Highlights from

The Advanced Vitreoretinal Techniques & Technology Symposium in Hong Kong
Introduction

On June 27, 2008, a group of thought leaders in the global retina community assembled at the Shangri-la Hotel in Hong Kong as faculty for the symposium "Advanced Vitreoretinal Techniques & Technology," or AVTT. This meeting, held prior to the start of the 2008 World Congress of Ophthalmology and sponsored by Alcon Laboratories, Inc., was well attended and featured several exciting presentations on vitreoretinal surgical techniques.

The faculty included esteemed doctors and professors from China, Korea, Indonesia, India, Australia, Hong Kong, Singapore, Taiwan, and the United States. The presentations featured a wealth of surgical videos and attendees surely benefited from the exciting techniques and information on new technology that was shared.

This supplement to Retina Today highlights some of those key points of the presentations. Further, the full presentations, videos, and slide sets will be posted on the retina channel of Eyetube.net, the video resource Web site produced by Bryn Mawr Communications, publishers of Retina Today.

I would like to thank Alcon Laboratories, Inc., for their support of this important medical education opportunity.

– Professor Allen C. Ho
Chief Medical Editor, Retina Today

The Physics of Vitrectomy and Advanced Fluidics

How cutting rates affect flow and outcomes.

BY PROFESSOR STEVE CHARLES

High cutting rates are better because they minimize the travel of uncut collagen fibers through the port and produce port-based flow limiting. Port-based flow limiting decreases surge and, therefore, retina breaks after sudden dense epiretinal membrane deforms through the port. It also produces greater fluidic stability and subsequent decreased motion of detached retina, and less pulsatile traction on attached retina.

Pressure-mediated events, such as occlusion break in phacoemulsification and fragmentation, and surge from sudden elastic deformation of epiretinal membrane through the port, benefit from port-based flow limiting.

Port-based flow limiting is instantaneous, whereas a system that requires human reaction time (limited to 400 milliseconds) or fluid to flow all the way to the console and back down 7 feet of tubing is way too slow. Although fluidic resistance is good for a vitreous cutter, it is a disadvantage for infusion. As such, we must compensate in 25-gauge technology by having a higher force to overcome the 20 to 25 mm Hg of loss that occurs in the infusion system because of resistance.

FACTORS AFFECTING PULSE AND FLOW

The parameters that affect pulse flow and flow rate include the following: cutting rate, port size, duty cycle, lumen size, and vacuum. Higher flow rates are less safe for surgery. Figure 1 shows the volume aspirated per cut with 20- vs 25-gauge surgery, with 20-gauge surgery producing much higher pulse flow.

It is important to make the distinction between cutting speed and cutting velocity. Cutting rate is measured in cuts per minute. The port diameter, vacuum
level, and cutting rate determine the average fiber travel per port open-close cycle, and therefore, determines the amount of vitreoretinal traction. The cutting rates are determined by four factors: valve dynamics, drive electronics, cutter friction, and moving mass.

Cutting velocity is measured in millimeters per second. The velocity at port closure is the only measurement that is relative to inertial cutting; however, inertial cutting has little relevance to vitreous cutters. The cutting velocity is determined by actuation pressure, cutter friction, moving mass, and spring rate.

Variable duty cycle produced by pneumatic cutters is preferable to a fixed cycle produced by electric cutters, largely because of the great difference in viscosity or resistance to mechanical deformation for (in order of lowest to highest resistance): (1) air, (2) perfluorocarbon, (3) balanced salt solution, (4) vitreous, (5) hemorrhage, (6) silicone oil, (7) dense epiretinal membrane or scar, or (8) sclerotic lens nucleus.

**TIPS ON TECHNIQUE**

The most technically accurate definition of efficiency in vitreoretinal surgery is how much vitreous is removed per volume unit of infusion fluid. This is technique driven — whether the port of the cutter is actually in the vitreous vs sitting somewhere in the middle of the eye attempting to draw vitreous in.

In the past, slow-response fluidics and low cut-rate vitrectomy cutters for phaco technique is dependent on moving lens material away from capsule, vitreous, and iris. As a result of phaco training, surgeons often hold the probe in one place, expecting the vitreous to come to the port. I hear it said often “It’s not working. That’s why I hate 25 gauge; you can’t get the vitreous out.” My answer to that is if you have the probe 8 mm away from the vitreous, what do you expect?

The technique that surgeons should be using is to move the port to the vitreous, and always have the port advance while cutting. It is critical that the probe is never pulled back while vacuum is applied, as this will cause vitreoretinal traction. The three key steps to avoid vitreoretinal traction are:

1. always move the port to the vitreous;
2. always keep the port in the vitreous; and
3. always advance the cutter.

**HIGH CUTTING RATES OPTIMAL**

It is my opinion that the fastest possible cutting rate is best for all tasks and all cases. The cutting rate should only be reduced if the delaminated epiretinal membrane or some other dense material is not coming through the port.

Finally, the vitreous is a highly nonlinear material with a filamentous network of hyaluronan and a collagen

<table>
<thead>
<tr>
<th>Year</th>
<th>Device/Procedure</th>
<th>Speed (cpm)</th>
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<tbody>
<tr>
<td>1970</td>
<td>Robert Machemer VISC</td>
<td>1971</td>
</tr>
<tr>
<td>1976</td>
<td>Machemer 2nd Gen VISC</td>
<td>1973</td>
</tr>
<tr>
<td>1983</td>
<td>Storz MicroVit Probe 400 cpm Steve Charles, MD &amp; Carl Wang, PhD</td>
<td>1985</td>
</tr>
<tr>
<td>1997</td>
<td>Accurus Probe 800 cpm</td>
<td>1998</td>
</tr>
<tr>
<td>2002</td>
<td>Enhanced Accurus Probe 2,500 cpm B&amp;L 25ga Cutter Tips 1,500 cpm Eugene de Juan, Jr. MD</td>
<td>2004</td>
</tr>
<tr>
<td>2005</td>
<td>DORC 23-gauge Probe 1,500 cpm Claus Eckardt, MD</td>
<td>2006</td>
</tr>
<tr>
<td>2008</td>
<td>Ultravit 20, 23, 25 gauge 5,000 cpm</td>
<td></td>
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Vitreoretinal surgery has experienced an astounding evolution since the 1960s, when vitrectomy was performed with a cellulose sponge and manual scissors (see Timeline, page 2). Even with significant advances in vitreoretinal surgical technology, however, a need for new advances remains. Since the introduction of microincision vitrectomy surgery (MIVS), surgeons have been requesting stiffer 25-gauge instrumentation and better fluidics, improved one-step trocar cannula incisions, and ultra high-speed cutting ability.

