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A NEW WAY TO SEE THE BIG PICTURE IN A MICRO ENVIRONMENT

High-definition, 3D visualization is causing a paradigm shift in vitreoretinal surgery.

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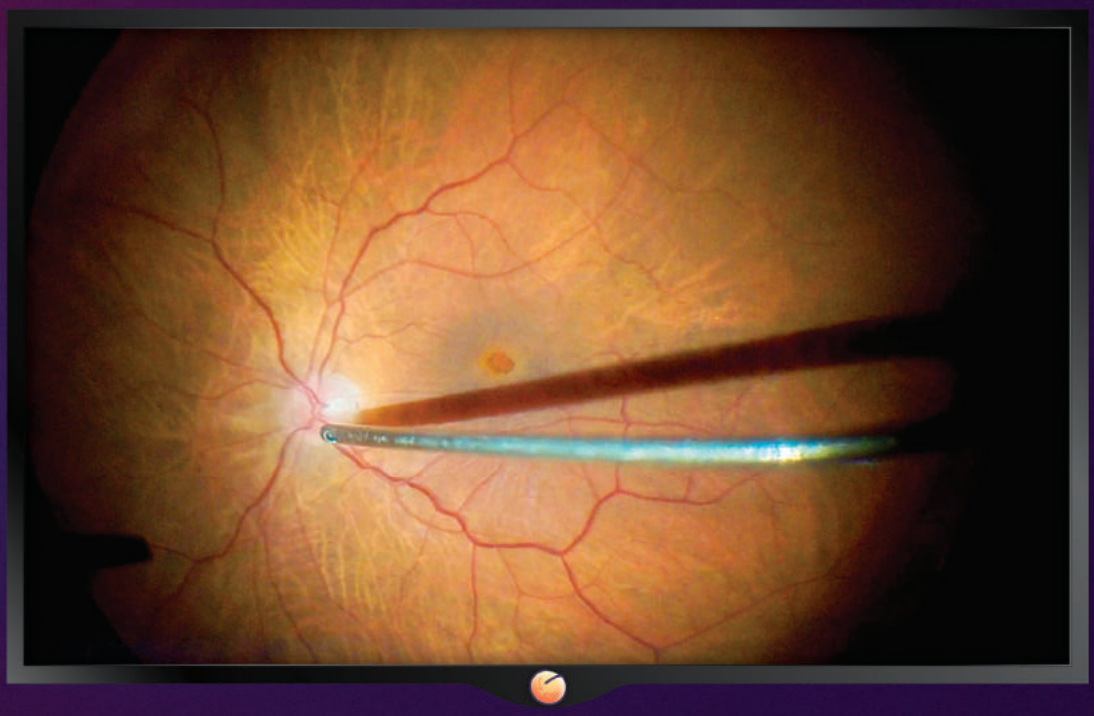

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A New Way to See the Big Picture in a Micro Environment

High-definition, 3D visualization is causing a paradigm shift in vitreoretinal surgery.

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Observing vitreoretinal surgery in real time on a 55-inch, ultra high-definition, 3D flat-panel display, retina fellows, residents, medical students, the entire operating room staff, and visiting surgeons quickly realize they are witnessing a significant paradigm shift in surgical visualization. The retina specialists performing digitally assisted surgeries with this 3D system (Ngenuity 3D Visualization System; Alcon) are in full agreement.

"In real estate, location is everything," says Kirk H. Packo, MD. "In surgery, visibility is everything. With this system, we can see things in ways that we could not see them before.

"But this is not just another way to look at the retina," Dr. Packo continues. "This system enables us to do things differently, because we are now in the digital realm."

The Ngenuity system utilizes a high dynamic range digital camera to convert an optical microscope into a digital imaging system. Wearing passive polarized 3D glasses, the surgeon and everyone else in the operating room can view the surgical field on a 4K monitor.

Dr. Packo is one of a growing number of retina specialists worldwide who are embracing this new technology. For this article, we also asked María H. Berrocal, MD, Marta S. Figueroa, MD, PhD, and Stanislao Rizzo, MD, to share their experiences with this 3D visualization system.

