SEEING THE WORLD THROUGH 3-D GLASSES

Grab some pearls for the coming world of 3-D heads-up surgery.

BY YOSHIHIRO YONEKAWA, MD

Three-dimensional heads-up vitreoretinal surgery is not a gimmick. We may be on the verge of a paradigm shift: away from microscope ocular–based visualization, and toward being able to sit back in the operating chair and view a large 3-D high-definition (HD) monitor that is powered by various image processing tools and diagnostic overlays. To quote my mentor George A. Williams, MD, regarding the technology, "This is a game-changer."

The concept and basic technology are not new. TrueVision has been developing 3-D surgery systems for about a decade, mostly for anterior segment surgery.[1] Outside of ophthalmology, this type of visualization platform is most well-established in the neurosurgical field.[2] Recent advances in cameras and digital image processing have made vitreoretinal surgery an attractive field to apply the technology.

Earlier this year, TrueVision and Alcon entered a partnership to advance the ophthalmic platform, which is now called Ngenuity.[3] The official launch took place during the 2016 annual meeting of the American Society of Retina Specialists.

THE SETUP

There are four parts to the Ngenuity hardware: camera, central processing unit (CPU), monitor, and polarized glasses. The setup is straightforward, and OR staff can easily assemble and disassemble the equipment. First, the oculars are removed from the operating microscope and the camera is attached in its place. (That is, for now, you still need a microscope.) The assistant's oculars can be kept in place, but they should be rotated away from the side of the monitor so as to not obstruct the surgeon's view.

The camera is wired to the CPU, which processes the live feed and displays overlapping stereo images on the widescreen HD monitor. Three-dimensionality is then appreciated by donning the circularly polarized glasses. Several frame designs are available (Figure 1).

Figure 1. The Ngenuity polarized glasses come in several designs. From top to bottom: conventional, sporty, and clip-on. For those who wear spectacles, using the clip-ons or wearing the polarized glasses over the spectacles are comfortable options.

CAMERA, MONITOR, AND CPU SPECS

Two 1080p cameras (one for each eye) connect to a single display, providing 1920 x 2160 pixel resolution to the HD, 55-inch, 4K (8 million pixel) monitor. The monitor is mounted on a stand that allows it to independently move up and down, right and left, and to pivot in both directions. This monitor, introduced in February 2014, is an improvement over the company's previous 1080p (2 million pixel) monitor, which allowed only 1920 x 540 pixels per eye. The current setup permits 1920 x 1080 pixels per eye, for a total of 2,160 lines of resolution. Because we are now using a 4K monitor, there is still room for even higher resolution. (This is in the works, according to the company.) The latest version of the 4K monitor features an organic light-emitting diode panel for even sharper images, deeper black levels, and a thinner profile.

The Wi-Fi–connected CPU is housed in the base of the stand. It uses solid-state processors, heavy-duty graphics processing cards, and 2-TB hard disks that can store 100 hours of 3-D video footage. Like the latest generation of iPhones, Ngenuity employs high dynamic range (HDR) technology. HDR optimizes image quality by taking two images with different exposures in rapid succession and averaging the two. Therefore, two images per eye are being processed at any time. The CPU handles 60 frames per eye per second.

BENEFITS

Listed below are the main benefits we have experienced from operating with Ngenuity, along with pearls we picked up along the way to help make the transition to 3-D surgery comfortable.

Ergonomics

Tilted oculars, if used correctly and consistently, can reduce back and neck strain for ophthalmologists by eliminating the need to lean forward toward the microscope (Figure 2). However, there is something to be said for being able to sit back in your chair to operate.[4]

TIP:

I personally prefer using a chair with a backrest when operating heads-up, so that I can lean back and relax the entire spine (Figure 3). This can potentially add many years to the operating lifetime of some retina surgeons' careers.

Education

For the first time, students, residents, fellows, observers, scrub technicians, nurses, and even the anesthesia team can see exactly what the surgeon is doing. Everyone in the room using polarized glasses can become more involved in the case. The educational benefits are immense for training programs, and assistants and technicians are better able to anticipate subsequent maneuvers and required instrumentation.

The opposite is also true: As the attending, you can see exactly what your fellows are doing, so that you can better guide them through challenging cases. When switching seats may be necessary, there is the added benefit of not having to adjust the pupillary diameter each time.

