Three-dimensional, digitally assisted visualization systems are enhancing optical microscope-based approaches to vitreoretinal surgery. Besides the clear advantages of the 3-D technology over the traditional approach—4,000-pixel (4K) monitor, decreased light phototoxicity, digital enhancements, improved depth of field, digital filtering and high-dynamic range—these platforms can be integrated with other commercially available visualization systems.

Available 3-D systems include:

- Ngenuity 3-D Visualization System (TrueVision Systems and Alcon);
- Trenion 3-D HD (Carl Zeiss Meditec); and
- BV800 Viewing System (Leica Microsystems).

Currently, Ngenuity offers all the described features, including integration of endoscopy and intraoperative optical coherence tomography.

At a debate during the American Academy of Ophthalmology’s Retina Subspecialty Day last year, the audience voted on whether 3-D digitally assisted vitreoretinal surgery is ready to become the new standard. Although the audience voted largely no, the arguments were based only on image quality and teaching advantages. The digital integration with other technologies, though, is something unprecedented in our field, especially with regards to endoscopic vitrectomy. Here, we report on the state of the art of 3-D digitally assisted platforms in vitreoretinal surgery.

Evolution of Endoscopy

Harvey Thorpe, MD, first described endoscopic ocular surgery in 1934, well before pars plana vitrectomy became the gold standard in vitreoretinal surgery. In the early 1990s, Martin Uram, MD, at New York Eye and Ear Infirmary, introduced endoscopy to the vitreoretinal world. Despite slow initial progress (Continued on page 29)

**Take-home Point**

It’s a propitious time to incorporate endoscopy as a tool in vitreoretinal surgery. New three-dimensional technologies offer the possibility of integrating multiple visualization systems. Combined with the latest technologies, these systems should encourage experienced surgeons that have tried endoscopy in the past to try it again and younger surgeons to adopt it as well. This article reviews the advantages of endoscopy with a 3-D digitally assisted visualization system.

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in the developing this technology, it evolved toward the higher-resolution (17,000 pixels) and smaller-gauge probes (23-gauge in North America [Endo Optiks E2 endoscope platform, Beaver-Visitec International Inc.] and 25-ga in Japan [FiberTech Co. Ltd.]). This advance in technology made endoscopy more attractive to vitreoretinal surgeons.

However, endoscopic vitrectomy is still only being adopted by a few retina specialists. The learning curve can be steep, and a misconception exists that endoscopic vitrectomy has only a limited number of indications.

Advantages of Endoscopy

The advantages of endoscopy in cases of media opacity, such as cloudy cornea, trauma or endophthalmitis are well known, and it’s accepted as an alternative to temporary keratopros-
thesis or “blind vitrectomy.”

Surgeons unfamiliar with endoscopy may be unaware of the advantages of visualizing structures between the ora serrata and the retro-iridal space. Scleral depression or other technologies, such as the Topcon OMS-800 OFFISS microscope visualization system available in some countries, allow us to access the far periphery of the retina up to the ora serrata for shaving the vitreous base or peeling membranes. But they poorly visualize more anterior anatomical structures, which could aid in recognizing and diagnosing underlying pathology. We don’t know what we don’t know.

The availability of small-gauge endoscopy probes represented a big step forward. One of the advantages of a small-gauge endoscope is that it allows the surgeon to switch hands and reposition from superior to temporal trocars when he/she needs to address pathology in different locations.

In addition, valved small-gauge trocars also help maintain the fluidics control in more complex cases, representing an advantage over the larger-gauge trocars (19- and 20-ga) that glaucoma specialists use for endocyclophotocoagulation. The indications in clear media further extend the indications when media opacity is present (Table).11-17

Besides the limitations of straight small-gauge instruments when working in the far periphery, endoscopic visualization does pose some challenges for the newcomer. They include poor image resolution and limited