FIRST IMPRESSIONS

One of the benefits surgeons notice first when they begin using the 3D digital platform is the ergonomic advantage of operating in a heads-up position, not tethered to a microscope.

"When using a surgical microscope, you must bend your neck forward and hold your head still in an awkward position for long periods, which causes your back and neck muscles to go into isometric contraction," Dr. Packo says. "Toward the end of the day, that adds to your fatigue, and you realize you are becoming stressed and tired."

Maintaining this posture for prolonged periods may lead to chronic musculoskeletal problems for some surgeons. A survey of US retina specialists found that more than 55% experience back and neck pain, while 21% experience back pain, and 8.3% experience neck pain.[1]

"I appreciate the greater freedom I have in the operating room with heads-up 3D microscopy (Figure 1)," Dr. Rizzo says. "This technology eliminates the constraints of the binocular surgical microscope, allowing me to operate in a more physiologic position, which reduces fatigue."

According to Dr. Packo, the difference in comfort between heads-up surgery and traditional surgery behind the oculars cannot be overstated. "It is like sinking into the bucket seat of a luxury car when you have been sitting on a stool all of your life," he says. "These creature comforts add to the ease with which you proceed through the day, and that is something you will notice right away.

"While comfort is a wonderful advantage, it is not the reason why I think people should adopt 3D visualization, because there are other exciting aspects to this technology," Dr. Packo says. "It is like appreciating how comfortable you feel in that luxury car, and then discovering all of its amazing new features."

"The depth of field of the Ngenuity system is equal to or better than that of a traditional microscope, and the 3D image appears to be sharper. We can achieve high magnification while maintaining a wide field of view. When I visualize the retinal periphery, I do not need to magnify it, because the image is large enough."
—Stanislao Rizzo, MD

Compared with traditional surgical microscopes, this system offers:

- higher depth of field and working distance at the retinal surface in high magnification
- high dynamic range imaging that reduces instrument glare and illuminates shadows
- reduced light levels
- digitally applied colors to enhance visualization of ocular structures and tissues

Figure 1. Ergonomic difference from surgical microscopes: Ngenuity allows surgeons to operate while standing in a heads-up position, as shown in this photo in the OR with Prof. S. Rizzo and his surgical staff.

(photo courtesy of Stanislao Rizzo, MD)

ENHANCED RESOLUTION AND DEPTH PERCEPTION

A key component of the 3D visualization system is the high dynamic range camera. Coupled with the latest high-definition 55-inch OLED ultra HD 4K 3D flat-panel display, the system provides excellent resolution, image depth, clarity, and color contrast. With the 3D view, the surgeon has depth perception not previously available on standard television monitors.

"The level of magnification is incredible," Dr. Figueroa says. "Even with highly magnified images, the axial resolution and depth of field are quite good, allowing me to perform precise surgical maneuvers under excellent viewing conditions."

As with any new technology, the tendency is to compare and contrast it with what is currently in use. "In my opinion, the depth of field of the Ngenuity system is equal to or better than that of a traditional microscope, and the 3D image appears to be sharper," Dr. Rizzo says. "We can achieve high magnification while maintaining a wide field of view. When I visualize the retinal periphery I do not need to magnify it, because the image is large enough."

"The one thing that struck me—something that I feel I can do better digitally than optically—is surface macular work, such as macular puckers and macular holes."

—Kirk H. Packo, MD

Dr. Berrocal agrees. "I like that we have a much larger view of the surgical field, and the enhanced depth perception is useful when removing membranes, particularly epiretinal membrane, internal limiting membrane (ILM), and tractional retinal detachments."

In another comparison, Dr. Berrocal notes, "When looking into the microscope, particularly at the highest level of magnification, my view is limited to the area on which I am focused. With the Ngenuity system, however, I have a panoramic view of the entire retina. This is particularly helpful when I am peeling membranes in a proliferative vitreoretinopathy case or a severe tractional retinal detachment, because I can see if I am causing traction in a distant area, which I cannot see when I am looking through the microscope."

