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Vitreoretinal surgeons discuss the benefits of digital surgery using a new high-definition, 3D visualization system.

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If the retina subspecialty were a state, it would be Missouri, the “Show Me” state. When a new technology is described as revolutionary, transformational, disruptive, or a game changer, retina specialists prefer to draw their own conclusions, as was the case when Darius M. Moshfeghi, MD, heard about a new 3D visualization system (NGENUITY; Alcon).

“Although open to new technology, I was somewhat skeptical, mainly because I have been using microscopes for 20 years, and the Ngenuity system represents a significant paradigm shift,” Dr. Moshfeghi says. “But our colleagues in other fields have been using ocular-free displays for many years, and I was interested to see if it would change my surgical approach. ... I have to say, after one case, I was sold. To me, this is going to be one of those advances that will cause people coming out of the OR to say, ‘Wow! This is just a better way of performing surgery.’”

Dr. Moshfeghi is among a growing number of retina surgeons who have transitioned to digitally assisted vitreoretinal surgery with the new digital system. We also spoke with George A. Williams, MD, and Jeroni Nadal, MD, PhD, to learn their impressions of this new approach to visualizing the surgical field.

ABOUT THE SYSTEM

Based on technology developed by TrueVision 3D Surgical, which was introduced to the neurology and ophthalmology specialties in 2008, the new visualization system converts an optical microscope into a digital imaging system. The surgeon—in fact, everyone in the OR—views the surgical field in real time on a large, flat-panel display using passive 3D polarized glasses.

The latest iteration of the system, which has undergone a rapid evolution in a short period, incorporates a patented fifth generation image capture module into a 3D high dynamic range camera to provide excellent image quality, resolution, light balance capability, and brightness.

The system’s proprietary software enables video streaming in either 2D or 3D to one or more displays, and it can capture up to 100 hours of high-definition (HD) video, which can be edited and organized quickly. A 55-inch OLED ultra HD 4K 3D flat-panel display recently became available.

Compared with traditional surgical microscopes, the new digital visualization system offers:

- higher depth of field and working distance at the retinal surface in high magnification
- improved field of view
- high dynamic range that reduces instrument glare and illuminates shadows, allowing surgeons to use a lower illumination setting and thus reduce the risk of phototoxicity
- digital image filtering for various color effects to enhance visualization without the use of vital dyes

Researchers have investigated this technology’s utility for vitreoretinal surgery.

STUDIES SUPPORT USE IN POSTERIOR SEGMENT

Christopher D. Riemann, MD, an early adopter and proponent of the 3D visualization system presented the first retina cases using this technology at the American Academy of Ophthalmology Annual Meeting in 2010. Dr. Riemann, who holds a degree in biomedical engineering, is one of several retina specialists who have provided input on the design and functionality of the system for vitreoretinal surgery.

In 2014, Prof. Dr. med. Claus Eckardt used this technology during a live surgery to remove a subretinal fibrovascular...
tumor, a procedure that was simultaneously streamed in 3D to attendees at the Frankfurt Retina Congress. At that time, Prof. Eckardt stated, “I now routinely use digital microscopy 3D surgery in all my retinal and cataract cases, and I believe many surgeons will perform ophthalmic surgery this way within 5 years.”

In a subsequent report, Prof. Eckardt noted that he and his colleagues at Klinikum Frankfurt Höchst have performed more than 3,500 anterior and posterior segment surgery cases using the digital technology.

In a paper published earlier this year, Eckardt and Paulo reported results from a study of 20 nonsurgeon volunteers who completed fine-motor tasks with forceps, comparing the 3D visualization system with the traditional analogue microscope. They found that 91.7% of the volunteers preferred the ergonomics of the digital microscopy technique. The two methods were judged to be similar in speed, ease of microscopic manipulations, and sharpness of image. Significantly fewer mistakes were made with the digital method.

In the same report, the authors retrospectively analyzed the routine use of the 3D visualization system for more than 400 vitrectomies, encompassing the entire spectrum of vitreoretinal surgeries performed over an 8-month period. They concluded the digital microscopy method is well suited for vitreoretinal procedures.

**BENEFITS OF SHARED VISUALIZATION**

Dr. Williams has been using the digital system at Beaumont Hospital for about a year, and based on his experience with this technology, he predicts it will become the standard visualization platform for retina surgeons in the future (Figure 1).

“The first thing that impressed me was the teaching benefit,” he says. “We have a busy fellowship and residency, and for the first time in 30 plus years of teaching residents and fellows, I could see exactly what they were doing during surgery. That was a big plus for me. I felt I could be a more effective teacher, and I also had more control over the operation while I was teaching. This system is a complete game changer in this setting.”

As director of the vitreoretinal surgery fellowship program at Stanford University School of Medicine, Dr. Moshfeghi is also keenly aware of the 3D system’s value in a teaching institution.

