5 Points on
Using Wearable Technology to Record Surgical Videos

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Safe and efficient advanced surgical skill training is of tremendous importance. With the recent increase in Internet use for medical education, there has been a concomitant increase in video recording of surgical procedures and techniques. Surgical recordings have been used in a variety of ways—as live webcasts for remote participants, as "coaching" opportunities for surgeons evaluating their own performance in the operating room, and even as informational resources for patients about to undergo the same surgery.

Surgical multimedia is being delivered through several different outlets. Many academic conferences and meetings showcase videos of different procedures, and several subspecialty societies (eg, Arthroscopy Association of North America) house archives of technical videos for viewing by members. In addition, the VuMedi website offers videos and allows members to comment on them and interact with the videographers. Surgeons are even posting technique videos on YouTube and other public websites.

A large proportion of surgical multimedia is recorded with conventional high-definition video cameras.[1] Besides being able to experience a case at any time and from outside the operating room, the audience can watch from numerous vantage points, angles, and zoom levels. Also, surgeons' narration can be valuable in helping the audience follow along with the case.

Recording surgical multimedia historically required tight coordination and precise planning by surgeon and videographer. However, innovations in wearable technology now allow surgeons to literally wear video cameras and record procedures as they perform them, in real time—to act as both surgeon and videographer.

Two such products are Google Glass (Google, Mountain View, California) and GoPro Hero (GoPro, San Mateo, California), both of which allow surgeons to record exactly what they see during procedures (**Figure 1**). Using a wearable technology for surgical multimedia creation requires a deep familiarity




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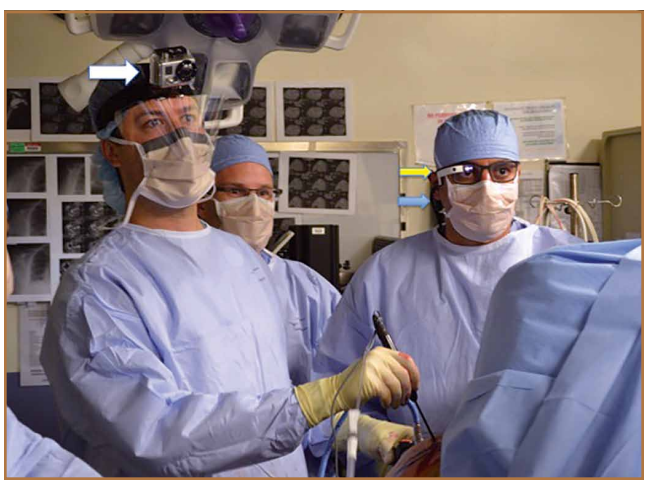
Figure 1. Wearable video-capture technology in operating room. Google Glass (yellow arrow, as worn by author ECM) can be worn with optional frame/lens from manufacturer. Recommendation is to record with unit plugged into external USB battery pack placed in surgeon's back pocket. Unit can be connected by USB wire (blue arrow) supplied by manufacturer. GoPro Hero 2 (white arrow, as worn by author CMJ) must be secured with head straps to surgeon.



with its capabilities and limitations. In this article, we summarize these products' similarities and differences and provide a technical overview for using wearable technologies in surgical multimedia creation.

1 Choosing a device

When purchasing either wearable device, several factors must be considered, including budget, possible uses outside the operating room, and possible limitations of the technology (**Table 1**). At this time, Google Glass is significantly more expensive than GoPro Hero. The Google Glass base unit costs $1500, and the GoPro Hero 3 model costs approximately $200 (higher-priced Hero models are available). Both devices require accessories (eg, portable battery unit, dedicated hard drive).

Device capabilities must also be considered (**Table 2**). Google Glass consists of both hardware and software. Users can record what is seen and heard through the lens and then use apps to create text and e-mail portals to online gaming, social media, and even golf-course GPS. The app market for Google Glass is nascent but undoubtedly will increase in volume and scope as more users adopt the technology (Google Glass comes with both Bluetooth and Wi-Fi and can function tethered through a smartphone). GoPro is mainly a hardware unit that can record in various settings (it is popular with athletes who want to capture and broadcast their participation in action sports). Newer GoPro Hero versions offer Wi-Fi, which allows streaming of video content to a smartphone or tablet through an app. Having clearly defined goals for a device—as they pertain to use outside the operating room, such as outdoor activities and underwater recording—may help the surgeon decide which product is more suitable. Last, it is important to consider limitations. Google Glass resolution is 720p (1280×720) for video and 5 MP for still images, and GoPro resolution can reach 1080p (1920×1080) for video and 5 MP for stills.