Dr. Packo adds, "The one thing that struck me—something that I feel I can do better digitally than optically—is surface macular work, such as macular puckers and macular holes. These cases make up a large portion of what average retina surgeons operate on nowadays. The first time I used Ngenuity for these types of cases, I could not help but smile at how beautifully and accurately I could see the ILM."

WIDE-ANGLE VIEWING WITH 3D VISUALIZATION

The 3D system can be used with all brands of microscopes, and it will accommodate both contact and noncontact wide-angle viewing systems.

"You can continue to use your preferred lenses, either a flat contact lens for macular work or the binocular indirect ophthalmomicroscope (BIOM; Oculus) for the periphery," Dr. Berrocal says. "I particularly like the BIOM because multiple lenses are available, not only disposable lenses but also small lenses for babies and high-magnification lenses for the macula. You can get much more utility from that system, and using it with Ngenuity is as seamless as using it with the microscope."

NEW APPROACH TO ILLUMINATION

With this new 3D visualization system, the surgeon can digitally enhance the image on the monitor, so that endoillumination levels can be reduced, minimizing light exposure to the patient's eye.

"That is another advantage of this system," Dr. Figueroa says, "because when we use light during surgery, there is always a risk of retinal phototoxicity. With this device, we can increase the illumination on the screen by adjusting the camera's iris aperture, allowing us to decrease the light entering the eye from the vitrectomy machine."

Dr. Rizzo also appreciates this feature. "Electronic amplification of the camera's signal can significantly brighten the image, with 20% lower light exposure," he says. "This allows us to enhance the brightness of the surgical field without exposing the retina to additional light."

Dr. Packo says he already had a sense of what a digital viewing system could bring to the operating room before he began using the digital platform. "While assisting my fellows at an optical scope—even though I could see at the scope in stereo—sometimes I would find myself watching the monitor in 2D, because the camera pickup was giving me better light and showing me more than the optical scope could pick up. With the video camera, we can dial down the light going into the eye and still see an image that often is superior to what we see at the oculars.

"Being able to dial down the light and potentially have less phototoxicity is a benefit," Dr. Packo continues. "Beyond that, however, is the fact that there are times that all surgeons say, 'Gee, it is dark. I just cannot see so well.' Every surgeon will admit that. But that almost would never happen with this system, because you can always lighten the image digitally."

Dr. Rizzo reports a specific example of this system's functionality as it relates to illumination. "I have noticed a reduction in glare during fluid-air exchange, as in phakic eyes," he says.

"Thanks to the ability to decrease illumination and increase the camera gain, while maintaining good peripheral visualization and high resolution."

DIGITAL FILTERS

Ngenuity's innovative color filters enable surgeons to customize how they visualize the surgical field to fit their needs.

"Various color filters can be applied digitally to enhance tissues," Dr. Figueroa says. "For example, we can improve our visualization of epiretinal membrane with a green filter. We can better identify the vitreous with a blue tint, and a red-free filter facilitates ILM peeling."

Dr. Packo equates the sensation of viewing the surgical field through color filters to putting on a pair of "blue blocker" sunglasses that improve visual clarity. "As you start to manipulate the colors, all of a sudden, you are seeing things you could not see before," he says. "While peeling diabetic membrane and looking through dense vitreous hemorrhage at the start of vitrectomy, you realize you can see better through it, and the enhanced contrast gives you a greater degree of comfort."

Dr. Figueroa appreciates the 3D visualization system's digital color filters because in some cases, she can avoid using dyes. "Although all of the dyes that we use for vitreoretinal surgery are biocompatible, sometimes there are signs of retinal toxicity after we use these dyes,"[2] she says. "Instead of using something that has a risk, although it is minimal, I can apply color filters to enhance the tissue and facilitate my maneuvers."