Alcon Laboratories, Inc., (Fort Worth, TX) has been developing a new vitrectomy system, which will be available shortly, the Constellation. The new probe on the Constellation, the UltraVit, differs from the Accurus probe in design, specifically, the probe actuation system.

**S P R I N G M E C H A N I S M**

The Accurus probe utilizes a spring-loaded system, where air pressure come in and fill the space behind the diaphragm. That pressure builds and pushes the diaphragm closed against the spring, the diaphragm is connected to a cutter needle through the cannula of the instrument. When it moves forward, it makes the cut at the port. The pressure is then released through the same channel and the return spring pushes the diaphragm back against the pressure.

The changes that have been made to the design of the UltraVit probe include a dual pneumatic actuation and the elimination of the return spring. As is seen in Figure 1, there is a similar access route for pressure. The pressure comes in through the connector, fills the space behind the diaphragm, and pushes that diaphragm forward. At the same time that the pressure is released, pressure is channeled through a second line that comes around to the other side of the diaphragm, pressurizes the opposite side, and pushes the diaphragm back in place. The action of alternately pressurizing the first and second connector causes the diaphragm to go back and forth and operates the cutter.

**H I G H E R C U T R A T E S A N D I M P R O V E D D U T Y C Y C L E S**

The UltraVit is capable of cut rates up to 5,000 cpm vs 2,500 cpm on the Accurus. The linear travel of the collagen fibers is reduced when cutting at a higher cut rate. The length of this travel of collagen fibers may correlate to the amount of traction on the retina. The objective of high cut rates is to reduce pulsatile vitreoretinal traction.

When the Accurus probe is operating at a low 500 cpm, the port open duty cycle is operating at approximately 80%. As the cut rate is increased, the duty cycle linearly decreases down to about 28% at the maximum cut rate of 2,500 cpm. In contrast, the UltraVit technology has a much higher port open duty cycle. At 2,500 cpm, the duty cycle is increased from 28% up to just a little bit over 70%, making the flow rate twice as high as the Accurus. At 5,000 cpm the port open duty cycle remains above 50%, which is just shy of twice the flow rate at twice the cut rate (Figure 2).

In contrast, an electric cutter operates from 500 cpm to 1,500 cpm with a fixed 50% duty cycle. Additionally, we can create a 3D mode where the duty cycle is changed instead of the cut rate of the probe (eg, constant 2,500 cpm with duty cycle varying between 30% to approximately 70%).

**S U M M A R Y**

The evolution from open-sky vitrectomy procedures to MIVS and high cut rates exemplifies the tremendous advances in vitreoretinal surgery. With better cutting, fluidics, smaller incisions and stiffer MIVS instruments, surgeons and their patients will benefit from more precise and safe procedures.

**ADVANCING THE TECHNOLOGY OF A PRESENT DAY VITRECTOMY SYSTEM**

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**Figure 1. The UltraVit pneumatic-driven cutter.**

**Figure 2. The relationship between cut rate and duty cycle on the Accurus, UltraVit, and electric cutters.**

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**Professor Steve Charles is Founder of the Charles Retina Institute in Memphis, TN, and is Clinical Professor in the Department of Ophthalmology, at the University of Tennessee College of Medicine. He is a consultant for Alcon Laboratories, Inc. Professor Charles can be reached via e-mail: scharles@att.com.**
In 1970, Robert Machemer, MD, developed the vitreous infusion suction cutter (VISC), an endoilluminated instrument for removal of the vitreous via a 3.3-mm opening in the pars plana. The VISC was a heavy instrument, when compared with today’s cutters, but allowed for surprisingly fine surgical technique. In the mid-1970s, the octome vitrector was introduced with a three-port, 20-gauge, 1-mm incision and this became the standard for vitrectomy for the next 30 years.

Twenty-three–gauge technology first debuted with the 23-gauge Visitec cutter (BD Medical, Franklin Lakes, NJ), followed by a 23-gauge system that I introduced in 1995. It was not until 2001, however, when Eugene de Juan, MD, introduced the transconjunctival 25-gauge sutureless vitrectomy system that microincision surgery began to take root in vitreoretinal surgery. This was followed in 2003 by a 23-gauge sutureless vitrectomy system developed by Claus Eckhardt, MD. Now, in 2008, microincisional vitrectomy surgery (MIVS) has become the new standard.

MIVS: 23 AND 25 GAUGE

A smaller incision offers the main advantages of greater postoperative comfort for the patient, a faster recovery time, and fewer postoperative medications, which is particularly advantageous, because as many as 30% of our patients may have adverse reactions to topical steroids. The disadvantages of small-gauge surgery include a lower level of efficiency as seen with the 25-gauge cutter, more flexible and fragile instrumentation, and adverse side effects that appear to be more frequent with 25-gauge vitrectomy: hypotony and endophthalmitis.

My experience is with both 23- and 25-gauge surgery using the Accurus vitrectomy systems (Alcon Laboratories, Inc., Fort Worth, TX). Twenty-three–gauge instrumentation has resolved many of the issues with 25-gauge surgery. I am able to use 23 gauge for both my straightforward and my more challenging cases and so generally prefer it.

For operating on eyes with large filtering blebs, however, such as in patients with macular pucker, I believe that 25 gauge is preferable because it is smaller and less invasive, allowing for preservation of the bleb. Very few filtering blebs survive 20-gauge surgery, but using a 25-gauge approach preserves the anatomic features of the bleb with minimal changes to its size. Although a 23-gauge wound is smaller than 20 gauge, it is still a larger opening that at times requires suturing.
EASE IN TRANSITION

In transitioning to MIVS, the main limitation to 25-gauge surgery lies in the flexibility and fragility of the instruments. To answer this problem, Alcon is planning to introduce shorter instruments that are stiffened at the hub of the junction with the handle.