“I love the fact that a fellow and a resident can be scrubbed in, and I can stand behind them, and all three of us are looking at the same monitor,” he says. “Everybody gets the opportunity to participate in the surgery, without any compromise to visualization.”

The advantages of this shared visualization on a large HD screen in the OR extends beyond the surgeon’s point of view, as the surgical support team also views procedures in real time.

Dr. Nadal has been using the 3D visualization system at the Barraquer Ophthalmology Centre for approximately 1 year. “Not only does the system enable us to teach other surgeons, but for the first time, people following the procedure have the same view of the surgical field as the operating surgeon,” he says.

Dr. Williams’ OR staff have commented on the impact this new technology has had on their experience.

“My nurses and scrub techs have repeatedly told me they find it much more enjoyable when they can actually see what is going on,” he says. “In addition, when medical students and residents walk into the room and see what we are doing for the first time, it is not unusual to hear a ‘Wow!’ or ‘OMG’ or a gasp, because they have never before been able to see what is going on inside the eye. I have to admit, even though I have been doing this for 30 years, it is remarkable when you see it on a big screen.”

Far from simply projecting a magnified version of what is seen through a microscope’s oculars onto a large display screen, the digital 3D system incorporates advanced technology that fine-tunes the image, compensating for some of the microscope’s shortcomings, while also enabling surgeons to employ various digital applications to enhance their view.

**ENLARGED IMAGE IN HD**

“One of the tradeoffs with the microscope is that the higher the magnification, the smaller the field of view,” Dr. Williams says. “With the Ngenuity system, I can still have significant magnification, but because I am viewing the image on a 55-inch screen, I still have a good field of view.”

Dr. Moshfeghi notes he usually does not increase magnification significantly when using an analogue microscope. “The reason for that is because resolution decreases as magnification increases, and other issues come into play,” he says. “Using optical magnification, the light appears diminished and the image becomes less steady and less sharp. With the 3D HD camera of the Ngenuity system, the image is large enough that...
I do not need to magnify it (Figure 2). I am looking at an eye that appears to be 12 inches to 18 inches across. This gives me a sense that everything I am doing is more readily available. The epiretinal membrane seems more approachable. A retinal detachment seems easier to repair.”

As an example, Dr. Moshfeghi described one of his first cases using the digital system. “I specifically chose more challenging cases because I wanted to give the technology a workout,” he says. “I had a sticky, adherent internal limiting membrane that was shredding and coming up in tiny pieces rather than a nice sheet. When this happens, not only is it a frustrating occurrence, but the work becomes quite tedious. The tedium adds mental anguish, which causes stress, which causes unhappiness. Using this system, I was able to easily identify the plane using the enlarged super-anatomic image on the monitor, and because I could easily see the membrane, the task became less tedious. Anything that can help me maintain a positive state of mind makes the whole day better.”

An advantage that Dr. Williams appreciates is the ability to show diagnostic imaging side-by-side with the live surgical field. “I can view my preoperative optical coherence tomography and angiogram on the screen while I am operating,” he says. “There is the potential for integration with other imaging technology. I do not have personal experience with intraoperative optical coherence tomography but that would be an obvious synergy. I think going forward the technology will be very flexible for us as we get better intraoperative imaging technology.”

**DIGITALLY ENHANCED ILLUMINATION AND COLOR FILTERS**

Noting that retinal phototoxicity is a concern with the use of xenon-based fiber optic endoillumination light sources, researchers recently conducted a pilot study to correlate endoillumination levels used during ocular-free vitreoretinal surgery to subjective digital image quality and 3D display luminous emittance. They concluded that a 3D digital platform with real-time digital processing and automated brightness control may allow for reduced intraoperative endoillumination levels and a theoretically reduced risk of retinal phototoxicity during vitreoretinal surgery.

“As a surgeon, I believe more light is always better, but I am very cognizant of the potential for toxicity, particularly when using dyes in the eye,” Dr. Moshfeghi says. “With the Ngenuity system, I can digitally enhance the image on the screen, which allows me to lower the light from the vitrectomy machine. I was using 7% illumination going in from the vitrectomy machine but getting the equivalent of 35% to 45% on the monitor, which is quite remarkable. This gives us greater ability to bring the light source closer to the retina with less fear of inducing toxicity.”

Dr. Williams also appreciates this benefit when using a wide-angle viewing system. “I find the binocular indirect ophthalmomicroscope (BIOM; Oculus Surgical) viewing system with HD lens works quite well with the Ngenuity system,” he says. “The technologies are complementary. For example, the ability to decrease illumination and increase the camera gain often diminishes problems with glare during fluid-air exchange, particularly in phakic eyes. The HD lens of this microscope provides excellent 130-degree peripheral visualization and high resolution.”

The digital 3D visualization system also enables surgeons to enhance tissue planes by adjusting light balance and contrast and applying digital filters of various colors. For example, a red-free mode may be beneficial when peeling the internal limiting membrane.