"Various color filters can be applied digitally to enhance tissues. For example, we can improve our visualization of epiretinal membrane with a green filter. We can better identify the vitreous with a blue tint, and a red-free filter facilitates ILM peeling."
—Marta S. Figueroa, MD, PhD

Dr. Berrocal agrees, adding "Not only is there less risk of potential toxicity when we use these digital filters, but this approach also expedites the surgery and is less costly."

RAPID ADAPTATION

When a new technology is likely to disrupt the status quo, users are understandably concerned about what will be involved in adapting to it.

"The learning curve for the Ngenuity system is minimal," Dr. Berrocal says. "Even during my first trial of the system, I was able to complete all of my cases—two epiretinal membranes, two tractional retinal detachments, a vitreous hemorrhage, and a macular hole—without needing to switch back to the view through the microscope, which was quite surprising to me."

Dr. Rizzo reports, "In my team's experience, the switch from traditional surgery with the microscope to the heads-up technique was made easily and in a remarkably short time.

"It was surprising how quickly a surgeon is able to feel comfortable and confident with this technique," Dr. Rizzo says. "In my opinion, this represents an important advantage for retina surgeons, particularly in complex cases."

Dr. Figueroa estimates an experienced surgeon will feel comfortable with the 3D visualization system in about 1 week or after approximately 10 cases, and she recommends starting with a simple case, such as an epiretinal membrane. "That was my first case using the Ngenuity system, and I felt very comfortable from the beginning of the surgery until the end."

FUTURE APPLICATIONS

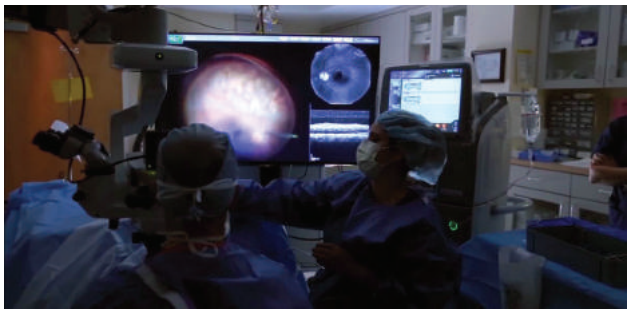
While the surgeons we interviewed appreciate the advances already incorporated into the latest generation of the Ngenuity 3D visualization system, they are looking ahead to other potential innovations.

"I think in the future, it will be possible to integrate the microscope into this viewing mechanism, so we rely less on our

INTEGRATING DIAGNOSTIC IMAGING

Another feature of the 3D visualization system that retina surgeons appreciate is the ability to view diagnostic images side-by-side with the live surgical field on the large monitor. This eliminates the need for the surgeon to look away from the microscope to refer to these images during surgery.

"We can export our preoperative optical coherence tomography and angiograms to the Ngenuity system in the OR," Dr. Figueroa says. "This allows us to visualize the optical coherence tomography on the screen—to identify where an epiretinal membrane is located, for example—while we are operating (Figure)."



(photo courtesy of Marta S. Figueroa, MD, PhD)

Figure. Using the 3D visualization system, the surgeon can import diagnostic images from the clinic and view them on the monitor next to the live surgical field.

current technologies," Dr. Berrocal says. "Ideally, the whole system will give us a panoramic view without requiring inverters or lenses, and we may be able to magnify certain areas selectively. The possibility of concomitant or superimposed optical coherence tomography and other imaging modalities viewed simultaneously on a large monitor will be priceless."

Dr. Rizzo concurs, adding, "Integration of the 3D system with other technologies, such as intraoperative OCT is an exciting possibility, particularly for complex cases."

Dr. Figueroa notes, "The potential of this digital platform is enormous. This is going to change the way we operate now and in the near future."

Dr. Packo likens the future evolution of this technology to what we have witnessed with our telephones. "For years we did just fine with the ubiquitous wired landline," he says. "The introduction of the digital cell phone was revolutionary. But look what our smartphones are capable of doing now! We cannot imagine that we ever existed without them. Our surgical imaging is on the exact same path."

