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Original Article

Assessment of Google Glass as an adjunct in neurological surgery

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Abstract

Background: We assess Google Glass ("Glass") in improving postoperative review ("debriefing") and augmenting education in Neurological Surgery at a tertiary academic medical center.

Methods: This was a prospective study. Participants were patients of Neurological Surgery physicians at a Tertiary Care Level 1 Academic Trauma Center. Resident physicians received a pre-questionnaire immediately following surgery. Next, the resident and attending physicians debriefed by reviewing the Glass operative recording. Then, residents completed a 4-part post-questionnaire. Questions 1–3 assessed: (1) the residents' comfort level with the procedure, (2) the quality of education provided by their superiors, and (3) their comfort level in repeating the operation. Question 4 assessed: (4) the perceived benefit of debriefing using Glass.

Results: Twelve surveys were collected. Scores were based on a 5-point Likert scale, with a higher score corresponding to a more positive response. For Questions 1–3, the average pre- and post-questionnaire scores were 3.75 and 4.42, respectively ($P < .05$). For Question 4, the average post-questionnaire score was 4.63, suggesting that postoperative Glass review improved their technical understanding of the procedure.

Conclusions: Glass significantly improved neurosurgery residents' comfort level and quality of training, and provided a high fidelity, reliable, and modifiable tool that enhanced residents' understanding, expertise, and educational experience. Of note, certain limitations such as variable battery life, variable image quality, and subpar compatibility with surgeon loupes must still be overcome for Glass to become a realistic addition to neurosurgical education.

Key Words: Education, Glass, interactive, neurosurgery, resident, video

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INTRODUCTION

Cameras were first employed in medicine in 1840 when Alfred Donne obtained pictures of bones, red blood cells, and teeth using a primitive microscope.[20] In 1959, Karl Storz and Harold Hopkins popularized the use of cameras in Otolaryngology by inventing a new generation of endoscopes.[13] These endoscopes simplified the process of filming surgical operations in 16 mm. At this time, recordings began to be shared among colleagues to improve standard of care and provide more direct academic instruction.

With significant advancements in technology, reductions in size have enabled the feasibility of using wearable technology in the operating room (OR).[1,3] Wearable technology, defined as an electronic device which is worn on one's body, holds immense potential for impacting the practice of and education within medicine. One particular wearable device, Google Glass (Google, Inc., Mountain View, CA), is worn similar to conventional eyeglasses and is capable of taking high-resolution photos (5 MP) and video (720 p) from the perspective of the wearer.[19] Glass costs $1500 and utilizes the following features: A computerized central processing unit, touch pad, display screen, high definition camera, microphone, bone conduction transducer, and wireless connectivity.[15] In medicine, Glass can provide an interface for Internet access, interdisciplinary communication, and hands-free utilization of clinical applications with the use of voice commands.[14]

In the past, Glass has been incorporated in surgical and nonsurgical fields including plastic surgery, cardiology, pediatric surgery, and otolaryngology.[7,11,9] Glass has shown the most promise in dermatology, a field that often requires remote consultations with external providers.[5,12] In medical education, Glass has also been effective in teaching anatomy.[4] Nevertheless, no studies have been conducted to assess Glass as a quality improvement tool and educational resource in neurosurgery. We sought to evaluate Glass in an American College of Surgeons Certified Level 1 Academic Trauma Center over a period of 3 months, in comparison to a head-mounted GoPro camera.

First, we aimed to identify neurosurgeons' levels of comfort using Glass. The technological specifications and method of use bear a moderate learning curve. In addition, some authors have described its physical incompatibility with the surgical loupes required for operation [Figure 1].[16]

Second, we aimed to assess the utility of Glass for postsurgical review of point-of-view (POV) recordings. At present, the microscale anatomy and time urgency of neurosurgical operations often makes it difficult to optimally educate residents. Glass may improve the attending physicians' ability to more effectively train residents by recording the procedures for subsequent review and discussion.

Figure 1: Use of Glass (left) and head-mounted GoPro (right) with a surgical loupe/headlamp

Third, we sought to identify the overall impact of Glass on residents' medical training and technical understanding of procedures. In addition to postoperative surgical review, a resident wearing Glass can live stream the surgical field from their POV to their superiors, who may fix errors and provide real-time modifications, live or remotely. Further, we used Glass as a cost-effective method to create educational vignettes, which are then posted remotely online for educational purposes.