Both devices require purchase of accessories. An external USB battery pack is useful for both devices, as is a password-encrypted hard drive for media storage. Lenswear does not come with the base version of Google Glass and is purchased separately from the company. GoPro users buy micro SD cards (~$50 per 64-GB high-speed transfer card) for storage on the device and may buy lithium-ion batteries as an alternative to the external USB battery pack.

Table 1. Comparison of Technical Specifications of Wearable Video-Capture Technology

Category	Google Glass	GoPro Hero 3
Starting price	$1500	$199-$399
Video resolution	720p	1080p
Still image	5 MP	5-12 MP
Internal storage	12 GB	N/A
Battery life	1-1.5 h	1-1.5 h
Webcast ability	Yes	No
Removable memory	No	Yes
File transfer	Portable HD via USB iPhoto	Portable HD via mini USB, microSD card slot

Abbreviation: HD, hard drive

Table 2. Comparison of Features of Wearable Video-Capture Technology

Category	Google Glass	GoPro Hero 3
Price		✔
Resolution		✔
Ease of use	✔	✔
Ease of file transfer		✔
Ergonomics	✔	
Durability		✔
Technical support	✔	
External uses	✔	

Author Update

In January 2015, Google announced that it was temporarily suspending its "Explorer" program, which allowed individual users to buy and test the device for personal use. However, Google is continuing its development of Glass with health care technology, among other areas of growth and development.[2,3]

2 Recording a successful surgical video

Unlike a camcorder, which typically is set on a tripod for conventional video recording of surgery, Google Glass and GoPro are intricately linked to the operator. Surgeons must be constantly aware of where they are during surgery and try not to let anything obstruct the camera's view.

Before starting a case, the surgeon using either device must ensure that its battery is fully charged, as a full charge typically supports 1 hour of continuous recording (the Google Glass battery is a lithium-ion 670-mAh internal unit). A full charge should be enough to capture a short case. Newer GoPro models, with a battery listed at 1050 mAh, provide 1 to 2 hours of recording. When more than 1 hour is needed, an external USB battery pack can be used. This pack allows the device to remain plugged in throughout the case (the pack is kept in the surgeon's back pocket). We recommend having an external battery pack that is at least 10,000 mAh (~$30 online retail), which easily provides 3+ hours of recording. Unfortunately, this arrangement can be cumbersome. Alternatively, with GoPro, additional batteries may be purchased, but the user needs to dismount the device in order to swap them in (may be difficult during surgery). With both units, partitioning a video into shorter segments conserves battery power and minimizes the risk of file corruption, which may occur if the battery dies or the device overheats.

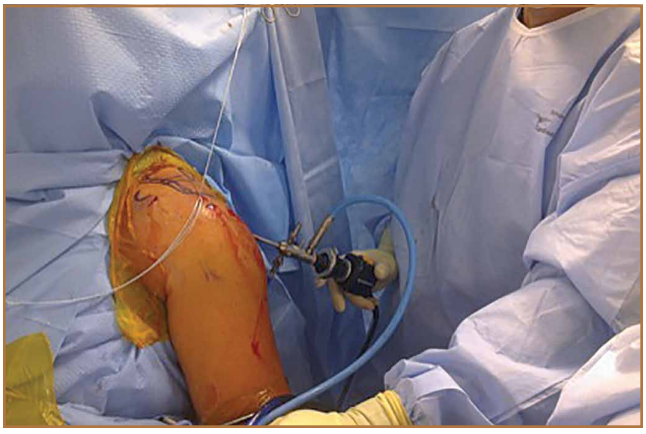


Figure 2. Hands-free image recorded by Google Glass voice command during arthroscopic shoulder surgery.

Google Glass users can bypass manual operation of the device by giving it voice commands (eg, start video, take still image). The exception is for recording video for more than 10 seconds (current default setting). Unfortunately, the surgeon must touch the device to start this recording, which means using extra gloves to preserve operating field sterility. Still images can be made through a combination of voice and head gestures and without manual intervention (**Figure 2**). Last, users must ensure that the device is not actively connected through Bluetooth to a mobile phone, as incoming calls, text messages, and e-mails may disrupt active recording and become a distraction. The connection can be deactivated by disabling Bluetooth on the host smartphone or by placing the phone into airplane mode and turning off Wi-Fi.

