Haptic Feedback during Virtual Reality Training Significantly Improves First-Year Orthopaedic Resident Performance of Drilling the Tibia

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INTRODUCTION:
Virtual reality (VR) simulation has received growing attention as a method for teaching orthopaedic surgery residents the fundamentals of common orthopaedic procedures. Incorporation of immersive features, such as haptic feedback, into the platform may assist in the learning of motor tasks without risk to patients. This study aimed to determine whether new orthopaedic surgery residents trained on VR with haptic feedback performed basic drilling better than residents who had practiced drilling on VR without haptic feedback.

METHODS:
Fourteen first-year orthopaedic surgery residents were enrolled during their first month of residency, prior to any clinical rotations. Each resident was randomized into "haptic" or "non-haptic" groups, and blinded to study goals and randomization. Residents participated in a VR tibia drilling simulation with haptic feedback either turned on or off (Figure 1). The VR simulation consisted of a brief orientation to the VR environment followed by 5 VR trials of drilling a tibia. Each resident then proceeded to a sawbones tibia drilling session (Figure 2) where total drilling distance and the drilled depth of the sawbones tibia were recorded across multiple trials. Total drilling distance was measured by 2 independent raters with the help of a plastic marker on the drill bit. "Overdrill" depth was calculated by subtracting the depth of the drilled tibia from the total drilling distance (Figure 3). All measurements were performed by raters blinded to study groups. Questionnaires were completed before and after the hands-on sessions with responses on a five-point scale. Statistics were performed; p<0.05 was considered statistically significant.

RESULTS:
There were no significant differences in demographics between groups including age (mean, 26.9 years), sex, prior operative experience, or prior VR experience based on pretesting questionnaires. Overdrill depth (Table 1) during the first sawbones trial was less in the haptic group than the non-haptic group (3.9 mm vs. 7.6 mm, p<0.01). Subsequent trials demonstrated no difference in mean overdrill depth between groups. Mean overdrill depth across all sawbones trials was less in the haptic group (3.9 mm vs. 5.5 mm, p=0.04). (Table 2). Overdrill depth was less in the haptic group than the non-haptic group only during the third VR trial (7.6 vs. 21.0 mm). Haptic group participants had significantly higher responses on questionnaires following the hands-on sessions, reporting more confidence in safe use of surgical tools (3.8 vs. 2.3, p<0.01), and higher likelihood to use simulation (4.3 vs. 2.8, p=0.04).

Figure 1: Study subject during a tibial drilling study

Figure 2: Study subject performing a tibia drilling procedure based on sawbones tibia. The opposite side of the tibia is covered so that the subject cannot see the drill exit on the other side, so they must rely primarily on tactile feedback to know that they have breached the second cortex. There is a plastic marker on the drill bit that slides back on the drill bit based on how far the subject drives the drill in.

Figure 3: A) The distance from the tip of the drill bit to the proximal aspect of the marker is used to quantify the total drilling distance. B) To determine the actual depth of the drilled tibia, a standard depth gauge is used to measure the distance between each cortex of the sawbones tibia. This account for any variation in the length of the drilled tibia. This account for any variation in the length of the drilled tibia. This value is subtracted from the total drilling distance to determine the “overall” depth, or the amount of over drilling that was performed.
DISCUSSION AND CONCLUSION:
With any learning tool, it is necessary to establish measurable quality parameters. In this study, we establish that initial tibial drilling performance is significantly improved with haptic vs. non-haptic VR training in first year orthopaedic residents. Based on posttesting questionnaires, the usefulness of VR simulation was rated significantly higher in the haptic group than the non-haptic group. The difference between each group’s mean overdill depth decreased after the first trial, demonstrating the learning value of VR training regardless of which VR simulation used. As the utilization of VR learning expands, application of VR with haptics to more complex and multi-step procedures has the potential to improve resident proficiency at surgical procedures.