Finally, we wished to demonstrate the benefit of Glass in optimizing interdisciplinary dynamics and communication in the OR. Glass-mediated communication eliminates background noise, provides unique vantage points, and on-screen remote guidance by team members not directly involved in the surgery.

MATERIALS AND METHODS

This prospective cross-sectional study was performed with IRB approval. Prior to the first operation, resident physicians received a tutorial on how to use Glass. Residents were asked to wear Glass during the surgery. Resident physicians received a pre-questionnaire immediately following the surgery. Next, resident and attending physicians debriefed by reviewing the Glass operative recording. Then, residents completed a post-questionnaire consisting of identical questions. Questions 1–3 assessed: (1) The residents' comfort level with the procedure; (2) the quality of education provided by their superiors; and (3) their comfort level in repeating the operation. Question 4 assessed: (4) The perceived benefit of debriefing using Glass.

Technological specifications of Glass

Glass connects to a phone via Bluetooth or wireless network, enabling hands-free Internet access. Using a 720 p high definition camera and microphone, Glass records video and audio with voice commands.[17] A bone-conduction speaker conveys audio to the user. The quality of its high-resolution display is equivalent to that of a 25-inch high definition screen viewed from a distance of 8 feet. Glass is equipped with 12 GB of usable memory, data which is continually synced to cloud storage. Finally, Glass contains a small, lithium-ion battery with capacity for a full day of typical use. Here, it is important to note that surgical use of Glass is not by any means "typical;" continuous high-definition video recording is particularly draining on battery life. The video feed can also be live-streamed to OR monitors or any internet-connected device via Pristine (Austin, TX) software, further exhausting battery life.

RESULTS

Twenty-five procedures were completed on twenty-five unique patients [Table 1]. Thirteen different clinicians used Glass. The procedures recorded included: Tumor resection, chronic subdural hematoma (cSDH) evacuation, ventriculostomy, vertebral fixation, spinal cord tumor resection, brain biopsy, ventriculoperitoneal shunt placement, and intracerebral hemorrhage (ICH) evacuation using the minimally invasive BrainPath[6,8] technique. Residents using Glass (n = 12) completed a pre- and post-questionnaire. Questions 1–3, which addressed comfort, utility, and the desire to continue using Glass, showed statistically significant improvements in response score (averaged pre- and post-survey scores of 3.75 and 4.42, respectively; $P < .05$). The post-questionnaires consisted of an additional question assessing residents' confidence that Glass debriefing augmented their technical understanding and procedural training. For Question 4, the average post-survey score was 4.63, indicating that residents believed postoperative Glass review substantially increased technical understanding of the surgery they had performed.

In our study, GoPro technology ("GoPro") was implemented to better illustrate Glass's technical deficiencies and overall feasibility in the OR. The GoPro is a high-definition, waterproof, and shockproof video recording device. It has gained popularity in extreme sports as well as clinical procedures due to its compact size, rugged durability, and impressive video quality. Here, GoPro was shown to have superior image quality, greater range of motion, improved battery life, and more straightforward physical compatibility with surgical loupes [Figure 1], as compared to Glass. However, GoPro was unable to mediate real-time dialogue as effectively as Glass since it does not have the capability of live-streaming the video feed. In addition, remote observation was limited to the screen of a smartphone instead of a larger laptop screen available with the application Pristine™ in conjunction with Glass. Medical students, residents, and attending physicians had the opportunity to wear each device during a scheduled operation.

Table 1: Cases completed using Glass

Cases Completed using Glass	Number
Chronic subdural hematoma (cSDH) Resection	6
Intracerebral Hemorrhage (ICH) Evacuation using the BrainPath Techinque	5
Metastatic Tumor Resection	3
Ventriculostomy	3
Glioblastoma Multiforme (GBM) Resection	2
Ventriculoperitoneal Shunt Placement	2
Vertebral Fixation	1
Spinal Cord Tumor Resection	1
Oligodendroglioma	1
Brain Biopsy using Robotic Arm (ROSA)	1
Total	25

DISCUSSION

Benefits – education, interdisciplinary communication, and surgical review

Glass has a variety of beneficial uses within the realms of medical education, interdisciplinary hospital communication, and local as well as remote surgical review. In regard to medical education, the training of residents is often difficult due to the complexities, microsurgical anatomy and time-pressures of the operating room. This is particularly the case within the field of neurosurgery. As a result, techniques in simulation and virtual reality have substantially improved the quality of this education.[2,18] Nevertheless, no study has investigated the educational benefit of Glass in neurosurgery. Glass gives residents the opportunity to review their own actions after the surgery with the attending who may provide critiques. Our data suggests that residents felt that the implementation of Glass in their surgical training improved their confidence, understanding, and surgical comfort. Furthermore, they felt that postoperative surgical debriefing substantially benefited their technical understanding of the procedure. Thus, Glass may reduce the number of cases required for a resident to master a particular procedure, as well as the incidence of human error.

