


**Robotics and Navigation in Spine Surgery:  
Where are we now?**

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**Disclosures**

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**Acknowledgements**

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- Several slides courtesy of Isador Lieberman MD and Richard Guyer MD



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### Introduction

- Technology is playing an increasing role in life, as well as spine surgery
- There has been progression of various image-guided and navigation systems, intra-operative imaging, surgical planning software, and robotic guidance



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### Introduction

- Technological advances in navigation and robotics in numerous areas
  - GPS
    - Self driving cars
    - Drones
    - Phones
    - Personal
- Implications for training future surgeons
  - Simulators
  - More navigation and robotics, less freehand techniques?
  - Dependence on technology?



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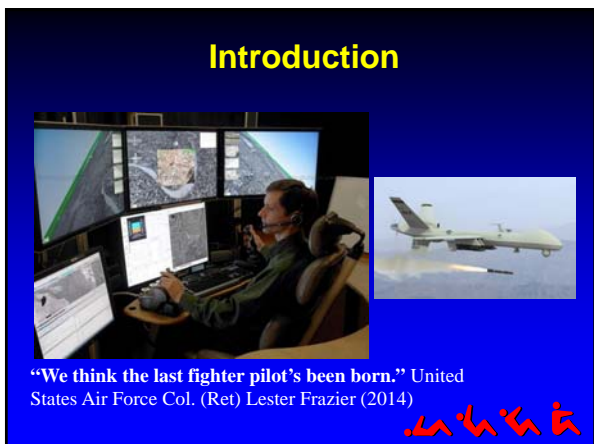
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### Introduction



“We think the last fighter pilot’s been born.” United States Air Force Col. (Ret) Lester Frazier (2014)

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## O-arm: Not Beneficial

- No significant benefit in improving screw placement in single level degenerative spondylolisthesis
- Cadaveric study found no difference in pedicle breach rate for O-arm vs. C-arm for screw placement




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## Trade-offs

- Data from a cadaveric study found:
  - Time to place instrumentation was shorter using O-arm
    - But set up time was longer
  - O-arm resulted in less radiation exposure to surgeons
    - But greater exposure to specimens

Tabaraee et al, Spine 2013




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## Navigation Accuracy Study

Kleck CJ et al. A new 3-dimensional method for measuring precision in surgical navigation and methods to optimize navigation accuracy. *Eur Spine J.* 2016 Jun;25(6):1764-74.

- 158 screws placed with navigation
- CT to CT comparison of tip location
- Projected pedicle screw track, pedicle probe track, and final screw position
- Average 5.92mm difference in final screw tip location as compared to projected location w navigated screwdriver
- Average 6.43mm with standard driver
- 5 screws were repositioned
- Would a robot increase accuracy?




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## Surgical Robots

- Modes:
  - Passive
    - Positioning surgical tools (guidance)
  - Semi Active
    - Mimic surgeons actions
  - Active
    - Perform procedure



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## The Evolution



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## Multiple Technologies In Development



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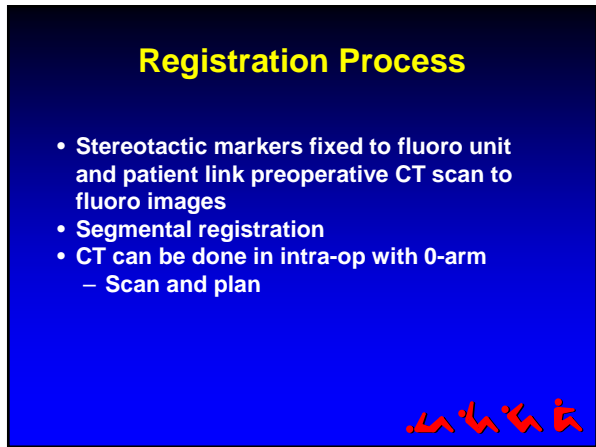
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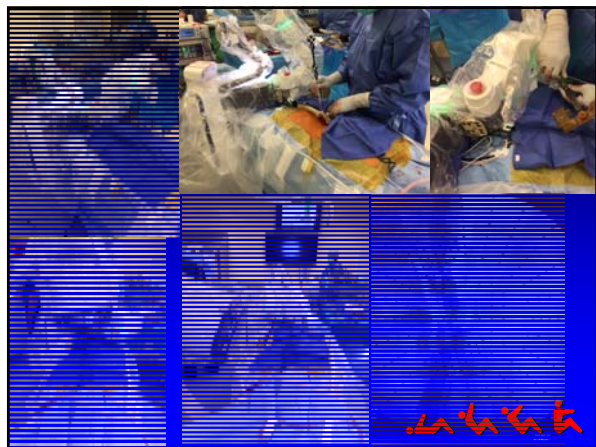
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## Robotic Studies

