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Observational Learning During Simulation-Based Training in Arthroscopy: Is It Useful to Novices? ☆

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OBJECTIVE: Observing experts constitutes an important and common learning experience for surgical residents before operating under direct guidance. However, studies suggest that exclusively observing experts may induce suboptimal motor learning, and watching errors from non-experts performing simple motor tasks may generate better performance. We investigated whether observational learning is transferrable to arthroscopy learning using virtual reality (VR) simulation.

SETTING/DESIGN: In our surgical simulation laboratory, we compared students learning basic skills on a VR arthroscopy simulator after watching an expert video demonstration of VR arthroscopy tasks or a non-expert video demonstration of the same tasks to a Control group without video demonstration. Ninety students in 3 observing groups (expert, non-expert, and Control) subsequently completed the same procedure on a VR arthroscopy simulator. We hypothesized the non-expert-watching group would outperform the expert-watching group, and both groups to outperform the Control group. We examined performance pretest, posttest, and 1 week later.

PARTICIPANTS: Participants were recruited from the final year of medical school and the very early first year of surgical residency training programs (orthopaedic surgery, urology, plastic surgery, and general surgery) at Western University (Ontario, Canada).

RESULTS: All participants improved their overall performance from pretest to retention ($p < 0.001$). At initial retention testing, non-expert-watching group outperformed the other groups in camera path length $p < 0.05$ and time to completion, $p < 0.05$, and both the expert/non-expert groups surpassed the Control group in camera path length ($p < 0.05$).

CONCLUSION: We suggest that error-observation may contribute to skills improvement in the non-expert-watching group. Allowing novices to observe techniques/errors of other novices may assist internalization of specific movements/skills required for effective motor performances. This study highlights the potential effect of observational learning on surgical skills acquisition and offers preliminary evidence for peer-based practice (combined non-experts and experts) as a complementary surgical motor skills training strategy. (J Surg Ed ▮:▮▮▮-▮▮▮. © 2017 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY INDEXING TERMS: Observational learning, Motor learning, Surgical simulation, Arthroscopy, Orthopaedic surgery, Error observation

COMPETENCIES: Patient Care, Practice-Based Learning and Improvement

INTRODUCTION

Surgical skills training has a direct and significant effect on patients' well-being and quality of care,[1,2] as surgical

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outcomes directly relate to a surgeon's skills.[3,4] Adequate training results in improved efficiency,[4,5] improved quality of surgery,[6] superior outcomes,[1,4,7] efficient use of healthcare resources,[7] decreased complications,[1,4,7-9] and reduced costs.[1,10]

Arthroscopy is a complex skill that can be challenging for trainees to learn efficiently in a busy teaching centre. Successful arthroscopists require excellent hand-eye coordination,[11-13] 3-dimensional visualization,[12-14] knowledge of anatomy and pathophysiology, knowledge of different procedures, good surgical judgment and experience.[13] In contrast to laparoscopy, successful acquisition of arthroscopy skills presents challenges due to the constrained and variable surgical fields relative to the different joints, each with slightly differing morphologies and limited space available for maneuvering. In addition, the various patient positions that are used during arthroscopy can alter the learner's frames of reference.[15,16] Because of this complexity, effective arthroscopic training is critical, as the learning curve is steep, the visuospatial demands for arthroscopy are high and trainees require many hours of practice and mentors' feedback to gain basic competence.[17,18]

Traditional surgical education practices, which continue to rely on the traditional apprenticeship model of instruction and the modus operandi: "See one, Do one, Teach one," are being scrutinized.[19-21] Changes in work hours, increased subspecialization and increased concerns about patient safety have motivated surgical educators to explore alternative educational strategies.[22]

Recently, Wulf et al.[23] identified that observational practice, external focus of attention, feedback and self-controlled practice were, together, effective methods for enhancing motor skill learning in medical education. Learning through observation has been a growing area of interest in neuroscience and motor control literature.[24] Several studies have demonstrated that individuals may learn a variety of simple visuomotor skills by watching the skills being executed by another individual.[25,26] Moreover, the processes that underlie this learning appear to be automatic, persistent and unaffected by distraction.[25] Recent unexpected evidence has shown that learning basic motor skills is enhanced by the observation of errors, rather than the observation of a flawless performance.[27] Brown et al.[28] demonstrated that observing trials which contained high degrees of error facilitated more rapid learning of a pointing task than observing trials which contained minimal error. Similarly, Buckingham et al.[27] demonstrated that individuals learn to apply the correct gripping and lifting forces to objects which have an unexpected weight after observing lifting errors, whereas they did not benefit from observing error-free lifts. The goal of the current study was to test these laboratory-based findings of error-based observational learning by introducing peer observation in the sensorimotor tasks of basic arthroscopic training.

Surgical learning needs innovative techniques to meet the modern challenges of skill acquisition. Learning by observation of error-laden performances done by other novices is a novel idea that contradicts the commonly held belief that motor skills are best learned by observing and imitating experts.[28,29] The purpose of this study was to examine the learning of surgical skills by measuring and comparing basic arthroscopic skills performance on a VR surgical simulator by students who observed either an expert or non-expert demonstrating the task (expert-watching or non-expert-watching), versus a control group who received no such intervention. We hypothesized enhanced learning and superior performance metrics of simulated knee arthroscopy following the observation of non-expert (high error) performance in comparison to the control group (no observation) or the observation of expert (low error) performance.

MATERIALS AND METHODS

Participants

Eligible participants were recruited from the final year of medical school and the very early first year of surgical residency training programs (orthopaedic surgery, urology, plastic surgery, and general surgery) at Western University (Ontario, Canada). All subjects were between the ages of 18 to 40, spoke English fluently and were screened to ensure that they had no prior experience with arthroscopic surgery, endoscopic surgery, or any form of surgical VR simulation. Most participants had baseline understanding of arthroscopic surgery, but had not seen or used the arthroscopic instruments or an arthroscopy simulator. The sample size was estimated from previously published study, which examined the effect of active observation on the learning of a simple motor task.[27] After informed consent, research assistants randomly assigned subjects to either the expert-watching, or non-expert-watching groups by coin toss. A Control group was added later to account for the effect of practice alone without observational learning.

The study included 2 testing sessions (discussed in sections later). Session 1 included a pretest (Test 1), intervention/rest and posttest (Test 2). Session 2 occurred 1 week later and included a retention test (Tests 3-5). The retention test was performed three times to evaluate the maintenance and recovery of skills after a resting period.

Simulator and Videos

The *insight* ARTHRO-VR (GMV, Spain, now called ArthroMENTOR, Symbionix, Ohio) is a validated VR arthroscopy simulator that was used in the creation of the non-expert and expert instructional videos ("Novice" and "Expert" videos) and for data collection during this study.[30-32] This simulator uses phantoms of a leg and a shoulder as well as a set of instruments (camera, probe, shaver, and grasper)