Low-Illumination Macular Surgery

The most patient-centered benefit of Ngenuity is, in my opinion, being able to substantially cut back on endoillumination levels. This is made possible by adjusting the camera's iris aperture during the case (Figure 4).

Another benefit during macular surgery is that, as you zoom in, the entire image enlarges so that there is no loss of field of view. Many of us prefer low magnification during macular surgery to maintain the overall view of the macula, but with Ngenuity we can attain high magnification while maintaining a widefield of view.

Color Manipulation

Real-time color manipulation of 3-D images is undergoing development. Red-free visualization and blue illumination of the vitreous are interesting modules that will soon be released as software updates for the system. The most useful image manipulation currently possible on this device is the gain adjustment, which can be helpful in decreasing glare during air-fluid exchange.

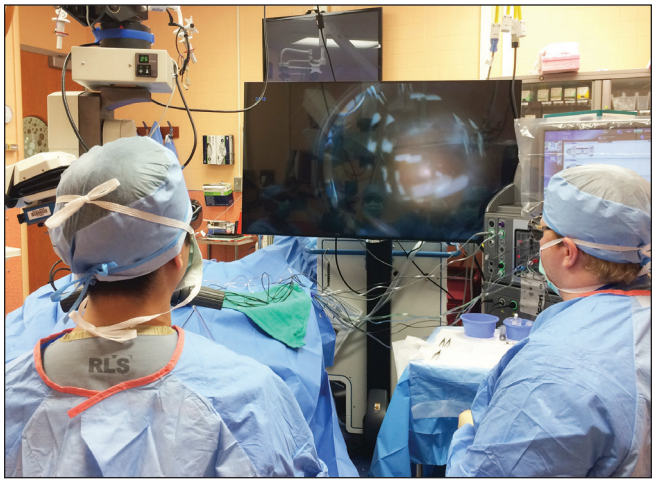

Figure 2. The 4K HD monitor is placed at the foot of the bed and oriented so that the surgeon is viewing the screen straight on. In this photograph of a case with Tarek S. Hassan, MD, the vitrectomy unit is placed between the monitor and the instrument table. Notice that it is facing the patient to allow more cord slack, and the monitor is swiveled toward the scrub technician. One of the monitor stand's legs is tucked under the patient bed to position the monitor as straight as possible. The room lights are turned on for illustration purposes, but 3-D monitors are best viewed with the room lights out.

TIP:

If you have an entourage of observers, it is best for them to stand behind you, or close by, so that they can appreciate the images at the highest resolution.

Beautiful Surgical Videos

For those of us interested in surgical presentations at meetings, Ngenuity significantly enhances the quality of surgical

TIP:

Macular surgeries can be routinely performed with endoillumination of less than 10% by opening the iris aperture to approximately 75% to 80% to allow more light to enter the camera (Figure 5). This greatly reduces the risk of phototoxicity. The aperture must be closed about halfway when returning to lower-magnification vitreous and peripheral surgery to allow a wider range of focus.

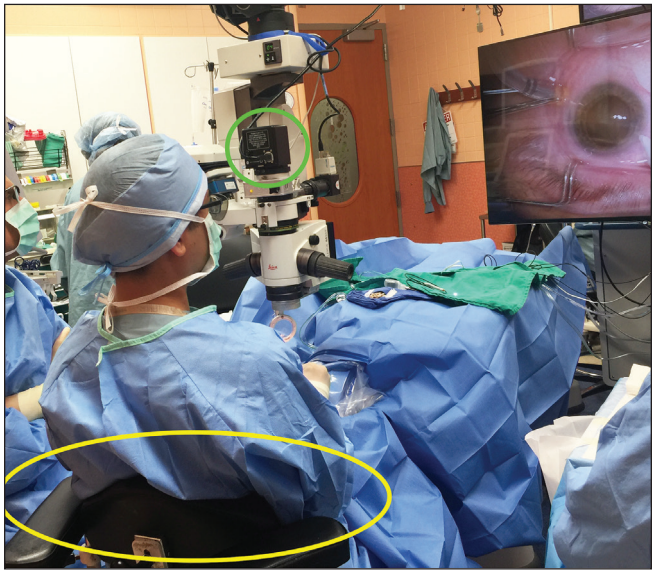

Figure 3. In this case with Alan J. Ruby, MD, I am using a chair with a backrest (yellow circle) for full back support. There is no need to lean forward or even to sit straight up. The Ngenuity camera is highlighted to show its placement (green circle).