“We can toggle between the different digital filters to enhance visualization of whatever membrane or tissue we wish to view,” Dr. Moshfeghi says.

Dr. Nadal notes, “The vitreous can be difficult to identify, so I particularly appreciate that I can apply a blue tint digitally by amplifying the blue gain. This is extremely useful for shaving the vitreous base.”

**IMPROVED DEPTH OF FIELD**

The 3D digital imaging offers increased depth of field and a greater panoramic view, which is distinctly different from the view through a traditional analogue microscope’s oculars (Figure 3).

“This is an important advantage for retina surgeons, particularly when we perform difficult surgeries, such as pars plana vitrectomy for proliferative vitreoretinopathy,” Dr. Nadal says. “In my experience, this system excels when I am using the bimanual technique for membrane peeling in diabetic cases and proliferative vitreoretinopathy.”

Dr. Williams also has found this aspect of the digital 3D system to be particularly beneficial.
system advantageous. “When I am working on the retinal surface, the depth of field with the Ngenuity system is better than when I use the microscope,” he says. “That allows me to be more precise in my dissections.”

Dr. Williams notes a substantial portion of his practice involves management of dislocated intraocular lenses. “Many of the patients I see are referred to me with anterior segment complications resulting in retinal complications,” he says. “I find the Ngenuity’s depth of field to be quite beneficial as I am managing anterior segment issues.”

DIGITAL MICROSCOPY COMFORT

Confident that the 3D system provides exceptional visualization, comparable to and sometimes better than the traditional surgical microscope, surgeons are finding the ergonomics of the system remarkable.

“Beyond the visualization and the magnification, the number one advantage for me is the comfort,” Dr. Moshfeghi says. “When using the surgical microscope, as the day goes along, your posture gets worse and worse, as you lean over the scope, trying to focus and be totally in the moment. At the end of a day in the OR, I typically come out feeling mentally drained and physically worn out, because of the stress it puts on your body. After a day using the Ngenuity system, I came out of the OR feeling like I could do more, and it was awesome.”

As Dr. Williams explains: “The ergonomics are based on the fact that you do not have to position yourself in relationship to the microscope. You can literally sit back and assume a more comfortable position. When we use a microscope, the position of the microscope is always fixed, so that we have to contort ourselves to fit the microscope, a position we may have to maintain for an hour or more. When we do not have to do that, we can be in a more comfortable position. This is particularly beneficial for surgeons who have back or neck problems.”

Dr. Moshfeghi notes, “Obviously, it is an extender of your surgical day, but it also may be an extender of your surgical career.”

SURGEON ADAPTATION

The introduction of a new surgical instrument or technique is usually followed by a period of adaptation, and this is true with the Ngenuity system. Concerns about an extended learning curve and potential negative effects on outcomes in vitreoretinal surgeries appear to be unfounded. An analysis of 32 consecutive cases—18 with an analogue microscope and 14 with the digital system—found no increase in surgical times or complication rates.6

“Everyone is concerned about transitioning to a new technique,” Dr. Williams says. “By our nature, we get comfortable with what we do. Frankly, that was my biggest concern before I tried the technology. I was pleasantly surprised how seamless the transition was. I found learning how to use the technology to be almost intuitive. Literally within a few cases, I felt like I had made the transition.”

Dr. Williams says his fellows and partners also adapted quickly. “I believe most surgeons will become quite comfortable with it within 10 or fewer cases. The fact that it is different may be somewhat uncomfortable, so you have to rethink some of your surgical reflexes that you have developed over a career. But I found the transition was not a significant issue at all.”

GETTING AN EDGE

Dr. Moshfeghi places the new digital system on par with other major advancements in the retina subspecialty. “When I look at vitrectomy right now, small-gauge surgery is an obvious advancement, as are wide-angle visualization and valved cannulas,” he says. “The use of dyes and steroid to enhance our view of retinal tissue and vitreous also gives us an advantage. I place the Ngenuity 3D visualization system in the same category as these advances.”

Dr. Nadal concurs. “The Ngenuity system is a very effective surgical system whose use, in my opinion, will definitely increase in the future.”

Dr. Williams agrees. “This is one of the most exciting technologies I have seen in my 30 plus years in vitreoretinal surgery,” he says. “As surgeons, we are always looking for ways to get an edge in the OR, and I think this technology will give us that edge.”

1. Riemann CD. Machine vision and vitrectomy: three-dimensional high-definition video for surgical visualization in the retina OR. Poster presented at: American Academy of Ophthalmology annual meeting; October 17, 2010; Chicago, IL.
5. Thornton S, Adam MW, Ho AC, Hsu J. Endoillumination levels and display luminous emittance during three-dimensional heads-up vitreoretinal surgery. Poster presented at: Association for Research in Vision and Ophthalmology annual meeting; May 4, 2016; Seattle, WA.
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