<table>
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<th>Table. Indications for Endoscopic Vitrectomy</th>
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<tr>
<td><strong>Media Opacity</strong></td>
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<tr>
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<td>- Endophthalmitis</td>
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<td>- Globe rupture</td>
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<td>- Intraocular foreign body</td>
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<td><strong>Clear Media</strong></td>
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<td>- Anterior proliferative vitreoretinopathy</td>
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<td>- Fibrotic posterior synechiae/small pupil</td>
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<td>- Giant retinal tears: trimming of the anterior flap</td>
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<td>- Large retinectomies</td>
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<td>- Hypotony</td>
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<td>- Intraocular lens instability/ subluxation/fixation</td>
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<td>- Proliferative diabetic retinopathy and neovascular glaucoma</td>
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<td>- Retained lens fragment/chronic cystoid macular edema</td>
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<td>- Retained silicone oil</td>
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<td>- Secondary intraocular lens implantation</td>
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Figure 1. Images show secondary intraocular lens implantation with sutureless intrascleral IOL fixation. The split screen from the Ngenuity 3D Visualization System combines wide-field visualization (A) and endoscopic view (B) using a 19-gauge endoscope through the corneal wound in an aphakic eye. During needle insertion, the endoscope confirms the intraocular entrance posterior to the ciliary processes. The first haptic is externalized with the 27-ga needle (C). Intraoperative optical coherence tomography (D) confirms the position of the intrascleral haptic (arrow).
How 3-D Endoscopic Vitrectomy Can Fit in Three Practice Scenarios

**For Experienced Surgeons.** Many experienced surgeons have tried endoscopy in the past and given up because of its difficulties. Now seems to be a friendlier time to give it another try. The more experienced surgeons embrace the technology, the more companies will be willing to invest on the field, and the more likely that endoscopy becomes a routine procedure in university-based hospitals. And the better the technology gets, the safer and more efficient it becomes, even for ambulatory surgical centers.

**For Teaching Surgeons.** The 3-D digitally assisted systems are ideal for teaching institutions. Attendings can control the cursor on the monitor and show exactly where he/she wants the fellows/residents to be. For the fellows first trying endoscopic vitreoretinal surgery, we recommend starting with silicone oil removal. Many times after we remove silicone oil, even after sequential fluid-air exchanges, multiple residual oil bubbles remain trapped behind the iris and on the anterior vitreous base. Endoscopy facilitates complete removal of all remaining droplets. Another clear advantage of this system is the video quality. What you see on the screen is what will appear in the same time the endoscopic image and the wide-field 3-D viewing as an endolitigator (Figure 2).

The most challenging aspects in learning endoscopic vitrectomy include having the right orientation,
being aware of the distance from ocular tissues and positioning the intraocular instruments. Traditionally during endoscopy, if the surgeon is struggling to find where the instruments are during the endoscopic view, one has to go back to the microscope to confirm the position or feel comfortable with the view. This takes a few seconds and annoys surgeons because of the need to readjust when they switch from the microscope to the endoscopy monitor and back.

However, the split-screen feature can allow the surgeon to skip this step because this information is readily available at any time during the surgery. Using the Ngenuity cursor, you can activate the split-screen feature, allowing simultaneous viewing of endoscopy and a wide-field 3-D image (Figure 3). In addition, new Ngenuity Datafusion software integrates the Constellation Vision System (Alcon), which allows surgeons to track key data parameters (intraocular pressure, flow rates, infusion pressure and laser power) in real-time, and offers additional functionality that allows for customization.

Using 2-D viewing in a 4K, 3-D platform substantially improves image quality and allows a better detection of tissue planes despite the inherent limitations of fiber optics in a small-gauge probe, although the stereopsis doesn’t change. The lighting systems in endoscopy tend to cause glare, although digital image enhancement can reduce the glare and confer additional advantages to this system.

Looking Ahead
The application of a 3-D digitally assisted imaging system to vitreoretinal surgery is one of the latest and most promising advances in our field. Combining improved image performance with technologies such as endoscopic vitreoretinal surgery, intraoperative OCT and video overlay features should help improve surgical precision and, ultimately, outcomes for our patients.

REFERENCES