Evaluating the use of Mixed Reality surgical navigation in screw removal

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Background: Surgical navigation is vital in many surgical procedures. Misplacement and poor navigation may lead to serious, potentially life-threatening complications. Therefore, techniques to optimize navigation remain an important aspect of surgical research. Screw removal procedures often present surgeons with intraoperative challenges due to difficulty visualizing screw trajectories and the use of cumbersome techniques. The current standard method relies on fluoroscopy-guided freehand trajectory visualization and manipulation. This technique can be time-consuming, radiation-intensive, prone to misalignment, and increase the risk of complications for the patient. Attempts at removing screws with improper trajectories can result in screw breakage, which complicate surgery as well as delay healing. This study aims to compare outcomes of using mixed reality (MR) for screw removal procedures in terms of time efficiency and surgeon usability compared to fluoroscopy-guided techniques, which serve as the control in this study.

Methods: Using the Brainlab™ Mixed Reality Reverse Trajectory application and the Magic Leap™ head-mounting device (HMD) as well as the current fluoroscopy-based system, 3 orthopedic surgeons removed 4 screws from a 3D-printed model of the proximal femur covered in silicone with pre-cut screw trajectories in each model. The time to remove each screw and X-ray requirements were measured for each surgeon using both the MR system and the current fluoroscopy-guided technique. Following the procedure, the NASA TLX survey was administered to each surgeon to compare the task load for each technique.

Results: Results showed shorter procedure times on average for all 3 surgeons. The average time to remove screws using fluoroscopy was 271 seconds (n=11) and the average time to remove screws using MR and navigation was 174 seconds (n=11). A paired t-test was run to calculate significance and yielded a p-value of 0.1027 (n=11, sd=195). The screw incision accuracy is still under investigation and being measured via post-op CT scans. The NASA TLX scores showed surgeon 1 experienced a 45.45% decrease in mental demand when using the MR compared to fluoroscopy and surgeon 2 experienced an 83.33% decrease in mental demand using MR. Surgeon 3 experienced the opposite, likely associated with the challenges associated with inaccurate calibration during the procedure, in which they experienced a 180% increase in mental demand when using the MR. Surgeons 1 and 2 experienced a 12.5% and 24.15% decrease in physical demand using the MR when compared to traditional fluoroscopy, whereas surgeon 3 experienced a 120% increase in physical demand using the MR. Surgeon 1 and 2 experienced an 8.3% and 50% decrease in temporal demand when using the MR compared to fluoroscopy and surgeon 3 experienced a 100% increase in temporal demand using the MR.

Conclusion: In conclusion, while surgeons 1 and 2 experienced a significant benefit in terms of efficacy and usability, surgeon 3 did not experience a benefit when using MR compared to fluoroscopy. Therefore, our overall data shows no significant difference between the two in terms of time of procedure and workload. This study serves as a foundational framework to test MR versus current techniques, and more research needs to be done to determine the benefit of the technology in the operating room and to patient safety.