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Shoulder Arthroscopy Simulator Training Improves Shoulder Arthroscopy Performance in a Cadaver Model

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Abstract

Purpose—The purpose of this study was to quantify the benefits of shoulder arthroscopy simulator training with a cadaver model of shoulder arthroscopy.

Methods—Seventeen first year medical students with no prior experience in shoulder arthroscopy were enrolled and completed this study. Each subject completed a baseline proctored arthroscopy on a cadaveric shoulder, which included controlling the camera and completing a standard series of tasks using the probe. The subjects were randomized, and nine of the subjects received training on a virtual reality simulator for shoulder arthroscopy. All subjects then repeated the same cadaveric arthroscopy. The arthroscopic videos were analyzed in a blinded fashion for time to task completion and subjective assessment of technical performance. The two groups were compared with students t-tests, and change over time within groups was analyzed with paired t-tests.

Results—There were no observed differences between the two groups on the baseline evaluation. The simulator group improved significantly from baseline with respect to time to completion and subjective performance ($p < 0.05$). Time to completion was significantly faster in the simulator group compared to controls at final evaluation ($p < 0.05$). No difference was observed between the groups on the subjective scores at final evaluation ($p = 0.98$).

Conclusions—Shoulder arthroscopy simulator training resulted in significant benefits in clinical shoulder arthroscopy time to task completion in this cadaver model. This study provides important additional evidence of the benefit of simulators in orthopaedic surgical training.

Clinical Relevance—There may be a role for simulator training in shoulder arthroscopy education.

Introduction

There is an increasing interest in virtual reality simulators to augment arthroscopic surgical training.¹ While all surgical skills have a learning curve and require dedicated practice to obtain mastery, arthroscopic techniques present additional challenges to the learning curve.² Simulators provide an opportunity to develop and maintain arthroscopic surgical skills in a safe and time-efficient manner.^{1, 2} The benefits of simulator training have been well-documented in the aviation industry, and similar strategies to improve orthopaedic training warrants consideration.²

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Previous work has demonstrated that shoulder simulator performance correlates with level of clinical shoulder arthroscopy experience, and that improvement in clinical arthroscopy experience is reflected in improved performance on the simulator.^{3, 4} Similarly, shoulder simulator performance correlates with performance of similar tasks in cadaveric shoulder arthroscopy.⁵ Translation of simulator training to improved subjective performance in the operating room has been demonstrated in knee arthroscopy.⁶ However, to our knowledge no studies have investigated if shoulder simulator training results in improvement in clinical arthroscopic skills. While it is likely that simulator practice will improve shoulder arthroscopy performance, the extent of benefit, if any, is unknown.

The purpose of this study was to quantify the benefits of shoulder arthroscopy simulator training with a cadaver model of clinical shoulder arthroscopy. We hypothesized that simulator training would improve shoulder arthroscopy performance.

Methods

Seventeen first year medical students who had no prior experience in shoulder arthroscopy were enrolled and completed the study. This cohort represented all of the eligible students who were willing to participate. There were 9 men and 8 women. Each subject completed a baseline proctored arthroscopy on a cadaveric shoulder. The subjects were randomized, and nine of the subjects received training on a virtual reality simulator for shoulder arthroscopy. All subjects then repeated the same cadaveric arthroscopy 3 months after the initial session. The study was approved by the institutional IRB. All subjects provided informed consent and were compensated \$200 for their time.

A right shoulder cadaveric specimen was prepared prior to the first subject evaluation. The arthroscope was inserted via a standard posterior portal, and a standard anterior rotator interval portal was placed by the proctor. The glenoid was marked using an arthroscopic bovie to create standard reference points to touch with the probe. The glenoid was marked at the bare spot and at the 3, 6, 9, and 12 O'Clock positions at the labral edge. The subjects controlled the camera and the probe, and were asked to sequentially touch each point starting at the center and returning to the center before moving on the next point (center, 12 O'clock, center, 3 O'clock, center, etc.). The final task was to pass the probe proximal to the biceps and return to the center of the glenoid. An experienced arthroscopist could complete the entire task in under 30 seconds. The sessions were proctored by a sport medicine fellowship trained surgeon who was blinded to the randomization, and were recorded using the arthroscopic equipment. The proctor provided assistance if the camera came out of the joint.

The simulator training was performed on the ProCedicus arthroscopy simulator (Mentice Corp, Goteborg, Sweden) and the training protocol has been described previously (Figure 1).^{3, 4} Briefly, the subjects are required to manipulate a simulated probe to touch a series of eleven targets within the virtual shoulder while navigating a simulated camera. After the target is successfully touched, a new target appears in a new location. The session was complete after successfully touching all eleven targets, and there were six sessions in total over a 3 month period.

