Development and Validation of a Free Online Simulator for Transforaminal Lumbar Interbody Fusion Training

Emil Haikal, Léonard Swann CHATELAIN, Antonia Blanie, Dan yehiel BENHAMOU, Emmanuelle Ferrero, Virginie Lafage

INTRODUCTION: TLIF is a common spinal procedure with significant risk. Despite the need for training, simulation access remains limited due to high costs and technical barriers. No free, accessible simulator for TLIF currently exists.

METHODS:

In a multicenter randomized controlled trial, orthopedic residents were assigned to either simulator training or a traditional PDF operative technique.

The simulator depicted a virtual patient in a prone position with a posterior lumbar approach (Fig. 1A-B). Virtual fluoroscope, microscope (Fig. 1C), and essential surgical instruments were available. Users followed on-screen instructions, selecting instruments in the correct order, with errors triggering a red flash. The body envelope could be removed to analyze anatomy at each step (Fig. 1D). The final simulator was accessible on computers and smartphones.

A traditional PDF-based operative technique, derived from surgical guidelines, served as the control. Residents completed a pre-training questionnaire to assess baseline knowledge. After 45 minutes of training, they performed a TLIF procedure on a sawbone model under blinded examiner supervision (Fig. 1E).

Surgical step adherence was assessed using a 38-item checklist; technical performance was scored with OSATS (35 points). Confidence and satisfaction were also evaluated.

RESULTS: Forty-two residents were included (21 per group). The pre-training scores were not significantly different (2.4/3.0 vs. 2.1/3.0, p=0.34). The simulator group had higher checklist scores (32.7/38 vs. 28.8/38; p=0.01). OSATS scores were not significantly different (26.7/35 vs. 23.3/35; p=0.17). The simulator was especially effective for residents with fewer than 15 prior TLIF observations. Satisfaction was significantly higher in the simulator group, highlighting its pedagogical value (8.7/10 vs. 6.6/10, p=0.002).

DISCUSSION AND CONCLUSION: This is the first free, open-access TLIF simulator evaluated in a randomized trial. It significantly improved adherence to procedural steps, particularly in less experienced residents. Its accessibility makes it ideal for home learning and low-resource settings. The model may be extended to other procedures or customized for patient-specific   training.
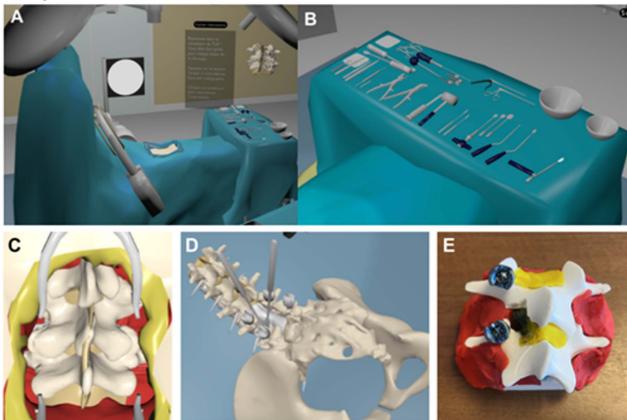

Figure 1: Fig. 1 (A) Intraoperative view of the simulator. (B) View of instruments required for the TLIF procedure. (C) Microscopic view of the operative site. (D) Option to hide the body envelope to visualize the spine. (E) Sawbone model at the end of the validation phase (commercial clay was used to replicate the soft tissues).