SURGICAL SIMULATION: VALIDATING METHODS TO IMPROVE ORTHOPAEDIC RESIDENT SKILLS COMPETENCY

Gary T. Ohrt, Matthew D. Karam, Geb W. Thomas, Jenniefer Y. Kho,
Tameem M. Yehyawi, J. Lawrence Marsh, Donald D. Anderson

The University of Iowa, Iowa City, IA
email: gary-ohrt@uiowa.edu web: http://poppy.obrl.uiowa.edu/

INTRODUCTION

Surgical reconstruction of fractured extremities is a complex procedure that orthopaedic residents must master during training. Currently, training is based on an apprenticeship model, which while beneficial, is not uniform and does not provide any means to assess skills competency. Surgical simulation can help address shortcomings in the training model by providing residents opportunities to (1) practice procedures that they may not otherwise perform and (2) practice said procedures efficiently until competency is achieved, (3) while limiting exposure of patients to undue risk.

However, before a surgical simulator construct can be used to assess competency, its scientific validity must be established.[1] A well-designed and rigorously validated simulator can provide quantitative, repeatable assessment of specific surgical skills and can predict performance in the operating room. Our long-term goal is to provide a beneficial surgical simulator module for fracture reconstruction that can be modified for different fracture models and anatomic locations.

METHODS

A simulation training and assessment program focused on improving articular fracture reduction skills in a tibial plafond model has been developed (Figure 1). The simulation uses various multi-segment, radio-dense polyurethane foam (bone surrogate) fracture patterns inside a synthetic soft tissue housing (Sawbones Inc.). The task is to reduce fragment displacement and fixate a three-segment fracture with Kirschner wires, operating through a limited anterior window in the soft tissue housing while using fluoroscopy for visualization.

Participant hand motions are tracked using a four-camera Qualisys motion capture system. The

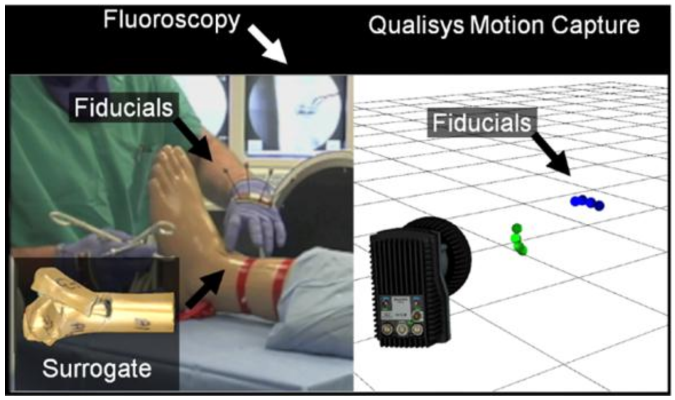

Figure 1. Left: In-progress simulation showing fiducials and soft-tissue housing. Bottom Left: Fracture surrogate pattern. Right: Fiducials shown in motion capture software.

simulation is synchronously recorded from multiple video sources, including from a head-mounted camera that enables determination of when and where attention is focused. The video streams are consolidated into a single composite split-screen video (Figure 2), for later one-on-one feedback from a surgeon/educator.

Residents were assessed on time-to-completion and objective error in reducing the fracture. The

Figure 2. Video of Simulation, Clockwise from Top Left: Head Mount, Top View, Fluoroscopy, Wide Angle.

reduction inaccuracy was assessed by comparing post hoc 3D laser scans to an ideal reconstruction of the fracture using Geomagic Qualify software (Geomagic Inc.). Motion capture data were processed to provide the number of discrete hand actions and cumulative hand motion distance. Radiation dose and fluoroscopy time were also recorded. The OSATS global surgical skills metric [3] was used to rate the residents on their performance in nine areas, and an overall score was calculated. The rating was done by a senior orthopaedic traumatologist.

In a prior study, we found that senior orthopaedic residents had more deliberate hand motions (less cumulative hand distance, a surrogate for less iatrogenic wound bed trauma) and scored better on task performance than more junior residents.[2]

Building upon that earlier work, a training program consisting of cognitive and motor skills modules was developed. The cognitive module was implemented through an online course that included a pretest, general knowledge about plafond fractures and fluoroscopy, and online video performance reviews. The motor skills module focused on acquiring motor skills by direct instruction and dedicated practice on a simulated model (different fracture pattern from test model), with real-time feedback from an orthopaedic traumatologist.

To evaluate the new training program, six first-year and six second-year orthopaedic residents were randomly assigned to either an intervention or control group. Simulations were run with both groups before and after training in the intervention group. Training occurred 24 to 48 hours prior to the second surgical simulation.

RESULTS AND DISCUSSION

There were no significant differences in the metric of articular surface step off (Table 1) attributable to training. However, both the control and intervention groups showed improvement of nearly 1 mm. Current analysis methodology does not yet account for the rotation of fragments, which may play a large role in quality of reduction, and may show a difference with the training.

Table 1: Fracture reconstruction inaccuracy

	Average Articular Displacement (mm)		
	Control	Intervention	P Value
Pre-Training	4.73	4.93	0.827
Post-Training	3.63	4.00	0.603
P Value	0.34	0.21	
Improvement	1.10	0.93	0.886

Judged by OSATS scores (higher score is better) from the pre and post training simulations (Table 2), there was a significant improvement associated with the intervention, while the control group did not experience significant improvement or worsening. This indicates that the training was effective in improving the aspects of fracture reduction that a senior orthopaedic surgeon would find important.

Table 2: OSATS Rating Scores

	OSATS Overall Score		
	Control	Intervention	P Value
Pre-Training	28.8	20.5	0.000
Post-Training	28.5	32.7	0.029
P Value	0.79	0.001	
Improvement	-0.3	12.2	0.003

CONCLUSIONS

The articular surface comparison results did not show significant differences between the control and intervention groups. However, the OSATS scoring showed a post intervention difference between the two groups.

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