Accuracy of the Microsoft HoloLens for neurosurgical burr hole placement

Emily Rae[1], Andras Lasso[1], Matthew Holden[1], Evelyn Morin[2], Ron Levy[3], Gabor Fichtinger[1,3]
[1]Laboratory for Percutaneous Surgery, School of Computing, Queen's University, Kingston, Canada
[2]Department of Electrical and Computer Engineering, Queen's University, Kingston, Canada
[3]Department of Surgery, Queen's University School of Medicine, Kingston, Canada

Introduction: Tracked navigation systems require large carts of equipment, are operated by specialized technicians, and are generally impractical in bedside neurosurgical procedures. For beside procedures such as a twist-drill crainiostomy for the removal of a subdural hematoma, navigation could optimize the placement of the twist drill in relation to the underlying fluid. Increased accuracy could improve surgical outcomes as incorrect placement of twist drill holes may result in complications such as injury to underlying brain tissue [1]. The Microsoft HoloLens is an optical see-through head-mounted display and is considered the best performing augmented reality technology currently available and the most suitable for clinical use [2]. We use the Microsoft HoloLens to display a hologram floating in the patient's head to mark a burr hole on the skull. We evaluate the feasibility of using the Microsoft HoloLens to mark a burr hole within a clinically acceptable range of 10 mm.

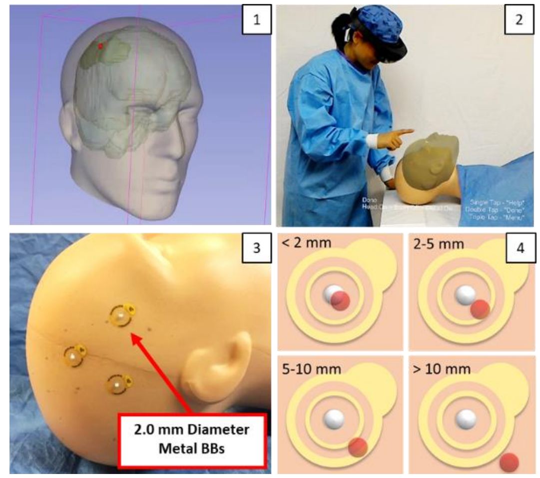

Figure 1: 3D model of the head, hematoma, and brain created from the CT scans (1), a view of the surgeon registering the model (2), the plastic phantom with 2.0mm diameter metal BBs (3), and the different ranges of accuracy using the marks on the base of each BB (4).

Methods: A 3D model of the head, hematoma and burr hole is created from CT images and imported to the HoloLens (Figure 1-1). The hologram is interactively registered to the patient and the burr hole is marked on the skull (Figure 1-2). 3D Slicer, Unity, and Visual Studio were used for software development. The system was tested by 6 inexperienced and 1 experienced users. They each performed 6 registrations on phantoms with fiducial markers placed at 3 plausible burr hole locations on each side of the head (Figure 1-3). Registration accuracy was determined by measuring the distance between the holographic and physical markers (Figure 1-4).

Results: Inexperienced users placed 98% of the markers within the clinically acceptable range of 10 mm (Table 1) in an average time of 4:46 min (range 2:18 – 9:39 min). The experienced user placed 100% of the markers within the clinically acceptable range (Table 1) in an average time of 2:52 min (range 2:15 – 3:39 min).

Table 1: Percentage of marker placements within each range and the total percentage of markers within a clinically acceptable range as performed by both inexperienced and experienced users.

User's Level of Experience	< 2 mm	2-5 mm	5-10 mm	> 10 mm	Within Acceptable Range (< 10 mm)
Low	35%	24%	39%	2%	98%
High	50%	0%	50%	0%	100%

Conclusion: It is feasible to mark a neurosurgical burr hole location with clinically acceptable accuracy using the Microsoft HoloLens, within an acceptable length of time. This technology may also prove useful for procedures that require higher accuracy of location and drain trajectory such as the placement of external ventricular drains.

References:

[1] Horn et al., "Bedside twist drill craniostomy for chronic subdural hematoma: a comparative study," *Surgical Neurology*. 2006 Feb; 65(2):150-3; discussion 153-4.

[2] Qian et al., "Comparison of optical see-through head-mounted displays for surgical interventions with object-anchored 2D-display," *International Journal of Computer Assisted Radiology and Surgery*. 2017 Jun;12(6):901-910