Currently, the easiest way to transition to 25-gauge surgery is to do so in the setting of combined phaco/IOL and vitrectomy procedures.

Dr. Stanley Chang is Director of Ophthalmology, Columbia University Medical Center New York Presbyterian Hospital and Edward S. Harkness Professor of Ophthalmology, K. K. Tse and Ku Teh Ying Professor of Ophthalmology. Dr. Chang is also Chairman of the Department of Ophthalmology at Columbia University College of Physicians and Surgeons in New York. He states that he is a consultant and speaker for Alcon Laboratories, Inc.

Constructing a Wound for MIVS

This step is critical for successful outcomes.

BY PROFESSOR ALLEN C. HO

Microincisional vitrectomy surgery (MIVS) refers to transconjunctival sutureless vitrectomy surgery that is smaller than 20-gauge. The shift to smaller incisions began when 2-mm and 3-mm incisions used in the 1970s with the vitreous infusion suction cutter (VISC) were reduced to 0.9 mm with 20-gauge pars plana vitrectomy (PPV). Incisions were further reduced by almost a half a millimeter to 0.6 mm with 25-gauge technology, which was first introduced by Bausch & Lomb (Rochester, NY). Twenty-three–gauge vitrectomy was introduced by Dutch Ophthalmic Research Center (DORC; Zuidland, The Netherlands), to answer complaints of fragile and over-flexible 25-gauge instrumentation. The incision size for 23-gauge vitrectomy is only slightly larger at 0.75 mm. Alcon Laboratories, Inc. (Fort Worth, TX) followed by introducing its MIVS platforms, in both 23- and 25-gauge.

The potential advantage to MIVS include less tissue trauma, decreased postoperative inflammation, increased patient comfort, faster visual recovery time, decreased corneal astigmatism, and shorter intraoperative duration. My personal preference for MIVS is 23-gauge vitrectomy using the Accurus (Alcon Laboratories, Inc.). The external probe diameter is sufficiently small at 0.64 mm, and the cut rate of 2,500 cpm is identical to 20-gauge technology, and the flow rate is similar. Additionally, the location of the 23-gauge port from the tip is 50% closer than with 20-gauge probes. The increased rigidity of the instrumentation helps to answer any control problems due to the overflexibility of 25-gauge instrumentation.

The basic components to wound architecture include conjunctival displacement, globe fixation, angled scleral incision, a specific closure technique, and routine use of subconjunctival antibiotics.

CONJUNCTIVAL DISPLACEMENT AND GLOBE FIXATION TECHNIQUES

One of the key components of an incision for sutureless surgery is to have a mismatch between the conjunctival and scleral entry. If these two wounds are aligned, it
will allow egress of vitreous (hypotony) or possible ingress of bacteria (endophthalmitis).

Figure 1 shows stabilization with calipers, which is important because in 23-gauge surgery, there is significant motion rotationally as the eye is being driven circumferentially downward into the socket. Another way to fixate the eye is to displace the conjunctiva with a cotton tip, which is shown in Figure 2.

There are a variety of instruments for stabilizing the eye. The Fine-Thornton 13-mm ring (Katena Instruments, Denville, NJ), seen in Figure 3, has little teeth and swivels on the underside. I use the Fine-Thornton Ring for patients who have softer eyes, high myopia, or previous surgery. I also use it for cases of reoperation and deep-set eyes, where extra purchase is required.

Other instruments with which I have experience for globe stabilization include the 23-gauge MIVS stabilization plate and the Dugel MIVS Entry Plate (Figures 4 and 5). The angled incision should be longer in the sclera, as opposed to a short wound that would go directly through the sclera. If trocar is angled, the cannula hub will not be perpendicular to the sclera as the trocar is removed; rather, it will be tilted, reflecting the architecture of the wound. The longer the angled incision is, the better it seals.

**WOUND CLOSURE**

For wound closure, I use a partial air fill for most cases, per the recommendation of Steve Charles, MD. For cannula removal, I use a technique that I learned from David Boyer, MD. I insert a solid instrument through the cannula system, so that when the cannula is disengaged, it is not hollow and no vitreous can come through. I then massage the wound. Initially, I used a cotton tip, but I have switched to a solid instrument such as a muscle hook.

I then reposit the conjunctiva to create the mismatch of the conjunctival wound and the scleral wound. If a leak exists, bubbles will be visible both through the scleral wound and subconjunctivally; try to massage the wound to stop the leak, but keep a low threshold for placing a single tranconjunctival and transscleral suture to ensure closure if necessary. After I massage the wound closed, I remove the infusion cannula leaving the infusion on and supporting the globe throughout this time. I place a forceps adjacent to the infusion cannula to support the eye...
wall as I remove the infusion cannula. With no support, the globe is at risk for eversion, which would result in subsequent wound leakage. After all of the instruments are removed, I repeat the massage technique.

To prevent infection, I always use subconjunctival vancomycin because most organisms responsible for postoperative endophthalmitis are sensitive to vancomycin. I will usually also inject subconjunctival steroid.

When finishing a 23-gauge vitrectomy case with the Accurus, the wound may appear oval in shape.

**MULTICENTER 23-GAUGE MICROINCISION VITRECTOMY STUDY**

My colleagues and I performed a multicenter, multisurgeon study\(^1\) that looked at the short-term safety and efficacy of 23-gauge vitrectomy. One hundred and twenty-one patients undergoing pars plana vitrectomy for a variety of retinal conditions were enrolled. For the study, a MIVS technique was employed, using conjunctival displacement, globe stabilization, and angled incision, 10\(^\circ\) to 30\(^\circ\) from the scleral tangent. The main outcomes of the study were visual acuity, intraocular pressure (IOP), and postoperative complications (hypotony, wound leak or bleb, retinal tears, endophthalmitis, or vitreous hemorrhage).

The short-term follow-up showed favorable visual acuity results and stable IOP (Figure 6). There was a low rate of complications among those patients followed, including no cases of endophthalmitis.

In summary, MIVS has several benefits to the patient and the surgeon. The learning curve with 23-gauge largely exists outside the eye. Wound construction is important, as described above. Once inside, 23-gauge surgery is similar, if not identical, to 20-gauge vitrectomy. The learning curve for 25-gauge surgery, however, exists inside the eye, although efforts are underway to improve the rigidity and illumination issues that currently make it a more difficult MIVS technique.

