Exploring the Role of 3D Simulation in Surgical Training: Feedback from a Pilot Study
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INTRODUCTION:
The potential of 3D software simulation in surgical training has been recognized for years. This field offers an opportunity for surgical trainees to gain experience performing difficult procedures with complex anatomy in a safe environment. Simulation also offers a standardized environment that supports objective evaluation of skill acquisition. But while many 3D simulators have been developed for surgical education, their use has not become widespread [1]. Although some studies have demonstrated efficacy of 3D simulators for specific procedures, it remains unclear how to best realize the potential of this technology when training students [2]. The objectives of this study were three-fold: 1) to evaluate the efficacy of a 3D software simulation tool we developed for pedicle screw insertion; 2) to gather feedback about the utility of the simulator and to use this feedback to make improvements; 3) to help identify the ideal context and role in which such simulation is best used in surgical education.

METHODS:
The study population consisted of residents of orthopedic surgery and neurosurgery with varied experience performing spinal surgery. Students were recruited from a spine surgery course and gave informed written consent to participate in the Research Ethics Board approved study. Participants were randomly assigned to subject or control groups, with residents of equal PGY levels being split evenly among groups. The study and control groups were each assigned two cadavers. Both groups received standard training on pedicle screw insertion. The subject group then received an additional one-hour session of training and practice with the pedicle screw simulator using a CT-based 3D model of their assigned cadaver’s spine (Figure 1). Expert surgeons were present to answer clinical questions during this period. All students then inserted pedicle screws into the cadavers. Finally, screw insertions were graded by a panel of three blinded experts.

Screws were assumed to be independent events, and 2 grading methods were used: 1) Heary et. al.’s method whereby screws receive one of five grades based on clinically significant criteria, with grade I and II screws considered acceptable while grades III to V are unacceptable [3]; 2) a scheme which records each direction that screws are misplaced and if the screws have problems with insertion point and/or angulation. Problems with selection of screw size were ignored since this was not emphasized in the course. Chi-square tests for independence were used to analyze differences between the groups. A questionnaire was also used to collect anonymous feedback from the students. The questionnaire included 6 questions regarding the usefulness of the simulator on a 5-point Likert scale from ‘Strongly Agree’ to ‘Strongly Disagree’ and one question asking if students had sufficient time. Mean and standard deviation were calculated for Likert scale responses. The questionnaire also asked for written feedback, including comments and suggestions for improvements to the simulator.

RESULTS:
Screw sample size was 95, with the subject group placing 45 screws and the control group placing 50 screws (Table 1). The control group outperformed the subject group on most categories except for lateral breeches and placement of entry point. There were 17 respondents to the questionnaire: all 10 members of subject group and 7 members of the control group who tried the simulator after the course (Table 2). Of these respondents, 76% agreed or strongly agreed that the simulator is beneficial as an educational tool.

DISCUSSION:
The screw data that was collected failed to show an overall improvement with the simulator. In fact, the control group was significantly better than the subject group in several categories. The best explanation for these results is the quality of the cadavers’ spines. The grading experts noted that the spines randomly assigned to the subject group had severe problems of scoliosis, osteoporosis, and suspected spinal metastases, while the control group cadavers had superior quality bone. Thus, the low number of cadavers (N=4) very likely confounded the results, and future studies need to account for this (e.g. by assigning a mix of subject and control students to each cadaver). Other factors that may have confounded the results are the variable skill of students seen (N=21), or perhaps a group effect where one particularly strong student helps nearby students perform better. One positive result was in the placement of entry points, which is probably the skill most easily taught by the simulator and least affected by poor anatomy. The improvement in the subject group, while not significant (p = 0.127), suggests it might be possible to demonstrate the simulator’s efficacy with higher N.

A majority of students indicated that they enjoyed using the simulator and felt it was useful, while offering many valuable suggestions for improvements. These suggestions focused on 2 areas: improvements for ease of use and increased teaching to be incorporated within the simulator. The use of such feedback is invaluable in developing complex educational tools such as 3D simulators, and will be incorporated in future versions of our tool.

The study also highlights the issue of the ideal context in which simulation should be used. Current teaching methods most often employ simulation only in short, focused skill acquisition classes. But when discussing this issue with both residents and surgery professors, most felt such simulators would be best used over a longer time period, initially to learn the technique and later for preoperative planning. It was also clear that many students and professors felt simulation should be incorporated directly into the curriculum to best reap its benefits, rather than be used simply as an adjunct or optional learning tool.

REFERENCES:

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