Computer-guided navigation to advance translational spine models

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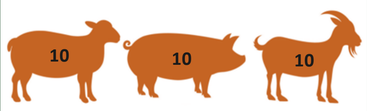
Introduction

- Large animal spine models (including sheep, goats, and pigs) are critical for advancing regenerative and translational spine research.
- Their anatomical and biomechanical similarity to the human spine makes them invaluable for developing and testing spinal fusion and intervertebral disc regeneration strategies.
- Accurate pedicle screw placement in these models remains technically challenging due to anatomical variability and smaller pedicle dimensions.

This work evaluates the feasibility and accuracy of navigation-guided pedicle screw placement across three large animal species commonly used in spine research.

Materials & Methods

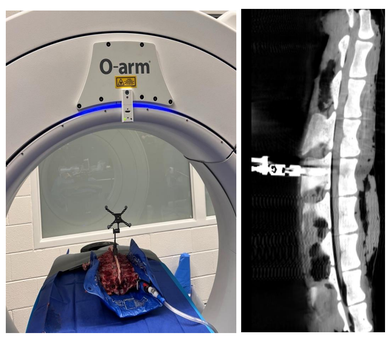
Specimens: Lumbar spines from ovine, caprine, and porcine



N=30 Pedicle screws



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:

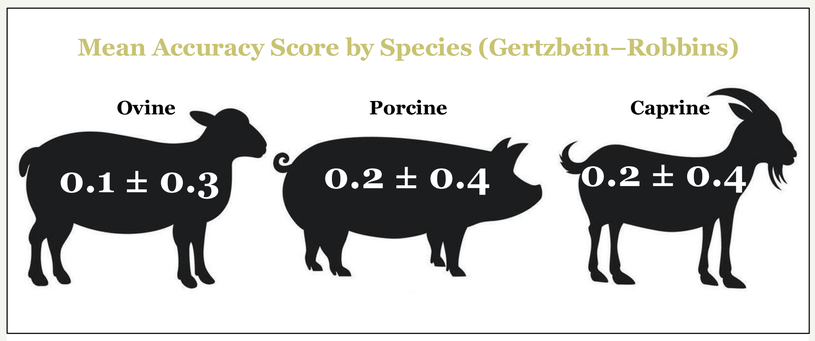
-Planning time

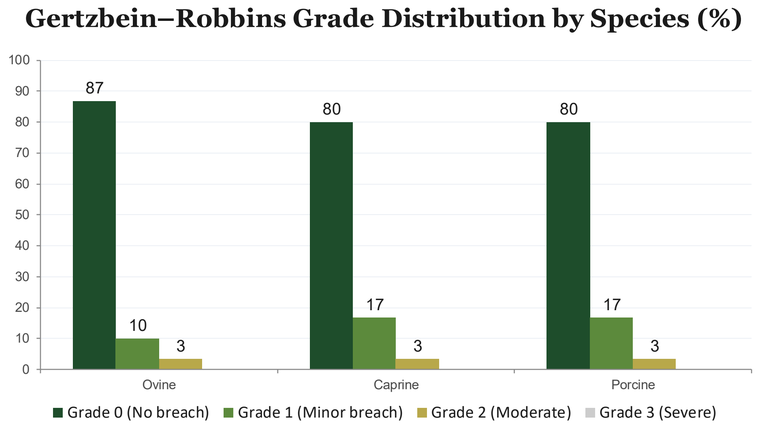
- Drilling time and Learning effect

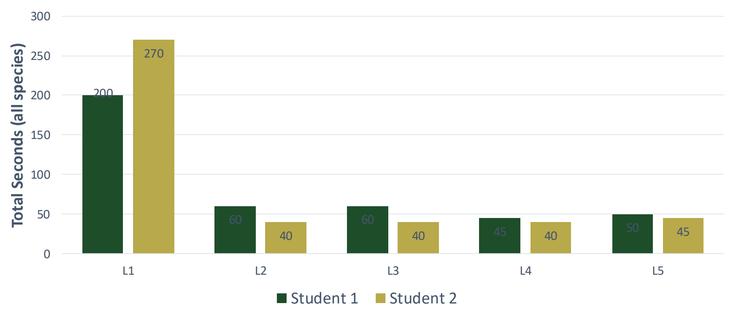
Table 1: Gertzbein-Robbins classification

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

Results







- Lumbar Pedicle screws from L1 – L6
- 25/30 screws Grade A (83.3%)
- 100% clinically acceptable
- Mean planning/drilling times with learning effect note
- Zero Grade C–E violations across all species

Planning & Drilling Time — Trend Across Species

Species	Planning Time	Drilling Time	Learning Effect
Ovine	Moderate	Moderate	Rapid
Caprine	Moderate	Moderate	Rapid
Porcine	Fastest	Fastest	Most rapid

Key Takeaway

- Navigation-guided procedures achieved clinically acceptable precision
- High accuracy is maintained even with first-time operators.
- The technology compensates for operator inexperience.
- Navigation helps standardize outcomes across different skill levels.

Discussion

Improved Precision

✓ 25/30 screws Grade A (83.3%), 5/30 Grade B (16.7%), zero Grade C, D, or E. ≤2mm breach is still considered clinically acceptable, so the effective "safe placement" rate is 100%

Enhanced Reproducibility

✓ Navigation standardized screw trajectories across three anatomically distinct species. Reduces biological variability and strengthens the preclinical model's statistical validity

Educational Platform

✓ Vet Students with no prior experience achieved 83.3% accuracy on their first attempt. Drilling time decreased across all spines, demonstrating a rapid intraoperative learning curve.

Translational Relevance

✓ Accurate instrumentation supports standardized delivery of biologics and implants in multi-species regenerative models. Reduced placement error directly improves the fidelity of outcomes in disc regeneration and fusion studies

Conclusion

- Navigation-guided pedicle screw placement achieved 100% clinically acceptable accuracy across 30 screws in three large animal species.
- A pronounced learning effect was observed within each spine, with first-level planning/drilling times 3–5× longer than subsequent levels, confirming rapid skill acquisition.
- 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

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