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Immediate Auditory Feedback is Superior to Other Types of Feedback for Basic Surgical Skills Acquisition

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OBJECTIVE: We examined the effect of timing and type of feedback on medical students' knot-tying performance using visual versus auditory and immediate versus delayed feedback. We hypothesized that participants who received immediate auditory feedback would outperform those who received delayed and visual feedback.

METHODS: Sixty-nine first- and second-year medical students were taught to tie 2-handed knots. All participants completed 3 pretest knot-tying trials without feedback. Participants were instructed to tie a knot sufficiently tight to stop the “blood” flow while minimizing the amount of force applied to the vessel. Task completion time was not a criterion. Participants were stratified and randomly assigned to 5 experimental groups based on type (auditory versus visual) and timing (immediate versus delayed) of feedback. The control group did not receive feedback. All groups trained to proficiency. Participants completed 3 posttest trials without feedback.

RESULTS: There were fewer trials with leak ($p < 0.01$) and less force applied ($p < 0.01$) on the posttest compared to the pretest, regardless of study group. The immediate auditory feedback group required fewer trials to achieve proficiency than each of the other groups ($p < 0.01$) and had fewer leaks than the control, delayed auditory, and delayed visual groups ($p < 0.02$).

CONCLUSIONS: In a surgical force feedback simulation model, immediate auditory feedback resulted in fewer training trials to reach proficiency and fewer leaks compared to visual and delayed forms of feedback. (J Surg Ed ■:■■■-■■■.

KEY WORDS: force feedback, auditory, visual, immediate, delayed, surgical skills, surgical education

COMPETENCIES: Systems-Based Practice, Practice-Based Learning and Improvement

INTRODUCTION

Surgical residents suture multiple wounds daily and are required to have the skills necessary to perform these tasks without supervision.[1] Surgical residents must learn the appropriate amount of force that can be applied to various types of human tissues without causing damage. Currently, feedback for surgical residents regarding the amount of force applied is provided in the operating room either via subjective assessment by their faculty stating that there was too much tension exerted on the tissue or objectively through visual feedback from a bleeding vessel, tearing of tissue, or breakage of the suture.

Though learning technical surgical skills has traditionally been in the operating room, a myriad of factors have increased challenges to training and have resulted in fewer learning opportunities for the surgical resident. Such challenges include increasing regulations limiting resident duty hours, a range of newer surgical techniques, and increased concerns regarding patient safety.[2-6] Furthermore, although structured feedback is essential for the advancement of surgical skills, others have found that there is a discrepancy in the perception of giving and receiving feedback from faculty members to surgical residents.[6,7] Feedback given to surgical residents tends to be infrequent and without a standardized format.[6,7]

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TABLE. Five Experimental Groups with Timing and Type of Feedback Groups

Groups	Timing of Feedback	Type of Feedback
Control	No feedback	
Immediate auditory	Immediate	Auditory (verbal + buzzer)
Delayed auditory	Delayed (After 5 trials)	Auditory (verbal)
Immediate visual	Immediate	Visual (graph + leak)
Delayed visual	Delayed (after 5 trials)	Visual (graph)

Formative feedback to the learner is paramount to the successful acquisition of skills. It has been defined as "an assessment which is used for improvement (individual or program) rather than for making final decisions or accountability. The role of formative assessment is to provide information which can be used to make immediate modifications in teaching and learning."[8,9] Summative feedback, on the other hand, has been defined as "assessments at the conclusion of a course or program … generally used for accountability purposes or to judge the value or worth of a program or course and are usually collected at or near the end of a program or course."[8,9] Therefore, formative feedback occurs during the process of learning, providing opportunity for immediate improvement and modification of the skill while summative feedback occurs at the end of the learning experience, which is useful for improvement on subsequent trials.[8,9]

Using simulation curricula has been suggested to mitigate some of the challenges to training and enhance surgical training. It has been repeatedly shown to be an effective tool to improve operative skills of residents.[10-12] Specifically, force feedback simulation models have been shown to be useful for enhancing tissue handling skills.[2,13,14] Some studies have suggested that training with real-time visual feedback of instrument motion in virtual-reality and augmented-reality simulators have a positive effect on learning.[1,2] There are multiple studies regarding skills transfer to the operating room after implementation and practice of surgical simulation curricula.[6,15-17] Participants who achieve surgical skills proficiency-based benchmarks perform better on assessments and have fewer errors in the operating room than those who do not receive simulation training.[6,15-17] Proficiency goals generally include time to complete the exercise and errors committed. Under the proficiency-based training paradigm, a trainee will practice this exercise repeatedly until he/she can meet the proficiency goal. At this point, the trainee is considered proficient (i.e., equal to an expert's performance on the specific exercise).[18]

A few studies have examined skills improvement using simulation-based force feedback models using different types of feedback. Hsu et al.[2,14] built a model that measures force while knot-tying. Their study provided immediate visual feedback and found that participants exerted significantly less force after training on their model.[2,14] Cutler et al.[19] conducted a study on a peeling exercise simulating retinal surgery and found that adding auditory feedback resulted in less force, improved performance and greater precision. The gaps in these studies are that they do not compare proficiency training using both immediate versus delayed and type of feedback using auditory versus visual.

The aim of our study was to examine the effect of timing and type of feedback on the performance of surgical knot-tying in novice medical students using visual versus auditory and immediate versus delayed feedback. Our hypotheses included (1) participants who received any feedback regardless of timing or type of feedback would perform better than those who received no feedback, (2) participants who received immediate feedback would perform better than those who received delayed feedback, and (3) participants who received auditory feedback would perform better for surgical skills acquisition compared to those who received visual feedback regardless of timing of feedback (Table).

MATERIALS AND METHODS

After obtaining Institutional Review Board approval, a randomized trial was conducted at the University of Texas Health Science Center at San Antonio (San Antonio, TX) from September 2016 to March 2017.

We recruited 69 first- and second-year medical students via e-mail. Participants were asked to complete a demographic questionnaire that included age, gender, years of medical school, their interest in pursuing surgery as a specialty and whether they had completed a surgical clerkship before participating in this study. No identifying information was collected.

To ensure that participants knew how to tie a secure surgical knot, they were required to complete a surgical knot-tying curriculum and train to established expert level proficiency metrics.[20] Trials were conducted on a knot-tying model that simulated a bleeding vessel as measured by the amount of pulling and pushing forces that were applied to the vessel (in Newtons) and leak occurrence (Fig. 1).

In the surgical knot-tying task, study participants tied knots (4 throws and 2-handed) using 3-0 silk suture on a force feedback model mounted approximately 4 in deep.[2] The surgical task used the model developed by Hsu et al.[2,14] and contained an 8 in segment of Silastic tubing (0.025 in I.D. 0.047 O.D., Dow Corning, Midland, MI) connected to a sensor that measured the amount of force in Newton meters being exerted on the tubing in 2 dimensions—