healthcare

- The project is part of a major collaboration agreement between Karolinska University Hospital and Philips Healthcare