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**Requirements for 25-gauge MIVS**

**BY DR. SJAKON GEORGE TAHJIA**

The benefits to 25-gauge vitreoretinal surgery are, in my opinion, patient comfort and speed of the procedure, compared with 20-gauge surgery. The ability to perform procedures quickly under local anesthesia makes a big difference in many cases, there is minimal trauma to the sclera and the conjunctiva, and no patch is required the day following surgery. Additionally, 25-gauge surgery is ideal for combination with phaco. From the standpoint of practice management, it is important that vitreoretinal surgeons learn how to perform microincisional vitrectomy surgery (MIVS) in order to keep up with technologies that are being offered to patients. Analogous to this situation is the cataract surgeon who is performing extracapsular cataract extraction while the surgeon down the road is performing phaco.

**SPECIAL CONSIDERATIONS WITH 25-GAUGE INSTRUMENTS**

Some factors that deserve special consideration when discussing technology include the small port of the 25-gauge probe, illumination issues, the limited availability

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**Figure 6.** The short-term follow-up showed favorable visual acuity results (A) and stable IOP (B).
of 25-gauge instrumentation in some parts of the world, single-use components, and the need for making watertight sclerotomy wound closures.

Small port. For the smaller port on the 25-gauge probe, I have compensated by using a maximum vacuum of 600 mm Hg, 37 mm Hg to 44 mm Hg infusion pressure. Additionally, I use a cut rate of 1,300 cpm or faster for vitreous—the cut rate can be lowered to 1,000 cpm or slower to remove pieces of epinucleus.

Lighting. Endoillumination is important with 25-gauge vitrectomy. Halogen lighting is insufficient; xenon lighting is a better option for 25-gauge procedures. Due to its smaller lumen, it requires a brighter light source than 20 gauge.

Available 25-gauge instrumentation. Instrument availability can also be an issue with 25-gauge vitrectomy. Currently, a 25-gauge fragmatome is not available and silicone oil injection/extraction can take significant time. On the other hand, endodiathermy can easily be performed using a laser probe on continuous mode, or aspiration can be achieved using the vitrectomy probe. For perfluorocarbon, indocyanine green, or trypan blue, I recommend using a straightened corneal cannula. If necessary, one of the 25-gauge sclerotomies can be enlarged to 20 gauge to finish vitrectomy with 20-gauge instruments.

The good news is that there are now 25-gauge Grieshaber DSP (Alcon Laboratories, Inc.) instruments newly available: the Active Backflush soft tip, internal limiting membrane (ILM) forceps, and scissors.

Disposable instruments. In general, disposable instruments for 25-gauge vitrectomy should not be reused, simply because they were not designed for multiple sterilization and reuse. Many of us have had success with reusing 20-gauge instruments, so this is an important consideration. Specifically, a disposable 25-gauge vitrectomy probe that is reused will not function well. The performance of forceps designed for single use will deteriorate with each additional use. Finally, active backflush soft tips are difficult to clean, thus should not be reused.

Tight sclerotomy seal. I always use angled entry, as in 23-gauge procedures. Before slowly pulling out the cannula, I lower the pressure. After the cannula is out, I apply pressure on the wound with the tip of a muscle hook, and then smooth the conjunctiva over the sclerotomy. Finally, in cases of previous vitrectomies, in which silicone oil has been used, or where I suspect a leak, I use a 8.0 absorbable suture.

SURGICAL EXPERIENCE

The Table shows my preference for a variety of vitreoretinal cases in terms of 25 gauge vs 20 gauge. I use 25 gauge alone or in combination for most cases, except for complex retinal detachments, for which I feel more comfortable using 20-gauge instrumentation. There continues to be a learning curve with 25-gauge technology, but the benefits are significant, and as I gain experience, the techniques and steps required become easier.

Dr. Sjakon George Tahija is the Vitreoretinal Consultant and Medical Director at the Klinik Mata Nusantara, Jakarta, Indonesia. Dr. Tahija states that he has no financial relationships to disclose. He can be reached via e-mail at sgtahija@austindo.co.id.

### Table 1. Preferred Gauge for Individual Surgical Cases

<table>
<thead>
<tr>
<th>Surgical Case</th>
<th>Preferred Gauge</th>
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<tbody>
<tr>
<td>Premacular Membranes</td>
<td>Always 25 gauge</td>
</tr>
<tr>
<td>Vitreous Hemorrhage</td>
<td>Always 25 gauge</td>
</tr>
<tr>
<td>Simple Detachments</td>
<td>Sometimes 25 gauge</td>
</tr>
<tr>
<td>DR</td>
<td>25 or combo 25/20 gauge</td>
</tr>
<tr>
<td>ROP: Stage 4B</td>
<td>25 gauge</td>
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<tr>
<td>Dropped Nucleus</td>
<td>25 gauge or 20 gauge</td>
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<tr>
<td>Endophthalmitis</td>
<td>25 gauge</td>
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Macular Hole Surgery: 20 vs 25 gauge

Internal limiting membrane peeling *au naturel.*

**BY DR. ROBERT BOURKE**

As a result of my early experiences with macular hole surgery and subsequent success with internal limiting membrane (ILM) peeling, I took a relatively mechanistic approach and became an advocate of ILM peeling for all cases. My motto from 1995 has been “peel it and seal it.” In the 1990s, not many surgeons were performing ILM peeling. Rather, most were inducing a posterior vitreous detachment and...
using air tamponade, which requires a patient to be face down for 3 to 4 weeks—a solution I find to be unacceptable for my patients.

In this article, I will review the approaches to closing macular holes and present a case for why the ILM provides the answers needed for success. I will also review my technique for ILM peeling au natural, unaided by visualization tools.

TECHNIQUE

To peel the ILM in macular hole cases, I first perform my core vitrectomy and induce a posterior vitreous detachment with 25-gauge vitrectomy probe. In the earlier cases in this series, I used either a 20-gauge bent MVR blade or a standard 25-gauge needle to create and edge to the ILM, after which I pick up the edge with Grieshaber DSP ILM forceps and remove the membrane. In the past couple of years, my technique has been to pick up the ILM directly with the forceps.