The arthroscopic videos were analyzed in a blinded fashion for time to task completion and subjective assessment of technical performance by the same fellowship trained surgeon. All videos were analyzed at the same time in random order, such that the evaluator was blinded to both the time of evaluation (baseline and final evaluation) and the study group (simulator and control). Time to task completion was the primary outcome parameter. Subjective evaluation of each recorded arthroscopy session was performed using a modification of the

Global Operative Assessment of Laparoscopic Skills (GOALS).⁷ The videos were scored from 0 to 5 points for four domains including dexterity, depth perception, efficiency, respect for tissue. The top score for each domain was 5 and the worst score was 0. The scores were averaged to give an overall performance score for each subject.

The groups were compared with students two-tailed t-tests. Change over time within groups were assessed with paired two-tailed t-tests. The level of significance was set at $p < 0.05$.

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Results

There were no observed statistical differences between the two groups at baseline with respect to time to task completion (Table 1). On follow-up assessment, the subjects who had undergone training on the arthroscopy simulator were significantly faster than baseline ($p = 0.002$), and significantly faster than control subjects ($p = 0.04$). Trained subjects were on average 90 seconds (30%) faster than control subjects at the follow-up assessment, and improved by an average of 187 seconds (45%) from baseline.

There were no observed statistical differences between the two groups at baseline with respect to the overall subjective performance score (Table 2). There were no observed statistical differences between the two groups at follow-up assessment ($p = 0.98$). Both groups improved significantly from baseline ($p < 0.05$).

Discussion

The results of this study support our hypothesis that simulator training results in significant improvement over controls with respect to time to task completion in cadaveric shoulder arthroscopy. The observed 30% difference in time to completion is likely to be clinically meaningful, and may further facilitate education by providing more time to refine skills with a mentoring surgeon.

While we did not observe a difference between the groups with respect to the subjective performance score, previous work in the knee demonstrated that simulator training resulted in improved subjective performance in the operating room.⁶ However, baseline performance was not assessed in the operating room prior to randomization in this study. We found that both groups improved significantly from baseline on the subjective score. The improvement in the control group was unexpected, and likely reflects the benefit of familiarity with the task. A similar phenomenon was noted in 2 medical students in a previous report regarding performance on a shoulder simulator.⁴ A recent study demonstrated retention of simulated arthroscopic meniscus repair skills over a six month interruption in task performance.⁸ In contrast, a study of retention of shoulder arthroscopic skills demonstrated loss of skills back to baseline after a 6 month interval.⁹ Further study is warranted to determine retention at different time points.

Limitations

A potential limitation of this study is that the subjects in this study were medical students with no previous endoscopic experience. These students may derive the most benefit from the simulator training, and the results may not be generalizable to trainees with more experience. Previous work has demonstrated that there is a wide variation in the innate

arthroscopic skills of medical students.¹⁰ We also observed a wide variation in skills with some subjects taking three times as long to complete the task. A greater number of study subjects may be helpful in future studies, given the variability in baseline skill. Assessment of additional parameters beyond time to completion and subsection evaluation, such as the number of times the subject removed the camera from the joint, may also be beneficial. In addition, future studies are necessary to determine the benefits of simulation for trainees with different skill levels, as well as investigate the relative benefits of simulation compared with traditional orthopaedic education in the cadaver lab and operating room.

Conclusions

Shoulder arthroscopy simulator training resulted in significant benefits in clinical shoulder arthroscopy time to task completion in this cadaver model. This study provides important additional evidence of the benefit of simulators in orthopaedic surgical training.

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Figure 1.
Proedicus arthroscopy simulator

Table 1

The total time to complete the task for each group at baseline and final evaluation with $\pm$ standard deviation and (range). The Simulation p value compares the control group to the simulator group at each time point. The improvement p value compares the baseline and final scores for each group.

	Baseline	Final	Improvement p value
Control	363 $\pm$ 141 (202–655) seconds	325 $\pm$ 89 (252–523) seconds	p=0.52
Simulator	420 $\pm$ 127 (195–599) seconds	233 $\pm$ 81 (130–371) seconds	p=0.002
Simulation p value	p=0.39	p=0.04	

Table 2

The mean overall GOALS score for each group at baseline and final evaluation with $\pm$ standard deviation. The Simulation p value compares the control group to the simulator group at each time point. The improvement p value compares the baseline and final scores for each group.

	Baseline	Final	Improvement p value
Control	1.63 $\pm$ 1.19 points	3.13 $\pm$ 1.55 points	p=0.048
Simulator	1.67 $\pm$ 0.71 points	3.11 $\pm$ 0.93 points	p=0.002
Simulation p value	p=0.93	p=0.98	