Figure 4. The Ngenuity camera (A). The sliding knob is used to adjust the iris aperture size. The iris apertures are on the bottom of the camera (B). The larger the aperture, the more light enters, but the depth of focus shallows. The smaller the aperture, the less light enters, but the depth of focus deepens. Having the iris open midway is a good place to start for vitrectomy cases. When switching to higher magnification for macular surgery, the iris can be slid further open so that endoillumination can be substantially lower. Because the range of focus required for macular surgery is small, the shallower depth of focus is not noticeable because one is operating well within that range with the full stereopsis provided by the Ngenuity system.

videos using one's existing microscope. Video recording starts with one press of a key, and 10-minute continuous segments are recorded, each approximately 2GB to 3 GB in size. The total file size is therefore larger than what we are accustomed to. Proprietary video editing software is required to put together edited videos, which can then be saved either as high-resolution 2-D or 3-D videos. The 3-D files will display as side-by-side videos (right and left eyes) on regular monitors but will play as stereo 3-D videos on 3-D monitors or projectors. This is a cost-effective option compared with buying the most expensive operating microscope and video systems.

Complex Cases

Heads-up surgery is not just for macular cases. It facilitates the most complex of vitreoretinal surgeries, from diabetic tractional retinal detachment, to proliferative vitreoretinopathy, open-globe–associated retinal detachment, endophthalmitis cases, scleral fixation of intraocular lenses, and any other vitrectomy indication (Video).[5,6]

CHALLENGES

As with any new technology, there are aspects that we must adjust for. The learning curve for heads-up surgery is

TIPS FOR SETTING UP THE OR

- The best resolution is obtained when you are viewing the monitor straight on. The legs of the monitor's stand can be tucked under the patient bed, and the bed and railing adjusted so that the screen can overlap with the bed (Figure 2).
- In order to minimize or eliminate turning one's head to view the monitor, I prefer sitting slightly off center toward the direction of the screen, and I slightly rotate the chair toward the screen.
- The vitrectomy unit must be placed further from the patient than is usual to allow unobstructed views. If the lines are too taut, the vitrectomy unit can be turned to face the patient and the monitor swiveled toward the surgeon and scrub tech to allow access to the touch-screen (Figure 2).
- The view is better in the dark, even for anterior segment work. The room lights should be out, and this may require adaptation by assistants and scrub techs.

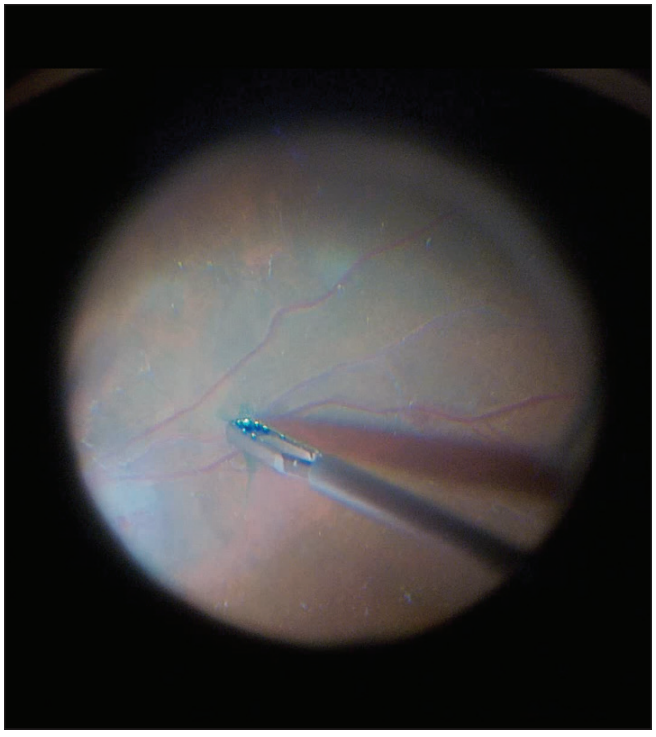

Figure 5. Internal limiting membrane peeling in a case with Jeremy D. Wolfe, MD. The illumination was lowered as the aperture size was enlarged. This unedited image shows the endoillumination at 5% to 7% with the aperture opened to approximately 80%. Stereopsis was unchanged, and there was more than enough focus range for macular surgery.

surprisingly short. Once you are in the eye, it feels like second nature, even during the first case. After five to 10 cases, you are not thinking about the microscope. This also pertains to the 0.09-second latency between your hand motion and the image motion. The delay is noticeable (barely) if you look for it, but 0.09 seconds is truly insignificant, and you do not notice it while operating in the eye. Nevertheless, TrueVision and Alcon are working to further decrease this infinitesimal lag time.