When performing ILM peeling au natural, I use either a 25-gauge needle or simply forceps. It is important to be aware of visual cues when peeling au natural. For example, if using the needle, the ILM should be engaged and pushed forward and upward. The ILM may “twang” a bit, almost like a guitar string. When the ILM is engaged, a V-shaped striae will be visible behind the tip of the forceps, behind the tip of the needle. The edge is more easily visualized at this point. Visual cues that aid in confirmation that the ILM has been successfully peeled include a color difference where the membrane has been peeled, and a diaphanous mosaic-like appearance can be seen with transillumination.

To peel the ILM, I recommend using forceps (Grieshaber ILM 25-gauge forceps, Alcon Laboratories, Inc.) Peeling should begin at the free edge or the most convenient location away from the hole, outside the maculopapillary bundle and preferably not over the retina vessel. Peeling should move toward the fovea, parallel with nerve fibers. Halfway through procedure, tearing should stop and remaining ILM half should be approached from opposite direction; radial excision can be considered if it is apparent that peeling at the hole’s edge is impossible.

Once I have complete ILM peeling, I check the posterior border vitreous space and perform a fluid-air exchange. The tamponade I use most (out of habit more than any other reason) is 8% perfluoropropane C3F8.

Postoperatively, I instruct my patients to remain postured facedown for 50 minutes out of every hour for 7 days.

CLINICAL EXPERIENCE

In 1995, 20-gauge surgery was the gold standard for vitrectomy surgery. During this period (1995-2007), I moved from the learning curve of 20-gauge ILM peeling for macular hole surgery to 25-gauge ILM peeling.

The au natural ILM peeling method was reviewed in three retrospective analyses of 536 macular hole cases, all performed by myself, with data collection performed by outside groups to evaluate the success of closing macular holes with unaided ILM peeling surgery. The first study was published in 1999 and evaluated 100 eyes over the
was significantly associated with the failure to seal one macular hole failed to seal out of 136 cases, which were sealed, which is a 97% closure rate. In era 3, in 100 eyes (95% closure rate), In era 2, 291 out of 300 eyes undergoing ILM peeling surgery with 25-gauge technology between 2004 and 2007 (era 3). Table 1 shows my success rates in each study. My complete peel success rate with both 20- and 25-gauge technology improved over time, and as the rates of failure to peel also improved, my learning curve dwindled.

ANATOMIC CLOSURE RATES

The anatomic closure rates in era 1 were 95 out of 100 eyes (95% closure rate), in era 2, 291 out of 300 were sealed, which is a 97% closure rate. In era 3, in which 25-gauge technology was exclusively used, only one macular hole failed to seal out of 136 cases, which was a 99.3% success rate.

In era 1, we found that the failure to remove the ILM was significantly associated with the failure to seal (P<.001). Additionally, we found that the learning curve for ILM peeling directly correlated to the failure to peel/seal, because the five failures all occurred within the first 35 cases in the first 20 months of the study. Hole closure was associated with better visual acuity, and there was no association with serum, type of tamponade, or duration of macular hole.

Era 2 represents the bridging period from 20 gauge to 25 gauge. There was no preselection for performing 25-gauge surgery on patients and there were no difference in outcomes seen between 20-gauge and 25-gauge surgery. During era 3, in which only closure rates with 25-gauge were reviewed, there was no significant outcome when compared with the second study of both 20- and 25-gauge surgery (P=.14).

VISUAL ACUITY OUTCOMES AND COMPLICATIONS

The visual acuity outcomes for all three eras are seen in Table 2. The lines of vision gained as well as lost improved from each era to the next. The mean visual acuity gain for the first era was 2.7 lines, and for the second and third eras the mean visual acuity gain was 4 lines and 3.3 lines, respectively.

The complication rates for each era can be seen in Table 3. In general, the rates of retinal detachments and intraoperative tears has decreased from era 1 to era 3. Loss of one line of visual acuity dropped from 9% of cases in era 1 to 1.47% of cases in era 3.

The most interesting finding from these cases involves reopening of the macular holes. I have had only three holes reopen in 536 cases, one in each era, with the first resulting from failure to peel the ILM. My experience seems to be quite different from what is seen in the literature, where a reopening rate of 4.5% to 9.5% has been reported. My hypothesis is that this translates to a better rate of sustained hole closure for cases where ILM peeling was performed.

OBSERVATIONS AND RECOMMENDATIONS

I recommend that surgeons be obsessive when peeling the ILM; check the posterior border of the vitreous base to decrease the risk of retinal detachment.

In contrast, one can be relatively relaxed regarding the fluid/air exchange. It is not necessary to aspirate out every last bit of fluid. For example, the port on the the 25-gauge vitrector is not as close to the tip as it would be on a backflush flute.

Postoperatively, it is important that the surgeon be aware of underlying cataract that may be causing decreased visual acuity. Additionally, the surgeon should take active prophylaxis against cystoid macular edema (CME) in the event of a cataract extraction. I recommend the use of an intravitreal steroid and monitoring with optical coherence tomography to enable early aggressive treatment of CME.

One of the factors that has slowed the transition from 20-gauge to 25-gauge surgery is the fear of hypotony. In my own experience, I have no cases of hypotony, and I do not believe myself to be particularly clever in my wound entry. I do, however, advocate air exchange for all cases of macular hole, believing that surface tension helps protect against hypotony. The improved trocar design on the 25-gauge Accurus system (Alcon Laboratories, Inc., Fort Worth, TX) has also helped make this transition easier.

The difficulties with overflexibility of the 25-gauge instrumentation are also undergoing improvements. For example, the new light pipes for 25-gauge surgery are approximately 75% stiffer than previous generations. Using effective techniques, such as peeling and sealing ILM removal au natural, can provide excellent outcomes with 25-gauge macular hole surgery.

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Retinopathy of Prematurity 
Stage 4: Buckle or Vitrectomy? 

BY PROFESSOR LI XIAOXIN

Retinopathy of prematurity (ROP) stage 4 is defined as partial retinal detachment and is divided into two subcategories: Stage 4A is an extrafoveal partial retinal detachment, and stage 4B is a fovea-off partial retinal detachment. The course of treatment for retinopathy of prematurity (ROP) stage 4A in particular gives rise to considerable controversy. The three main areas of argument are whether stage 4A ROP is progressive or regressive, whether coagulation is necessary in stage 4, and whether scleral buckle or vitrectomy should be used for treatment. In this article, I will discuss treatments choices and outcomes.