Google Glass users can see what is being recorded through the viewfinder prism, whereas GoPro requires precise framing of the video before recording. Framing is done by grossly aiming the device in the desired direction. However, there is no way to ensure exact aim during recording. If at any point during a case there is slight repositioning of the GoPro, there is a risk of recording the case out of the center of view. An important advantage to newer GoPro versions is the ability to control the device through a wireless remote that can be placed under the surgeon's gown. The remote can be used to pause and resume recording, without changing gloves, as is done with Google Glass. Last, because the minimum viewing distance from the surgical field is usually 18 inches or more, typically there is no loss of focus or blurring of the image from short-distance recording on either device.

3 File management and playback

Before using wearable technology in the operating room, surgeons must become aware of its limitations with respect to file storage and playback. Google Glass has a usable memory of about 12 GB (1 hour of video may require 1.5-2.0 GB). Conversely, GoPro's capacity is defined by the micro SD card used. Therefore, the Google Glass hard drive must be regularly maintained well before being brought into the operating room, whereas recording can be extended (with respect to memory) for the GoPro if the media card is large enough.

Both devices allow for wired file transfer, which may be done with Windows Explorer (PC) or iPhoto (Macintosh). However, Google Glass also allows for wireless transfer, through portable storage supported by Google. Although this type of file transfer may be convenient for short, everyday clips made outside the operating room, it is prohibitive for surgical media, mainly because of patient privacy concerns. With wireless transfer to a nonsecure cloud platform, there is a risk of breach of patient confidentiality. We therefore recommend against using wireless upload when producing surgical multimedia, as patient identifiers are likely to be included in the recorded audio or video contents. Conversely, with GoPro, the micro SD card can be used as a portable hard drive to transfer files to a laptop or media reader, obviating the need for wired or wireless transmission. Last, when using traditional wire transfer or memory card to upload to a hard drive, users must ensure that the drive complies with patient privacy laws and regulations.

4 Privacy and patient consent

As mentioned, great care must be taken to ensure that patient privacy laws are followed. This is especially relevant with content uploaded to online cloud storage, as with Google Glass. The upload may occur automatically if the unit is connected to a Wi-Fi hotspot. In addition, when using surgical media for a real-time webcast for education or demonstration purposes, surgeons must ensure that no protected health information is broadcast and that the patient and the surgical team are aware of the webcast and its purposes.

Before using wearable technology during patient care, patient consent must be obtained. Surgeons should ask the patient to consent to video recording of surgery or an encounter (eg, clinic visit) for education purposes. Our institution's consent form includes a section for this particular type of consent. If an institution's form lacks such a section, surgeons should consult their risk management department to ensure there is a proper avenue for obtaining patient consent to record the procedure or encounter. A separate, dedicated media consent form may be required. Last, whoever operates a wearable device should be careful to use the device only during encounters that have received explicit recording consent—as opposed to wearing the device in the hallways or elsewhere in the hospital, where protected health information might be inadvertently recorded.[4]

5 Putting it all to use

After successful recording of surgery, an effort should be made to produce a high-quality video for education or demonstration purposes. Unfortunately, there is no built-in optical zooming with Google Glass or GoPro, and recording segments in which surgeons focus on detailed anatomy (with high-quality zoom) may prove difficult. Online descriptions of do-it-yourself modifications to place zoom capability on GoPro devices may be useful in surgical video recording, particularly for small surgical fields (hand or foot surgery). In addition, footage may be zoomed in on during postprocessing (**Figure 3**), though some resolution will be lost in the editing.

