

Development and Evaluation of a Low-Cost 3D Printed Scoliosis Neuraxial Training Model

Man Kuan Lei, Lauren Nguyen, Scott Drapeau, Alexander Butwick, Pedram Aleshi, Peter Yeh, Jeremy Juang

Background

- Neuraxial procedures are more technically challenging in patients with scoliosis
- No commercially available scoliosis-specific trainers currently exist
- Existing models in the literature are non-reproducible, one-off prototypes

Study Objective: Develop an affordable, adaptable 3D-printed scoliosis epidural trainer

Design Goals: High fidelity, Reproducibility, Accessibility

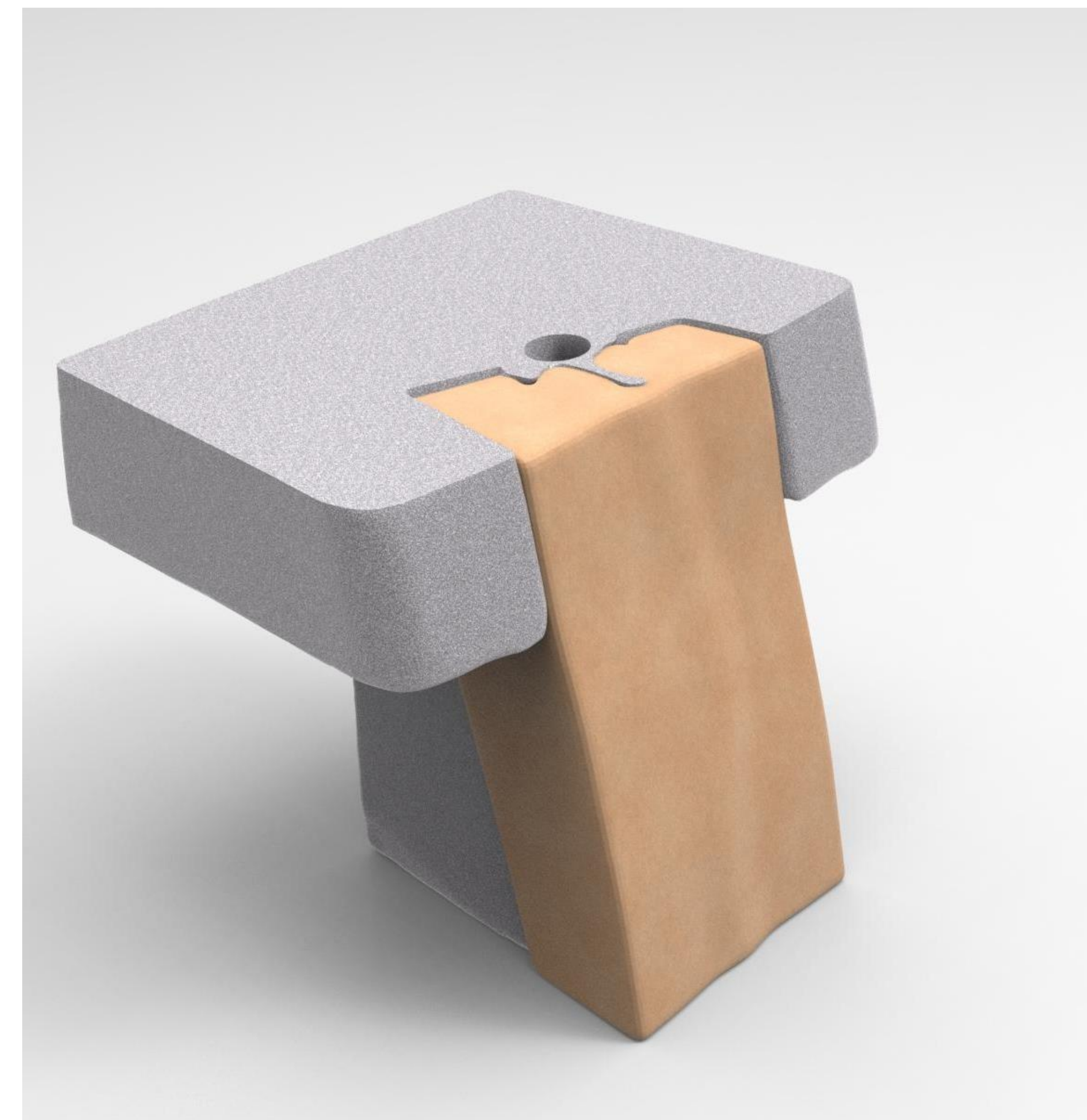
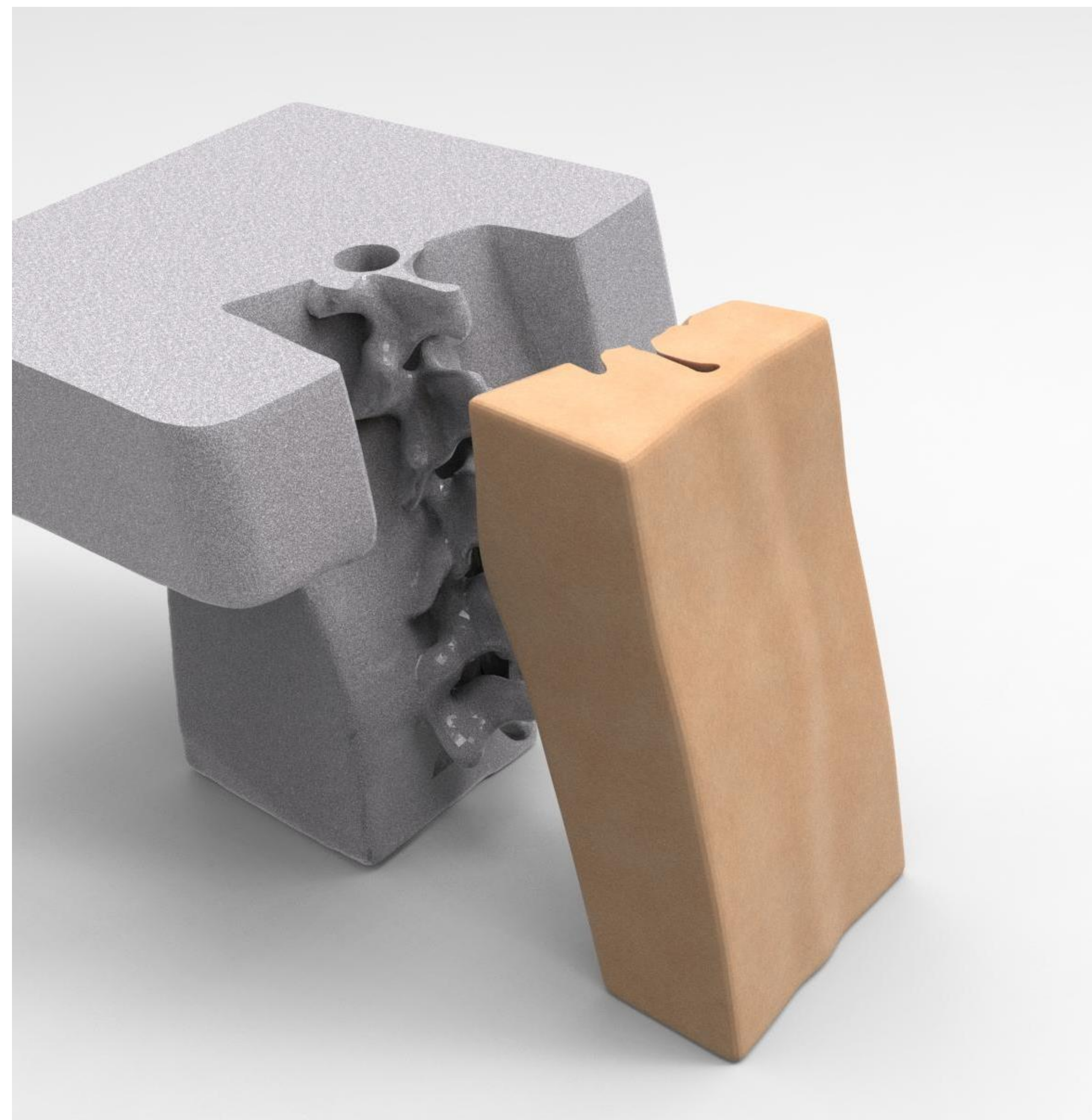
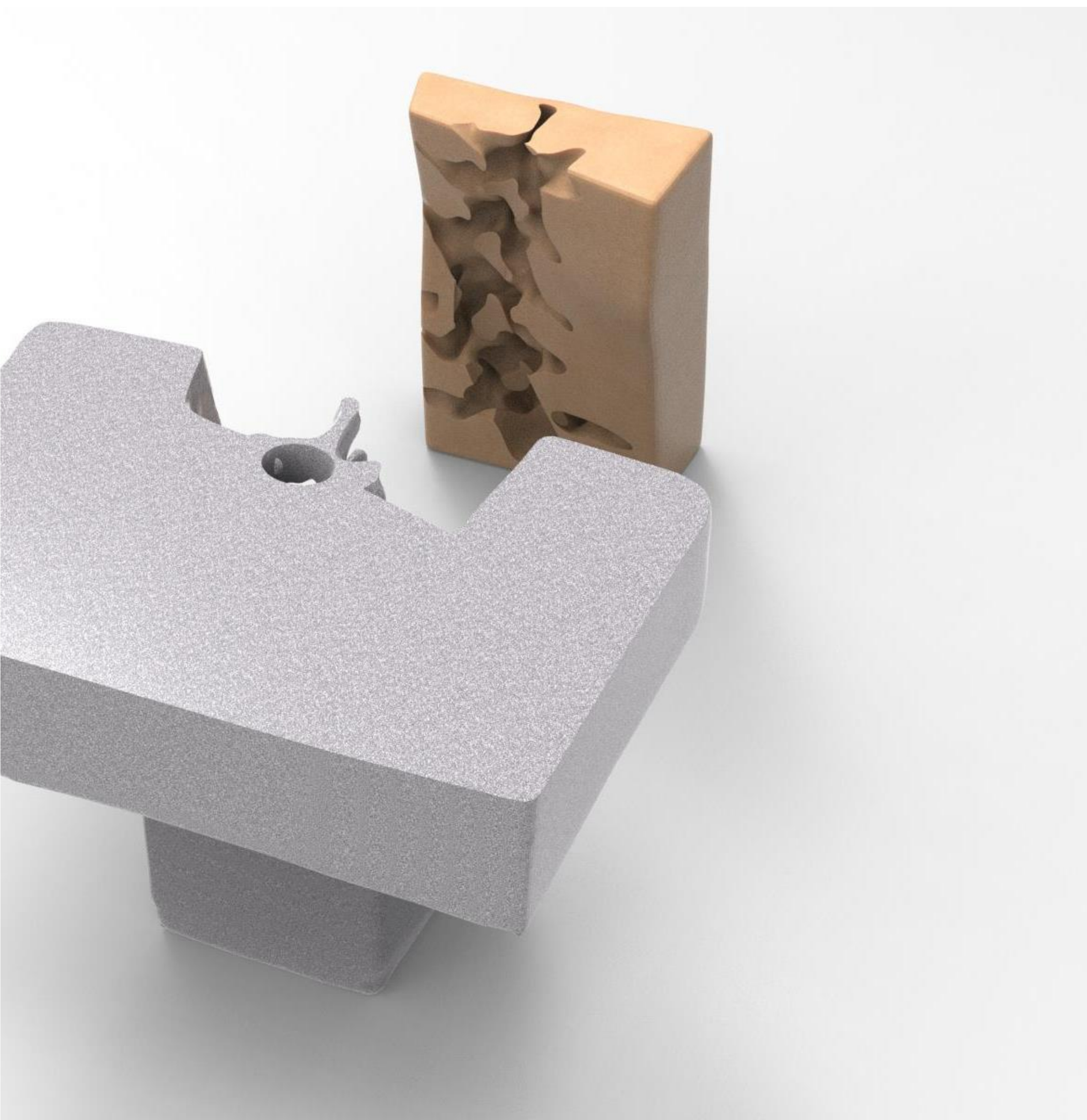
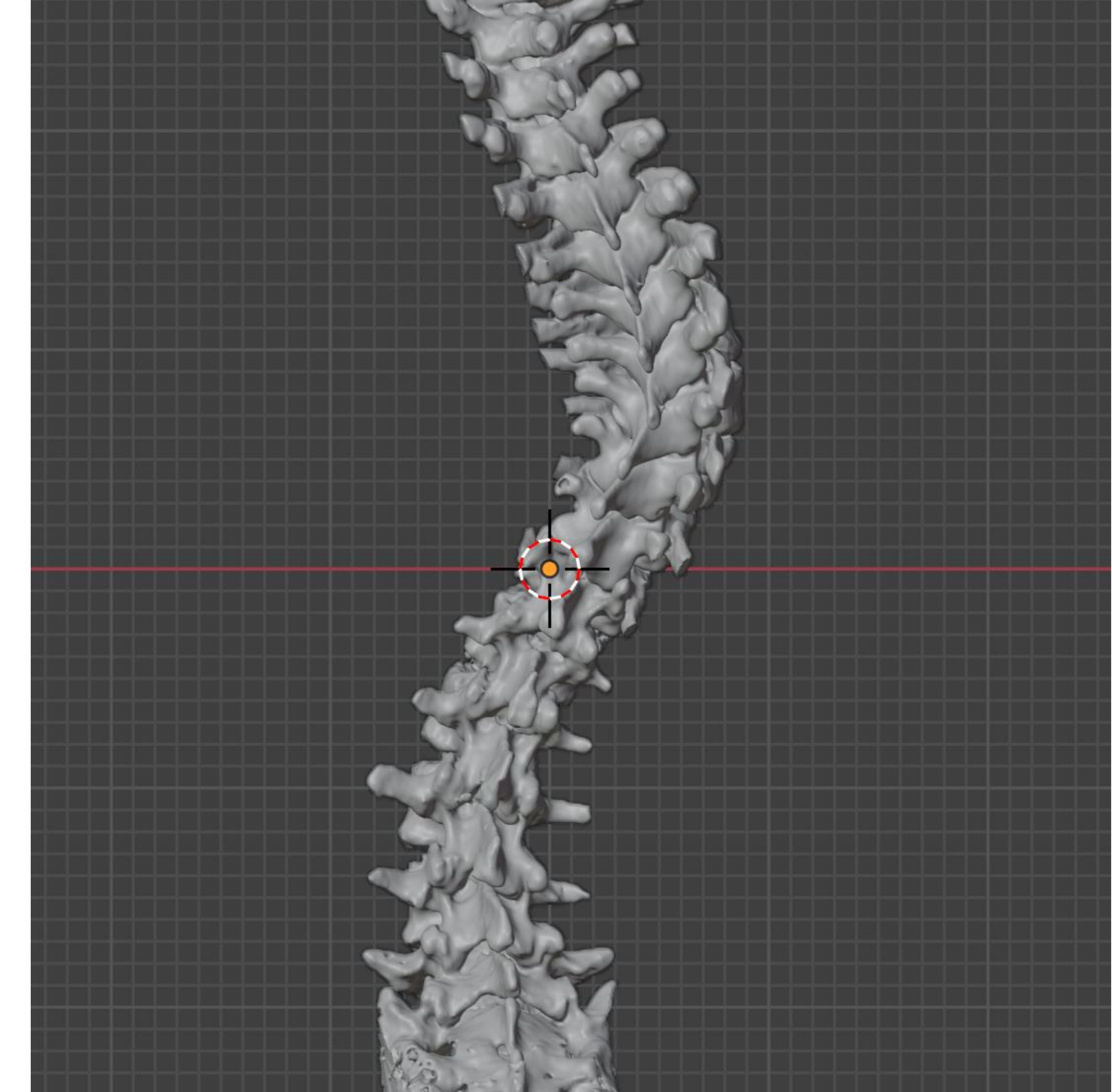