BACKGROUND
The natural course of ROP is seen in Figure 1. In stage 4 ROP, patients experience retinal detachment. The main cause of retinal detachment in stage 4 is undertreatment or lack of treatment with laser photocoagulation in stage 3 of the disease. The disease may also progress on its own to retinal detachment in spite of treatment that in most cases would be considered sufficient; this is most often seen in zone 1 ROP cases.

The pathogenesis for ROP Stage 4 is neovascularization regression to fibrosis, after which the vitreous condensation forms fibrosis tissue. This tissue traction extends from peripheral to the posterior pole of the retina, and causes vessel deformities (Figure 2) and retinal folds. The fibrosis shrinking causes a retinal tear in the coagulated area and induces combined traction-rhegmatogenous retinal detachment (Figure 3).

SURGICAL INTERVENTION
The goal in surgery for stage 4 ROP is to stop the shrinkage of fibrotic tissue and to stop the traction caused by fibrosis. Vitrectomy or scleral buckle can be used to treat ROP stage 4A. In the past, I have chosen to use a buckle in this early stage because it is a more simple procedure. Figure 4 shows scleral buckle at the time of surgery and 3 weeks postoperative. The angle has become smaller and lighter and despite the buckle, the eye later progresses to stage 4B (Figure 5).

I have changed my technique for stage 4A to use vitrectomy, which opens up the macula and the membrane and has produced more stability, in my experience (Figure 6).

TWENTY-FIVE GAUGE FOR ROP
I use a 25-gauge vitrectomy system (Accurus; Alcon Laboratories, Inc., Fort Worth, Texas) for ROP because the tissue of palpebrae is so small. Many infants at 31 weeks or 32 weeks gestation have large corneas which provide no space for entry with instruments of a larger gauge. The cornea of an adult eye is, on average, 12.0 mm and the many preterm infants corneas are 9.5 mm to 10.5 mm in size. Thus, I perform sutureless 25-gauge transcleral surgery for vitrectomies in ROP cases. I mostly use a cut rate of 1,500 cpm and a vacuum of 500 mm Hg. have also used vitrectomy for lens-sparing surgery for eyes in stage 4B with success.

I recommend that when performing a 25-gauge vitrectomy for stage 4 ROP, the parameters should be set as follows:
• low flow;
• low vacuum: 300 to 500 mm Hg;
• cutting technique: mince technique; ablation if necessary; avoid cutting clean; and
• cut rate: 1,500 cpm.
To prevent hypotony in these cases, I use a two-step scleral incision with an open conjunctiva, and I perform wound coagulation.

In summary, I have found that using 25-gauge vitrectomy for stage 4 ROP has resulted in better stability than scleral buckling. Therefore, I recommend this surgical technique over a scleral buckling procedure.

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The Advantages of 3D Technology and Lighting Systems with MIVS

BY DR. MANISH NAGPAL

The traditional way of performing a vitrectomy is proportional, with fixed cut rate, linear vacuum, and memory settings for different tissue densities. Three-dimensional (3D) technology on the new generation microincision vitrectomy surgery (MIVS) systems, however, offers a dual dynamic drive, which allows for simultaneous linear control of cut and vacuum and produces a resulting flow rate. These abilities enhance efficiency and maximize control.
LINEAR CONTROLS: PROPORTIONAL VS 3D VITRECTOMY

When performing proportional vitrectomy, a fixed cut rate and linear vacuum are used, and different memory settings are assigned to different tissue densities. If changing the linear settings for a specific approach, the vacuum or cut rate can be adjusted. For example, when the cutter is moving next to an already mobile tear in the periphery of the retina and the vacuum is higher there will be significant turbulence, which increases the risk for formation of iatrogenic retinal tears. This can be resolved by slowly lowering one of the modalities in a linear fashion.

When working in the core and mobile retina the vacuum can be slightly high with a decreased cut rate; however, as the cutter is moved toward the periphery, cut rate should be increased while keeping the vacuum constant. The result of this change in cut rate should decrease the overall turbulence near the peripheral mobile retina, allowing better and safer dissection in the periphery.

The dual dynamic drive is a vitrectomy modality on the Alcon Accurus system (Alcon Laboratories, Inc., Fort Worth, TX) vitrectomy system provides for simultaneous linear control of cut and vacuum, resulting in flow rates that both enhance efficiency and maximizes control. Figure 1 shows a screen shot, along with the surgery screen of the controls that I use for a 3D core vitrectomy.

Moving to the periphery, the vitreous is seen next to small retinal tears (Figure 2). Using 3D interface, one can cruise between slightly higher and lower vacuum depending on the direction of the cutter port in relation to the mobile retinal tissue. The cutter speed is kept as high as possible when close to the retina. The movement between these two settings is seamless, making proportional technology seem like a manual transmission in a car, and 3D technology seems like an automatic transmission in comparison.

As we move to MIVS, port-based flow limiting plays a large role. The port on the 23-gauge Accurus is shifted closer to the tip of the entire shaft; this greatly improves dissection. With the 23-gauge probe, it is possible to come extremely close to the retina for dissection of membranes. Normally, one would most likely need bimanual instrumentation or specialized scissors, but the 23-gauge cutter can go almost flush with the retina and cut the membranes safely, sparing most of the underlying retinal tissue.

Having the port so close to the tip also allows for a suction peel of the neovascular proliferation by raising the vacuum (Figure 3).

In summary, small-gauge cutting with the 3D Alcon platform provides a high degree of safety and control, which in turn results in increased efficiency.

ILLUMINATION

Illumination for vitreoretinal surgery has evolved parallel to the developments in MIVS, as surgeons’ need for better visualization through smaller gauge instrumentation has increased. The fiber optics have improved as well as innovations like the Tornambe Torpedo chandelier (Alcon Laboratories, Inc.), which has revolutionized lighting and visualization.