A NEW STANDARD IN SURGICAL VISUALIZATION

The expectation among surgeons who are using 3D visualization in their ORs is that this technology will quickly become the standard in vitreoretinal surgery.

"I have been using the Ngenuity 3D visualization system at the Careggi Teaching Hospital for approximately 1 year," Dr. Rizzo says. "We perform every ophthalmic surgery using the digital microscopy 3D visualization system. We also adopted it for episcleral surgery, for which we usually use surgical microscopes. I think 3D visualization is going to revolutionize routine microscopy in many respects."

Dr. Berrocal believes incorporating 3D visualization into her OR will possibly improve her efficiency. "Being able to see my surgical field better, larger, with more contrast, and with enhanced depth perception will make for more expedited surgery," she says. "I have always been an advocate of streamlined surgery, not just for the sake of efficiency but because I think it reduces complications. If we can do something in half the time, the chances that the patient will be uncomfortable, or will move, or that any other unexpected complications will occur are reduced. There is an immense value to that."

A TEACHING ADVANTAGE

"For anyone who trains residents and fellows, the Ngenuity 3D visualization system is an extraordinary advancement to enhance their surgical training, because both teacher and student are looking at the exact same thing," Dr. Packo says.

"As the teacher, I can use a sterile laser pointer on the monitor to show the fellow where to grab a membrane and what path to follow while peeling," he says. "It is almost like having your hands on the hands of a student driver, whereas

(photo courtesy of Stanislao Rizzo, MD)

Figure 2. The 3D-view, monitor-based system allows the full surgical team to see the same field of view as the surgeon with full stereo depth, as shown in this photo taken in the OR with Prof. S. Rizzo and his nursing and medical staff.

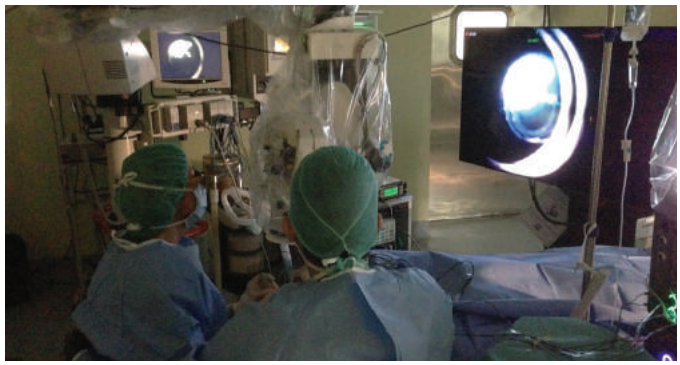


Figure 3. Dr. Figueroa performs a vitrectomy for proliferative diabetic retinopathy using the 3D visualization system.

you could never do that using the surgical microscope. It is extraordinary. And all of the other students in the room can see exactly what is going on. That is very cool. It will make you wonder how you were teaching without it."

Dr. Rizzo also appreciates the value of 3D visualization for teaching (Figure 2). "Viewing impressive 3D images on a large, flat, high-definition screen in real time makes this system an ideal educational tool for medical students, residents, and experienced surgeons. Also, beautiful surgical videos with enhanced quality can be easily obtained.

"In addition, the entire surgical team can see the same field of view as the surgeon with full stereo depth," Dr. Rizzo says. "Everybody has the opportunity to participate in the surgery."

Dr. Berrocal agrees. "I have always had a monitor in the operating room, but that is not the same. When the audience, the technicians, the circulators, everybody in the OR, plus any visiting surgeons can see the surgery in 3D, they can see the relationships between the structures. They can see the different tissue planes and how membranes are elevated. The Ngenuity system is ideal for teaching (Figure 3)."

1. Desai URT, Abdulhak MM, Bhatti R. Occupational Back and Neck Problems in Vitreoretinal Surgeons. Paper presented at: American Society of Retina Specialists Annual Meeting; August 2004; San Diego, CA.
2. Gandorfer A, Haritoglou C, Kampik A. Toxicity of indocyanine green in vitreoretinal surgery. *Dev Ophthalmol.* 2008;42:69-81.