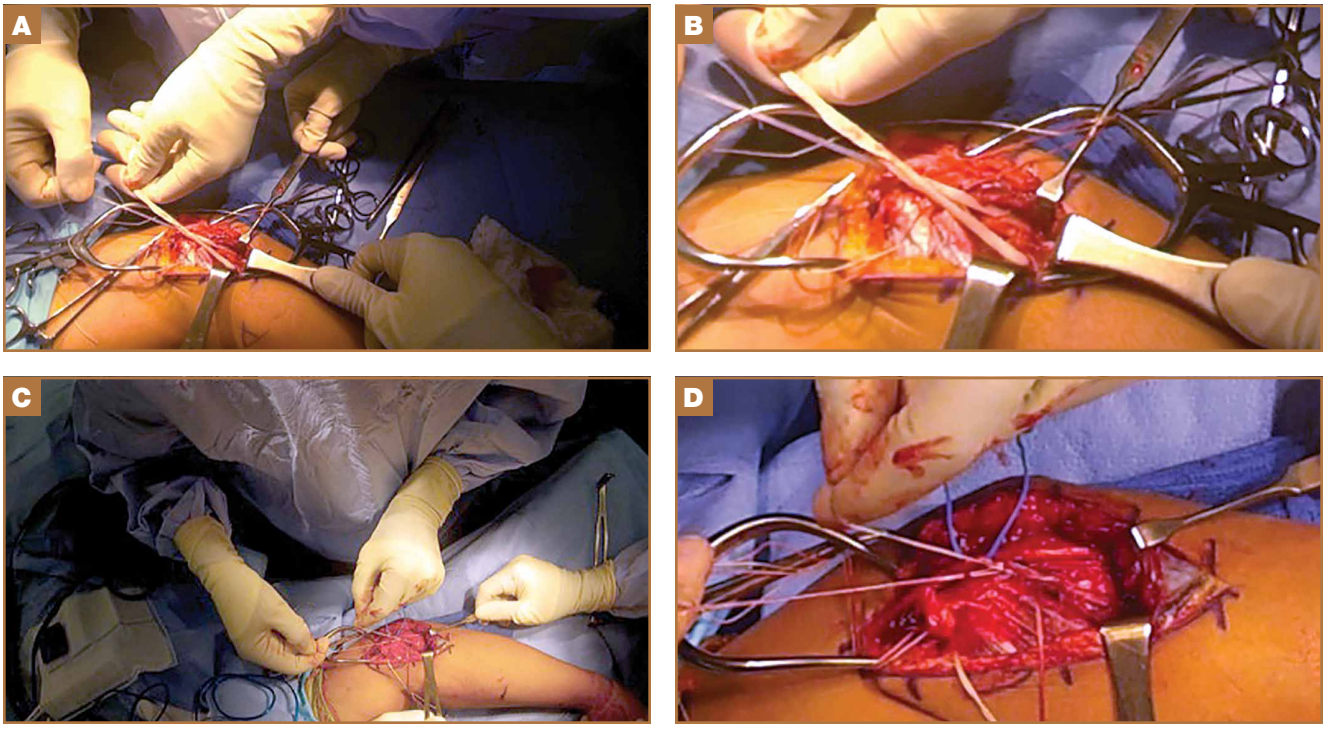


Figure 3. Representative still images from videos recorded with wearable technology. (A) Unzoomed image from Google Glass video of ulnar collateral ligament reconstruction. (B) Same image, cropped and magnified. (C) Unzoomed image from GoPro Hero 2 video of different ulnar collateral ligament reconstruction. (D) Same image, cropped and magnified.

There is no practical way to incorporate Google Glass or GoPro while using surgical loupes or a surgical microscope. As a result, videos recorded with wearable technology may not reach the minimum resolution needed for useful surgical technique videos, as these traditionally are produced on high-definition camcorders with optical zoom, allowing detailed viewing of anatomical structures without resolution loss through digital zoom or postprocessing editing.

There has been tremendous benefit in incorporating wearable technology into our practice. Videos made with Google Glass and GoPro have been successfully used for surgical preparation and training, allowing orthopedic surgical residents to rehearse surgery before participating in it. Alternatively, having used Google Glass or GoPro to record a case, residents have then been able to review each surgical step on video—thereby reinforcing their knowledge of the steps, techniques, pearls, and pitfalls before performing the surgery again. Footage from surgeries recorded with Google Glass and GoPro has also been shown at weekly technique-focused conferences, allowing surgeons to analyze particular steps and highlight applicable learning points. Last, attending surgeons in our practice have used wearable technology in "coaching" mode, either reviewing case footage to identify areas for improvement or sharing footage with senior surgeons in order to elicit feedback and suggestions for possible improvement.

As new iterations of wearable video technology come to market, with advancements in both hardware and software, surgeons may be able to enhance education and teaching through seamless recording of surgical procedures. Use of wearable technology may also begin to extend beyond the operating room—to outpatient settings, such as preoperative and postoperative physical examinations. The latest versions of Google Glass and GoPro Hero allow surgeons to record surgical procedures with relative ease, without the personnel, equipment, and coordination required for traditional surgical videography.

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Two accompanying videos are available online of surgeries recorded using Google Glass and GoPro.

This paper will be judged for the Resident Writer's Award.