The brightness of xenon white light compared to halogen light is seen in Figure 4. The extreme peripheral wide-angle visualization is significantly better than the previous generation of illumination that was available when we first transitioned to MIVS. We use the Tornambe Torpedo by inserting it using a 25-gauge MVR-made opening for chandelier illumination (Figure 5A), which is a very quick process that does not require placement of sutures. This chandelier illumination is particularly useful.
for performing peripheral laser on patients with diabetes (Figure 5B). It allows the surgeon to independently indent the periphery externally with one hand and perform endolaser with the other with ease and good visibility.

CASE REPORTS

Myopic vitreomacular traction. We used triamcinolone for a case of myopic vitreomacular traction and fiberoptic illumination, in addition to chandelier lighting. The chandelier allows the surgeon to view the extreme periphery, which can offer significant advantages in surgery.

Subretinal membrane. In a case of subretinal membrane that did not respond to three injections of ranibizumab (Lucentis, Genentech), we decided to remove the entire membrane with 23-gauge posterior vitreous detachment (PVD), using a high vacuum. Although some surgeons believe that it is difficult to create the vacuum required for PVD with small-gauge technology, I have found it to be extremely effective, allowing clearance of the large calcified chunks of membrane through a small incision.

Bimanual dissection. True bimanual dissections have become mostly unnecessary thanks to small-gauge cutters, but for stubborn adhesions, we use a bimanual approach with 25-gauge disposable scissors, which are very effective when entering at small (tighter) planes. The scissors can be held in one hand and the forceps in the other for safe dissection.

Giant retinal tear. A case of giant retinal tear with extensive proliferative vitreoretinopathy is difficult to maneuver unimanually with perfluorocarbon because the retina is covered with membranes and partly fibrosed and shortened. Bimanual maneuvers using the Tornambe chandelier make cases such as these easier.

Diabetic vitrectomy. In a case of diabetic vitrectomy, we used 23-gauge instrumentation with the chandelier. We used the Alcon 23-gauge fixation (manufactured by ASICO [Westmost, IL] for Alcon Laboratories, Inc.), plate because it allows a straight-in entry and it also has a flange, which helps to maintain the position of the cannula as the trocar is removed.

TOXICITY CONCERNS IN ILLUMINATION

Significant concern exists regarding toxicity and illumination, particularly with chandelier lighting. Extensive degeneration is caused by metal halide exposure. The degeneration is characterized by extensive pyknosis and reduction of nuclei in the outer nuclear layer, damage to ganglion cells, and edema formation.

Steve Charles, MD, in an editorial that appeared in Retina, said that when surgeons are making videos, bright light is often optimal.1 In long procedures, especially on the macula, bright light for long periods of time will result in damage to the photoreceptors.

All cameras for retina surgery have a gain function that can be used for videotaping surgery. Increasing the gain may result in a granular image, but the light will be sufficiently bright for video capture, which is a better alternative than increasing the source illumination and risking retinal toxicity.

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In vitreoretinal surgery, there are many choices that must be made in terms of technique and technology. The currently available choices for tamponade in vitreoretinal surgery are no tamponade (aqueous), air, silicone oil, and high-molecular-weight silicone. This article will discuss the available choices for operative tamponades and the indications for each type.

AQUEOUS (NO) TAMPONADE

The use of no tamponade has traditionally been regarded as an option for small retinal breaks. Martinez-Castillo et al., however, recently published data on pars plana vitrectomy (PPV) for rhegmatogenous retinal detachment (RRD) using aqueous tamponade for some more complicated breaks—at least 50% of the patients in the study had three or four breaks. Aqueous has no interfacial tension, so it essentially cannot be termed a true tamponade (thus, it is no tamponade).

There were 60 patients included in the study. Some of the breaks associated with proliferative vitreoretinopathy (PVR) were rather large and situated in the inferior fundus. Fifty-nine out of 60 patients had primary reattachment 1 month after surgery—an impressive success rate. The pre- and postoperative fundus photos and optical coherence tomography (OCT) scans of a typical patient in the study group (Figures 1 and 2) show that immediately postoperatively the edges of the retinal tear were sealed.

What this study showed was that instant adhesion is possible. For all of these cases, a perioperative tamponade, perfluorocarbon was used long enough for adhesion to occur, however, proper relief of traction was a prerequisite, as was drainage of all subretinal fluid.

There are advantages to the aqueous or no tamponade technique, the most obvious being that the patient does not need to posture. The theoretical advantages include the avoidance of inflammation, which has been shown to be a side effect of all tamponades, including gas. We can improve the success rate with aqueous tamponade, perfluorocarbon was used long enough for adhesion to occur, however, proper relief of traction was a prerequisite, as was drainage of all subretinal fluid.

In my opinion, this technique represents an exciting development in diagnostics as well. For those surgeons who use gas tamponade, it is frequent that retinal detachment will recur 3 to 4 weeks postoperative. We have traditionally cited this as due to PVR, but it is possible that a break has been left unsealed. Using the aqueous tamponade technique enable the surgeon to remove away the air bubble and run water back in to uncover any remaining breaks. If a patient passes this test, then no tamponade is required. If the surgeon is uncomfortable with no tamponade, he can replace the air bubble.

Marc Veckeneer, MD, developed a technique that uses triamcinolone acetonide, not in the posterior segment, but on top of the air bubble. The air bubble is filled almost to capacity and the crystals become enmeshed in the vitreous space and move similar to a gel, making visualization in vitrectomy better.

SILICONE OIL TAMPONADE

Silicone oil has been shown to be effective at macular hole closure. The mechanism of action of silicone oil is to displace the aqueous. The density of silicone oil does not appear to have an effect on dimension and geometry, as we found in a study where we compared high-density silicone oil (perfluorohexyloctane F6H8) with regular silicone oil tamponade in a model chamber eye. What we concluded that perfluorohexyloctane is essentially an “upside-down” silicone oil and should be no more effective than regular silicone oil.

Do we need perfluorohexyloctane? It is no more effective than normal silicone oil, so although it can be considered as an additional tool for surgery, it is not by any...
means a true improvement.

