

Efficacy of Virtual Reality in Orthopaedic Surgery Education: A Study on Femoral Neck Fracture Fixation

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INTRODUCTION: Orthopaedic surgery residency requires continuous learning of new materials and procedural skills. Traditionally, residents learn through reading technique guides and watching procedural videos followed by supervised application in the operating room. However, instructional videos often lack crucial details. Simulation labs and newer technologies like mobile apps, virtual reality (VR), and artificial intelligence have been introduced to address training gaps and enhance surgical competency. Despite these advancements, many residents still feel unprepared to practice independently. In this study, we sought to understand how a trainees' performance and short-term retention of a common orthopaedic procedure can be improved through VR training.

METHODS: First- and second-year medical students without prior exposure to femoral neck fracture fixation were recruited. Participants were randomly assigned to the technique guide group (n = 18), which acted as the control, or the virtual reality group (n = 17). The technique guide group studied a commercially available technique guide during three separate, one-hour training sessions. A commercially available VR headset was loaded with a procedural simulation for femoral neck fracture fixation. Participants in the virtual reality group completed 3-4 separate one-hour training sessions, spaced 2-3 days apart. After completing at least 3 training sessions, all participants attempted to perform percutaneous pinning of a femoral neck fracture on a SawBones model with synthetic tissue covering. A procedure was considered complete if each of the procedural steps were completed in the correct order. Procedural accuracy was defined as the number of incorrect steps normalized out of the 16 possible performed. After the procedure, a single orthopaedic surgeon assessed blinded videos of each participant performing the procedure, assigning each an Objective Structured Assessments of Technical Skills (OSATS) score. Student t-tests were used to compare mean OSATS scores, number of incorrect steps, and time for procedural completion between the two groups.

RESULTS: A total of 14 participants in the VR group and 6 in the technique guide group were included in the final analysis. Participants in the technique guide group had significantly higher mean Time and Motion ($p < 0.001$) and Total OSATS scores ($p = 0.033$) compared to those in the VR group (Table 1). No significant differences were found among the other OSATS subcategories. Similarly, no significant differences were observed between the two groups in the percentage of correct steps performed, number of normalized incorrect steps or hints, or procedural completion time (Table 2). However, participants in the VR group had a higher percentage of correct steps and a lower number of normalized incorrect steps compared to those in the technique guide group.

DISCUSSION AND CONCLUSION: Standard technique guide training for percutaneous pinning of a femoral neck fracture was associated with significantly improved OSATS scores compared to virtual reality training. However, virtual reality training was associated with a reduction in procedural errors compared with training using a technique guide. Our preliminary findings suggest that virtual reality alone provides comparable results to traditional learning methods in isolation. As an adjunct to established learning tools, virtual reality may enhance trainee's retention of the procedural workflow as well as help them gain familiarity with specific movements required to perform certain procedures. Further research utilizing larger sample sizes and evaluating VR-based simulations of other orthopaedic procedures are required before widespread application. Finally, future studies should evaluate the utility of virtual reality training at different levels of surgical education and residency training.

Table 1. Comparison of OSATS scores between VR and Technique Guide groups.

| OSATS | VR (N = 14) ^a | Technique Guide (N = 6) ^a | p-value |
|---------------------|--------------------------|--------------------------------------|--------------|
| Time and Motion | 2.71 ± 0.41 | 3.83 ± 0.41 | <0.001 |
| Instrument Handling | 2.21 ± 0.89 | 3.00 ± 0.89 | 0.088 |
| Flow | 2.43 ± 1.09 | 3.33 ± 0.82 | 0.086 |
| Knowledge | 3.07 ± 1.44 | 3.83 ± 0.41 | 0.225 |
| Total | 10.43 ± 3.48 | 14.00 ± 2.19 | 0.033 |

mean ± standard deviation

Table 2. Comparison of procedural accuracy and time to completion for percutaneous pinning of a femoral neck fracture between VR and Technique Guide groups.

| | VR (N = 14) ^a | Technique Guide (N = 6) ^a | p-value |
|--|--------------------------|--------------------------------------|---------|
| Percentage of Correct Steps | 80.36 ± 13.17 | 66.79 ± 21.80 | 0.308 |
| Number of Incorrect Steps ^b | 0.16 ± 0.20 | 0.49 ± 0.54 | 0.055 |
| Number of Hints ^b | 0.089 ± 0.072 | 0.054 ± 0.048 | 0.293 |
| Procedure Completion Time (minutes) | 17.69 ± 5.25 | 16.18 ± 6.52 | 0.545 |

^anormalized to account for total number of steps and number of hints

^bmean ± standard deviation