Glass was found to improve multidisciplinary communication and team dynamics in numerous ways. First, by using the live-streaming capabilities, it is possible to project the surgeon's view onto a laptop or the operating room monitors to allow other members of the team (circulating nurses, anesthesiologists) to follow the course of the surgery. The attending neurosurgeon was also able to view and critique the procedure at a distance without the impression of intruding on the residents' space. Second, Glass aided in staff communication within the OR. During a brain biopsy procedure, using the

ROSA (Montpellier, France) robotic arm,[10,21] the surgeon used Glass to communicate with the circulating nurse. In this situation, the nurse was viewing the operating field from the perspective of the surgeon, enabling her to adequately respond. In this manner, the surgeon was able to convey his need for a different instrument not available in the equipment set. He did so by simply placing the instrument he required in his field of vision, recording the view with Glass. Moreover, the use of Glass's speakers greatly diminished the background noise inherent to the OR. Dialog conveyed through the Glass technology was perceived as much clearer by both the speaker and receiver of the message. Glass reduced the miscommunication and ambiguity of requests that often occur between members of a busy, congested and stressful OR. Furthermore, Glass recorded team dynamics and the same procedure from different perspectives [Figure 2]. This provided a mechanism to retrospectively assess how members of the surgical team communicate and interact, while identifying areas for improvement.

Finally, in addition to enabling opportunities for resident education within the hospital, Glass can also provide a platform for remote learning. Glass can allow surgeons worldwide to create a database of educational surgical vignettes. These vignettes can be posted for public educational purposes. Viewers may watch first-hand surgical POV recordings to gain further experience observing surgeries and refining techniques. These recordings are particularly easy to edit, allowing the condensation of a long, often tedious, surgery into a one or two minute video ideal for remote learning and education.

Limitations of Glass – battery life, physical convenience, sterility, and image quality

While it has many functional features and capabilities, Glass has limitations that become particularly relevant in neurosurgery. First, due to the small structures of cranial cavity, and lack of color contrast, it is difficult to visualize the full depth of anatomy on film. Second, the bright lights of the OR in conjunction with Glass's camera sometimes cause over-exposure of the images making the videos difficult to view. For instance, recording of a cSDH evacuation did show the structures of the galea, cranium, and dura, but could not adequately distinguish subdural membrane from the underlying dura and arachnoid layers [Figure 3]. Decreasing light intensity solved this problem at the expense of the surgeon's ability to see. Nevertheless, in a ventriculoperitoneal shunt, the surgeon's initial incision to expose the skull was clearly visualized on video [Figure 4]. Glass was particularly effective in capturing overall panoramic views of the operative set up. The initial planning and approach for procedures was easily recorded and served as a valuable educational tool to minimize preparation time [Figure 5]. Second, a substantial limitation of Glass is its battery life. Longer procedures were not able to fully utilize this device without employing an auxiliary battery pack, which have to be attached to the device at all times. Third, Glass's live stream feature was occasionally fragmented, choppy and of poor resolution. Fourth, many procedures in neurological surgery require the use of a microscope and necessitate the removal of the Glass device by non-sterile hands. This was disruptive to operative flow. Fifth, Glass had to be secured on the surgeon's head with specialized straps to prevent the possibility of it falling off. The use of the surgical loupe while wearing Glass is difficult. Care must be taken prior to scrubbing in to ensure proper, functional and comfortable placement of both. Although the model of Glass used in this study has been discontinued, newer iterations of Glass that address its initial limitations (e.g., battery life, camera resolution, hands-free user interface), are currently being developed, in addition to an array of wearable technologies (e.g., Spectacles by Snap Inc.) in the pipeline. Finally, a limitation of the study itself may have been our small subject pool. We recommend further studies be conducted with greater samples of physicians.