Kantelhardt et al, Perioperative course and accuracy of screw positioning in conventional, open robotic-guided and percutaneous robotic-guided, pedicle screw placement.  
 Eur Spine J. 2011 Jun;20(6):860-8.

- 57 free hand cases vs 55 robotic assist cases (20 – open, 35 percutaneous)
- Robotic assistance significantly improved:
  - Implant accuracy, X-ray dosage, Complication rate, Re-operations, Average length of stay, Post-op opioids

“In robot-assisted procedures the rate of misplaced screws and duration of intraoperative x-ray exposure were significantly lower, while procedure times did not differ significantly”




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### What Is the Learning Curve for Robotic-assisted Pedicle Screw Placement in Spine Surgery?

Xiaohang Hu MD, PhD, Isador H. Lieberman MD, MBA, FRCSC



0% - 1.4% rate of malpositioned screws

“...the rate of the screws converted to manual placement decreased after the first 30 patients.”




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## Robotic Studies

van Dijk et al, Clinical Pedicle Screw Accuracy and Deviation From Planning in Robot-Guided Spine Surgery. Spine 2015 Vol 40, Number 17, pp E986 - E991

- 112 consecutive MIS patients
- 487 pedicle screws
- Start point, angle of insertion analyzed
- 97.9% of the screws were within 2mm (safe)
- No revisions due to malpositioned screws
- Cases where robotic guidance was aborted were not included..




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Int Spine J  
DOI: 10.1007/s00381-015-2876-1

REVIEW ARTICLE

**Robot-assisted and fluoroscopy-guided pedicle screw placement: a systematic review**

Hani J. Marcus · Thomas P. Coady · Dipankar Nathi · Guang-Ping Yang · Aron Durril

- 5 articles, collectively reported placement of 1,308 screws (729 robot-assisted, 579 fluoro-guided)
- Mixed results:
  - Higher level evidence data favored fluoro-guided
  - Remaining comparative studies supported robot-assisted placement
- **Conclusions: Insufficient evidence to unequivocally recommend one technique over the other**



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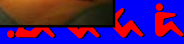

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**Summary: Robotic Advantages**

- Minimize intra-operative radiation exposure
- Improve screw placement precision, screw pullout resistance & deformity correction
- Facilitate less invasive exposures
- Enhance operative efficiency



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**Summary: Robotic Disadvantages**

- Technology still in development
- Pre-op CT required
- Set up time, draping is extensive
- Registration process can be time consuming
- Potential need to abort robotic guidance
- Initial cost of unit
- Trusting technology (for some)



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### Robotic Technical Notes

- Stable fixation for PSIS pins, spinous process pins
- Ensure that bridges/connectors are not in the way of the planned trajectories
- Tool skiving can lead to malpositioned screws
  - Ensure a flat “landing zone” or hold drill sleeve carefully
- Do not move patient after registration process
  - Retracting, placing screws, additional dissection, etc, if too forceful can lead to malpositioned screws



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### The Future

- Combination of navigation and guidance
- Trajectories for cage placement
- Outer cannulas for screws integrated to guidance system
- Deformity correction planning and rod bending
- Patient specific plan and implants
- Real-time feedback with navigation
- More active robotics, continued benefit of guidance



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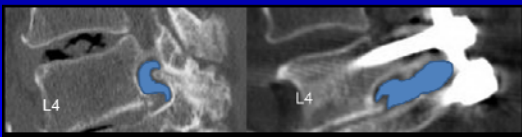
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### The Future

- Integrating semi-active and active robotics
- Watch in real time where the tools are located

Pre decompression      Post decompression



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## Summary

- Trade offs exist with each technology compared to traditional techniques
- Both robotics and navigation are advancing rapidly
- Look for the two systems to integrate more with each other
- There will always be a role for freehand technique
- Use the tools that allow you to deliver the best care



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Thank You



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