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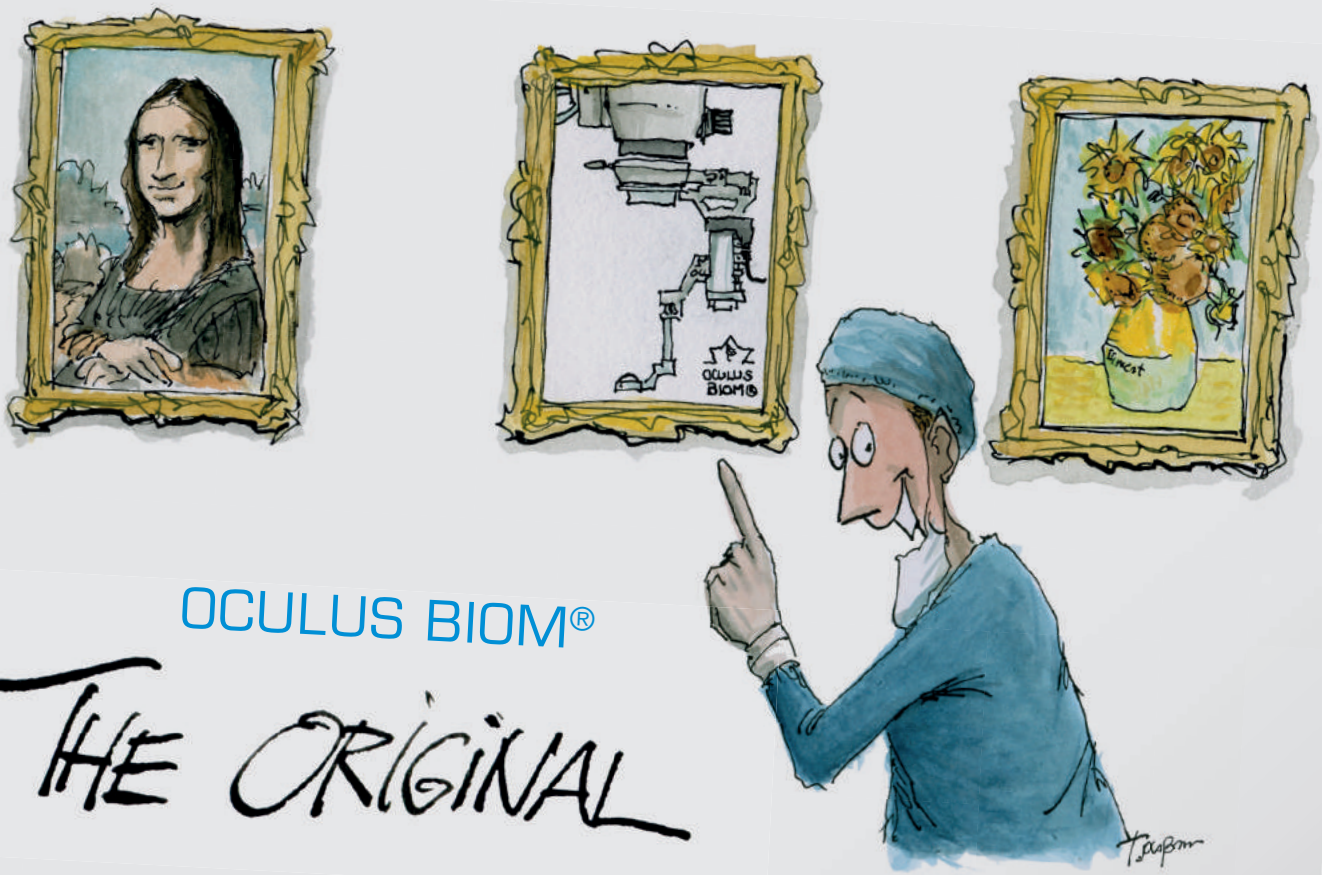

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