Surgical Navigation Enhances Precision and Training in Models for Regenerative Spine Therapies

Andres Bonilla, Kristen Sack, Nicole Erben, Howard Seim, Jeremiah Easley
Department of Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences

Introduction

- Large animal spine models are essential for testing regenerative therapies, biomaterials, and implants.
- Implant placement variability limits preclinical tissue engineering studies.
- Image-guided surgical navigation can improve precision and reproducibility.
- Novelty of this technology in Veterinary Medicine and Preclinical models
- Training new researchers to learn advanced procedural skills relevant to regenerative medicine.

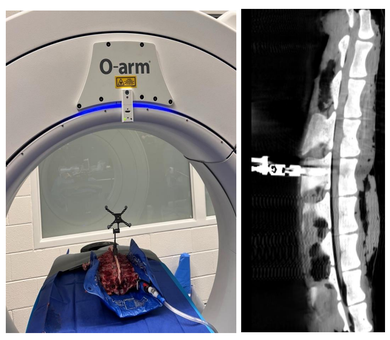
This study compared surgical navigation-guided and freehand pedicle screw placement by novice operators as a proof-of-concept for broader application.

Materials & Methods

6 ovine lumbar spines
N =60 pedicle screws
n=30 Freehand
n=Navigation



Experiment completed by 2 second year veterinary students with no prior experience in pedicle screw placement



- **CT = O-Arm**
- **Patient reference frame placed at L3**
- **Computer assisted surgical navigation with Stealthstation 8**

Pedicle (Polyaxially) screws: 3.5x 30mm

Metrics:

-Planning time

- Drilling time and Learning effect

Table 1: Gertzbein-Robbins classification

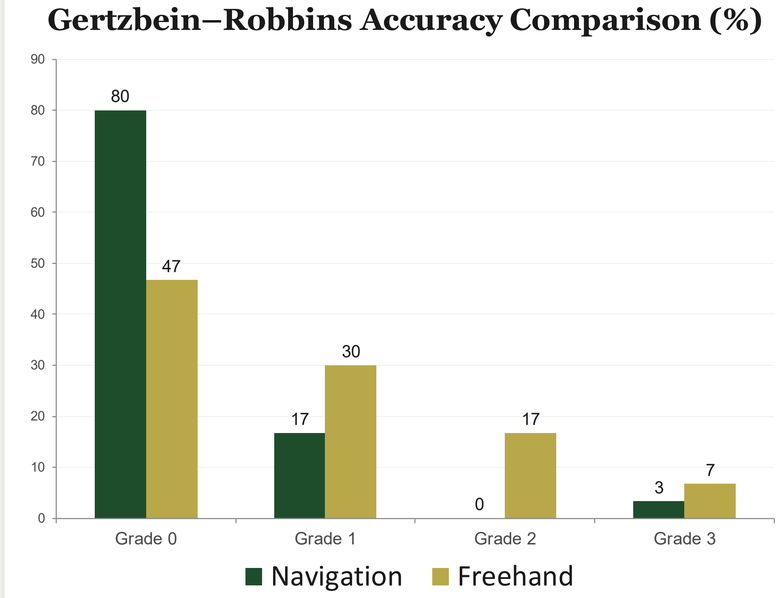
Grade	Breach Size (mm)
0	No breach
1	0 - 2
2	2 - 4
3	4 - 6
4	> 6

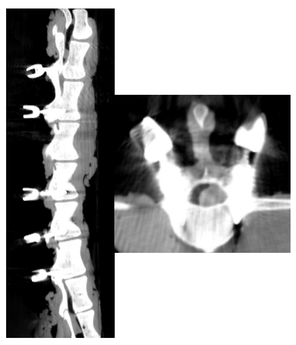
Results

Accuracy

80% Navigation No Breach

40% Freehand No Breach





- Lumbar Pedicle screws from L1 – L6
- Freehand average time taken to drill was 28s.
- Navigation Average time plan the trajectory was 23s and 60s to drill.

Procedure Time & Operator Outcomes

Metric	Navigation	Freehand
Planning time	Rapid (intuitive)	N/A
Drilling time	Longer	Shorter
Learning effect	Immediate	Variable
First-attempt accuracy	High	Lower

Key Takeaway

- Navigation-guided procedures achieved clinically acceptable precision (96.7% Grade 0–1).
- High accuracy was maintained even with first-time operators.
- The technology compensates for operator inexperience.
- Navigation helps standardize outcomes across different skill levels.

Discussion

Improved Precision

✓ Navigation yielded 80% Grade 0 (no breach) vs 46.7% freehand — with zero moderate violations. This is critical for protecting spinal cord and nerve roots in preclinical ovine models.

Enhanced Reproducibility

✓ Consistent screw trajectories reduce inter-animal biological variability, directly enhancing the reliability and statistical power of tissue engineering outcome data.

Educational Platform

✓ Novice veterinary students achieved accurate first attempts with navigation, demonstrating immediate skill transfer and safe early-stage learning in complex surgical procedures.

Translational Relevance

✓ The ovine lumbar spine closely mirrors human anatomy. Improved placement precision directly supports more clinically relevant preclinical models for regenerative medicine.

Conclusion

- Navigation-guided instrumentation significantly improves precision, reproducibility, and safety in ovine spine procedures.
- Importantly, it also serves as an effective educational tool, enabling early-stage researchers to safely learn complex techniques that support consistent delivery of regenerative therapies.
- This technology holds strong potential to accelerate both the development and translation of tissue engineering strategies

Future Directions

- Extend navigation to cervical spinal approaches in large animals
- Evaluate scaffold and biologic delivery precision *in vivo*
- Develop standardized navigation training curricula for veterinary surgical education
- Apply CT-navigation to large-animal intervertebral disc regeneration studies

Acknowledgments & Contact

The authors gratefully acknowledge the support of the Preclinical Surgical Research Laboratory and the Department of Clinical Sciences at CSU.
Contact: andres.bonilla@colostate.edu · Tel: +1 267-584-0388