Surprisingly, the one who may need slightly more time to adapt is the assistant, whose body and arms are faced perpendicular to the patient's head but whose face is turned toward the feet. The hand-eye coordination that the assistant is accustomed to must be adjusted, or else the assistant can use the side scope. That being said, this is a relative challenge that is overcome after a few cases. The same goes for anterior segment maneuvers, which may feel different from what we are familiar with. Because the movements in the anterior segment are faster than posterior segment movements (for example, suturing vs. vitrectomy/peeling), the 0.09 second latency may be somewhat noticeable in the beginning.

From the BMC Archive

Ergonomics and Retina
By Michael Dollin, MD; with Sunir J. Garg, MD; Sonia Mehta, MD; and Marc Sprin, MD
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Find the article online at: bit.ly/dollin316

UP AND COMING

Numerous upgrades for Ngenuity software and hardware are in various stages of development. Having a 55-inch monitor at one's disposal leaves room for image overlays, incorporation of information from the electronic health record, and integration with other devices. We can now manually upload patient images into a folder so that we can access them on the monitor during surgery, but in the future the process will be more streamlined and there will be improved integration of diagnostics.

Incorporation of intraoperative optical coherence tomography (iOCT) is an exciting possibility.[7,8] iOCT technologies can currently project images onto a separate screen (requiring the surgeon to look away from the microscope) or within the oculars (which allows limited space). Displaying the live iOCT image in a portion of the large monitor may be a more comfortable and safer approach. Some might feel hesitant about having diagnostics overlaid on the surgical view, but that will not be an issue because there is ample unused monitor space that the images can occupy.

Another exciting prospect is the integration of endoscopic views onto the monitor. Currently, endoscope-assisted vitrectomy requires the operator to look back and forth between the microscope and the small endoscopy screen.[9,10] An Ngenuity-integrated system will allow both views to be available on one large screen.

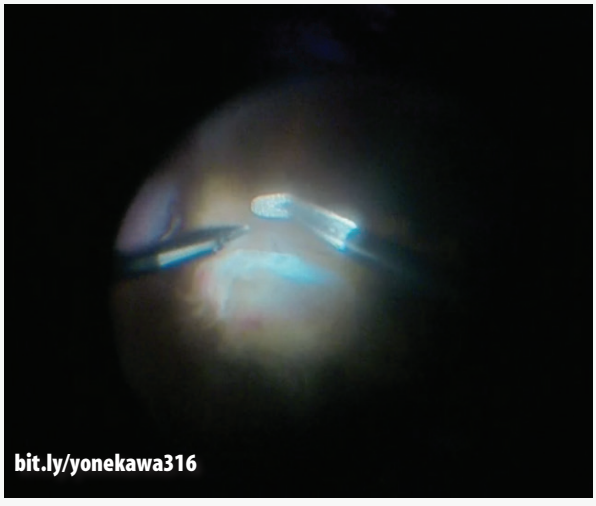
Finally, and potentially most groundbreaking, will be the possibility of doing away with the microscope altogether. Ngenuity, it is hoped, will be developed into a microscope-independent camera that can slide over the patient, so that there will be less concern about positioning and visual obstructions, and it will allow a smaller footprint in the OR.

Ngenuity is like a smartphone. An advanced base model has been made, and it will be continually upgraded. This flexible platform will incorporate new surgical and diagnostic developments as they occur. The surgeon will be able to choose which "apps" to install, creating a customizable surgical experience. ■

WATCH IT NOW

Heads-up 3-D for a Diabetic TRD

The Ngenuity platform is used in the case of a patient with long-standing untreated diabetes presenting with tractional retinal detachment (TRD) in both eyes. Hybrid 23/27-gauge vitrectomy is used.[5] The Ngenuity camera was connected to a Leica microscope, with the BIOM 5 wideangle viewing system (Oculus Surgical) and HTC macular lens (Insight Instruments).[6]



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