A FLEXIBLE ORTHOPAEDIC TRAUMA SURGERY BOX SKILLS TRAINER

Geb W Thomas, Donald D Anderson, Matthew D Karam, Brian Johns,
Salvador Rojas Murillo, and J Lawrence Marsh

The University of Iowa, Iowa City, IA, USA
email: Geb-Thomas@uiowa.edu

INTRODUCTION

A 2010 review of virtual reality simulators for orthopaedic surgery[1] found only 23 articles exploring working simulators, and only three related to fracture management, compared with 246 citations for laparoscopic simulators. Many of the recent contributions to orthopaedic simulation technology have emphasized haptic feedback such as for bone drilling [2,3] and amputation surgery[4]. One of the most successful laparoscopic simulators is the Fundamental Laparoscopic Simulator[5], with which trainees manipulate rubber bands and rings and tie knots with laparoscopic tools while viewing their movements on a remote camera display.

This work introduces a skills acquisition approach similar to arthroscopically or fluoroscopically guided orthopaedic surgery by simulating single or two-plane assessments of three-dimensional tasks. In this simulator, two video camera images substitute for fluoroscopic images, and simple pins are analogous to the tip of guide wires used in surgery. The current skills trainer focuses on the task of quickly locating a precise position and orientation utilizing two orthogonal view planes. The simulator is relatively inexpensive and radiation free, improving its utility in training programs.

METHODS

The skills trainer consists of two video cameras mounted on an aluminum frame. The cameras view a roughly 4”x4”x4” workspace from orthogonal positions: one views the workspace from 1.5’ above, the second camera points toward the participant from a position approximately 1.5’ behind the workspace. A screen between the workspace and the participant obstructs the direct view of hand motions in the workspace. This requires the participant to rely on the camera views visible on a monitor placed conveniently nearby to navigate the 3D environment. Currently a proctor controls the simulation, although the task may be self-guided.

Three tasks were devised for the trainees. The horizontal peg-in-hole task consists of a 4”x4” acrylic pegboard with sixteen, 0.125” diameter drilled holes positioned in view of the top camera. The trainee is given one minute to place, in order, as many 1” long, 0.109” diameter steel pins into the holes as possible using camera guidance. The vertical peg-in-hole task is similar, except the pegboard is aligned specifically so the drilled surface is perpendicular to (and thus not directly visible in) both the top and side camera views. This forces the participants to rely on corresponding numbered indicators on the sides of the pegboard to correctly determine hole locations from perpendicular camera views. As in the first task, the participant inserts as many pins as possible in two minutes.

The final task, the angle task, uses a 3/8” diameter, 6” long shaft constrained to a spherical joint at one end. Unlike the previous two tasks, the participant must manipulate and match the shaft angle to a computer-generated line overlaid on the two orthogonal camera views. The objective is matching as many generated line positions with the shaft as

Figure 1. Box skills trainer. A resident trainee places a peg on the horizontal pegboard. The proctor updates video images, visible on a display located behind the keyboard.

possible within one minute.

Trainees are first acquainted with each task with live video. After familiarization, the camera mode is switched to only generate static views. The trainee must then verbally request either an "AP" to see a still image from the top camera, corresponding to a antero-posterior fluoro shot, or a "Lateral" to see a still image from the back camera. The static images remain visible until a new image is requested, which immediately replaces the old image. Scoring was standardized across all tasks. Each correct pin placement or shaft position received 100 points, but each requested image deducted 10 points from the total score. Subjects performed each task three times. Afterwards each trainee completed a survey.

Our hypotheses were:

1. Task performance improves with practice;
2. Trainees perceive that the task was helpful to improve their surgical skill.

Six post-graduate year one, male orthopaedic residents participated in the experiment. These trainees were also introduced to a more realistic surgical simulation involving the reduction and fixation of a tibial plafond fracture on the same day.

RESULTS AND DISCUSSION

The average scores for the horizontal peg-in-hole tasks were 511, 638 and 723 for the three respective trials. The average scores for the vertical tasks were 403, 503 and 572. For the angle task, averages were 800, 930 and 930. A general linear model of performance on the horizontal task as a function of order and participant with order as a covariate and participant as a random variable indicates a significant linear improvement with repetition: $F(1,11) = 8.21$, $p = 0.015$, with a model adjusted R-square of 24.9%. A similar model of vertical task performance also shows a significant linear improvement with repetition: $F(1,11) = 9.16$, $p = 0.012$, with a model adjusted R-square of 88.45%. A similar model did not lead to a significant linear improvement with repetition for the angle task.

The six questionnaire items generally yielded inconclusive findings. The respondents found that movements were moderately similar to a previously reported, more realistic tibial plafond fracture simulation[6] (four 3's and two 4's) on a 5-point scale with 5 being very similar. Responses to whether the dexterity requirements were similar were widely varying, ranging from 1 to 4 with a mean of 2.5 and standard deviation of 1.05. The participants moderately agreed that practice with the simulator would improve their performance on the more realistic simulator or real surgery (each 3 on a 5-point scale with standard deviations of 0.8 and 0.6, respectively). Five out of the six participants felt that scoring the simulator as a game enhanced their experience.

CONCLUSIONS

The results support the hypothesis that task performance improves with practice. The residents were moderately convinced that experience with the box trainer would improve performance with the more realistic tibial plafond facture simulator. Combining our positive results with the benefits of a low-cost, radiation free simulator demands further study. In addition, this low-fidelity simulator, once validated, may play an important role in basic orthopaedic trauma skill assessment (similar to the FLS trainer in General Surgery).

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