Study Design/Methods

- Model adaptable on Genesis trainer base
- Open-source scoliotic spine file
- Fabrication: Blender, standard desktop 3D printers, silicone
- Low cost: ~\$40 per unit

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Results

33 participants total: 20 residents (60%), 13 attendings/fellows (40%)

Role	n	Average Neuraxials Performed	Average Prior Scoliosis Neuraxials Performed	Confidence (Median)	Most Common Approach	Skin Punctures (Median [Range])	Needle redirections (Median [Range])	% >1 Level Attempted	Median Time-to-LOR	LOR Success Rate
Attending	11	>50	>5	4	Midline	2 [1–10]	4 [1–20]	~36% (4/11)	3:27 min	100% (11/11)
CA3	11	>50	3–5	3	Mixed	2 [1–20]	8 [1–100]	~55% (6/11)	8:16 min	100% (11/11)
CA2	9	11–30	0–2	2	Midline	3 [1–10]	6 [0–50]	~56% (5/9)	8:13 min	~89% (8/9)
Fellow	2	>50	>5	2–3	Paramedian	6 [2–10]	8 [6–10]	100% (2/2)	8:40 min	100% (2/2)

Results

NASA Simulation Task Load Index (SIM-TLX) assessment tool

Domain / Measure	Median	Overall Pattern	Interpretation
Mental Demand	10	Moderate	Cognitive effort required for planning/decision-making
Physical Demand	5	Low	Minimal physical strain
Temporal Demand	9	Low–Moderate	Some time pressure, not dominant
Frustration	10	Moderate	Occasional stress/irritation
Task Complexity	12	Moderate	Perceived as cognitively challenging
Situational Stress	8	Moderate	Mild–moderate stress during task
Distraction	6	Low	Minimal environmental interference
Perceptual Strain	5	Low	Limited visual/auditory discomfort
Task Control	8	Low–Moderate	Generally manageable task navigation

Results

Performance feedback

Measure	Summary
Spinous Process Palpation	Good/Excellent: 28/33 = 85%
Skin Palpation	Good/Excellent: 14/33 = 42%
Overall Training Appropriateness	Good/Excellent: 29/33 = 88%
Comparison to Other Phantoms	Good/Excellent: 24/29 = 83% (excluding N/A = 4)
Qualitative Feedback	Realistic anatomy Helpful for complex cases Lacks patient feedback May be easier than real scoliosis patients

Conclusion

- Moderate cognitive workload
- Low physical/environmental burden
- Strong perceived fidelity and educational value
- Scalable
- Low-cost

Next Steps

- Improve realism and cost- efficiency
- Ultrasound-compatibility
- Simulator performance → clinical outcomes?

References

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