Comparison with GoPro

Paro *et al*. also compared Glass with GoPro. They found GoPro to be superior in recording surgical footage. Due to GoPro's ability to pivot on its horizontal axis, users did not have to engage in cervical flexion to focus the picture on the middle of the screen. Graphics resolution was also superior to Glass, with the GoPro device capable of capturing anatomy in greater detail [Figure 6]. Glass records in 720 p with 5-MP still shots, while the GoPro records in 1080 p with 12-MP still shots. Physical

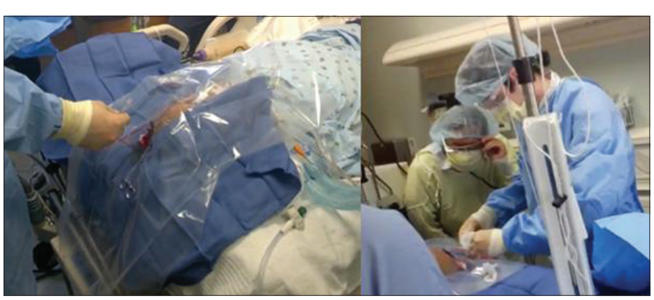

Figure 2: Bedside ventriculostomy with two views from two different Glass units

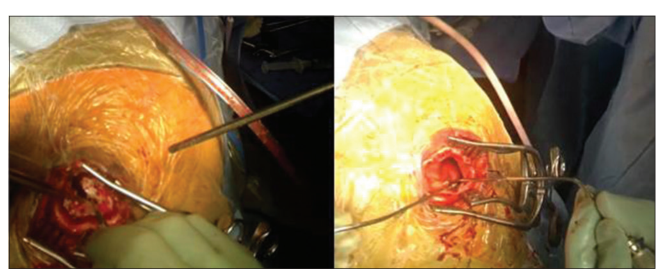

Figure 3: (Left) Opening of the dura mater in a cSDH evacuation. (Right) Craniotomy and visualization of the subdural space

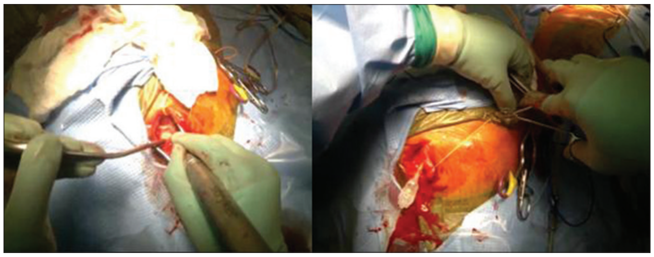

Figure 4: Ventriculoperitoneal shunt placement

Figure 5: Using probe to plan incision and approach

Figure 6: Image from the head-mounted GoPro

compatibility with surgical loupes was an issue with Glass, while not a problem with the GoPro. The latter device is worn as a headpiece instead of as eye wear (in the case of Glass), enabling surgeons to use loupes normally and simultaneously. However, the bulkiness of GoPro prevented long-term comfort, as the GoPro was five times heavier than Glass. Additionally, the GoPro did not allow the surgeon to wear a headlight as it occupied the space where a headlight would normally reside. Physicians found Glass more comfortable overall. Despite its various advantages, a notable limitation with GoPro is its requirement for a non-sterile team member to activate and end the recording. The physical size of the GoPro [see Figure 1] raises the concern of it or its components falling into the surgical field if not fastened securely.

The Glass recording can be activated by voice commands alone, limiting the user's need for non-sterile physical support. Finally, battery life was insufficient in both devices; Paro *et al*. found the GoPro to last 2 hours while the Glass only lasted 1 hour for continuous high-definition recording. Our experiences confirmed this finding. In summary, the GoPro provided superior image quality, lasted longer, could be worn with the loupes while operating, but required a non-sterile team member to activate and end all pictures or video.

CONCLUSION

Our study found Google Glass to have numerous benefits as an educational tool. We believe it can serve as a useful method to capture POV surgical footage for debriefing and creation of educational vignettes. Our survey, though subjective in nature, demonstrated significant improvement in resident medical education in Neurological Surgery at UCIMC, and residents felt more comfortable with their surgical skills following debriefing. Furthermore, despite its moderate learning curve, physicians felt comfortable using the device. In our experience, Glass also improved interdisciplinary communication within the OR, across the hospital, and with physicians in remote locations. Glass can also provide the opportunity to create a database of publically available educational surgical vignettes. Overall, we optimistically recommend further evaluation of Google Glass as an educational tool in neurosurgery; however, this statement rests upon the assumption that technical limitations are first addressed. These limitations include physical compatibility with loupes and headlights common in certain subspecialties, limited battery life, issues with sterility, and inferior image quality when compared to similar mobile technology.

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Conflicts of interest
There are no conflicts of interest.

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