We have published data on our experience with perfluorohexyloctane in routine clinical practice for 120 eyes published that demonstrates relatively good results.4

HIGH MOLECULAR WEIGHT SILICONE OIL

Silicone oil emulsification can result in inflammation, proliferative vitreoretinopathy, and glaucoma. Until recently, high viscosity purified silicone oil has been the only option to protect against this complication; however, this agent is a non-Newtonian, or nonconstant fluid. If the oil is stirred, the viscosity is reduced and this shear results in emulsification.

The solution to this issue is high molecular weight silicone oil within the normal silicone oil, which increases the extension of viscosity. Thus, if the fluid is placed under pressure, the molecules unfold into a long chain, making the mixture less likely to snap.

We have recently completed an in vitro study that showed that with as little as 5% of high molecular weight additives to silicone oil can eliminate the occurrence of emulsification (Unpublished data.) Depending on the results that we experience in human trials, it may be possible for surgeons to have less sheer viscosity, which is advantageous for microincisional vitreoretinal surgery. ■

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A Comparative View of 25- vs 23-gauge Vitrectomy Surgery

Twenty-three gauge overcomes limitations of small-gauge instrumentation.

BY PROFESSOR TANG SHIBO

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evry surgeon’s goal, regardless of specialty, is a small incision. The smallest incisions induce the least amount of trauma to surrounding tissue, have self-sealing properties, and heal more quickly. The advantages of microincision vitrectomy surgery (MIVS) include the transconjunctival approach to wound creation, the microincision, the sutureless sealing capabilities, and the high-speed cutters.

MIVS: 25-GAUGE SYSTEM

Indications for vitrectomy with 25 gauge include epiretinal membrane, macular hole, vitreous hemorrhage, non- or mild-proliferative retinal detachment, and central retinal vein occlusion. For selected cases, 25-gauge surgery induces less damage, allows for shorter operation times, and involves fewer complications.

The Accurus (Alcon Laboratories, Inc., Fort Worth, TX) 25-gauge vitrectomy set includes the trocar cannula, the infusion cannula, the vitrectomy probe, and the Griehaber

Figure 1. Incisions for 25-gauge surgery seal well over the course of postoperative recovery.

DSP forceps. The incision that is created for 25-gauge vitrectomy with the Accurus is vertical to the sclera.

The 25-gauge incision seals well, as is evidenced in Figure 1, which shows the wound-healing process over the course of 6 months on slit lamp and ultrasound bio-

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microscopy (UBM). There are scleral defects that are apparent at 1 week postoperative (Figures 1A-B) and 1-month postoperative (Figures 1C-D), but by 6 months, the defect is no longer present (Figures 1E-F).

Additionally, a histological study on 20- vs 25-gauge incision (Figure 2) shows that with a 20-gauge incision the reaction is severe, with some detachment on the left-hand side of Figure 2A at 7 days postoperative. Alternatively, there is minimal damage seen with the 25-gauge incision (Figure 2B).

The objections to 25-gauge surgery include the overly flexible instrumentation and the effects of this on control and efficacy on hard tissues.

MIVS: 23-GAUGE SYSTEM

To answer these objections, 23-gauge instrumentation was developed. Twenty-three gauge has evolved from all-metal instruments to the second generation Accurus 23-gauge system (Figure 3) that has funneled canula openings, making it easier to insert instruments. The infusion line on the 23-gauge system is also larger. I have found the instruments for the Accurus 23-gauge system to be comfortable, well designed, and highly functional. One of my favorite features is the close proximity of the port to the tip of the probe.

Other articles in this supplement discuss cutting and flow rates, but Figure 4 demonstrates the flexibility of the 23- vs the 25-gauge instrumentation. There is a significant difference between the flexibility at heavier weight loads, indicating that 23-gauge instrumentation would likely be more effective with more dense tissue. Note that there is little difference between the 23- and 20-gauge instruments at the heaviest weight load.

Indications for 23-gauge surgery are similar to what is indicated for 25-gauge surgery, but expands on that list to include more difficult cases that would not be recommended for 25 gauge, such as lensectomy and severe trauma.
The wound healing process, as seen on slit lamp and UBM in Figure 5, is similar at 1 month between 23 and 25 gauge, but at 6 months, the 23-gauge incision is healing better (Figure 6). Additionally, a small amount of scleral defect can be seen in the 25-gauge eye and none is seen with 23 gauge.

In conclusion, based on ease of use, intrapoerative safety, and patient comfort and recovery, my clinical experience is that 23-gauge vitrectomy overcomes the limitations of 25-gauge surgery and that all the benefits of 20-gauge surgery can be achieved in 23 gauge.

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MIVS Prospective Randomized Comparative Study:
Differences Between 23 and 25 Gauge

BY PROFESSOR YOUNG HEE YOON

Pars plana vitrectomy (PPV) is currently undergoing a paradigm shift from standard 20-gauge surgery to microincision vitrectomy surgery (MIVS) with 23- or 25-gauge technology. Accordingly, my practice pattern has changed since 2003 when I first began using 25-gauge technology. At that time, I used MIVS for only 20% of cases. As 25-gauge technology has advanced and improved, my usage has increased. At the beginning of last year, I was using MIVS for 49% of my cases. I had only first used the Accurus 23-gauge Surgical System (Alcon Laboratories, Inc.) in May 2007, but in a short period of time I was so pleased with the technology that I shifted more than half of the PPV cases that I was still performing with 20 gauge to 23 gauge. Interestingly, in spite of the new 23-gauge technology, the percentage of cases that I performed with 25 gauge remained at 49%.

SURGERY WITH 25 GAUGE

Since its first introduction in 2002, the 25-gauge cutter has evolved significantly. Newer cutters can enter the eye with less trauma, and result in better self-sealing incisions/sclerotomies.

Illumination has also become safer and brighter with the advent of the xenon illumination system, which is five to six times brighter than halogen and making chandelier lighting a more viable option for bimanual surgery.

In addition, more 25-gauge instruments are now available, including curved scissors, internal limiting membrane (ILM) forceps, aspiration accessories, and active/passive aspiration accessories.

Last year my colleagues and I performed a study, which has been submitted for publication, on the efficiency and safety of 25-gauge vitrectomy for diabetic cases. For the study, we reviewed and compared the medical records of 45 consecutive cases performed with the 25-gauge vitrectomy probes with 45 20-gauge PPV diabetic cases of matching age, sex, and diagnosis. Diagnosis included vitreous hemorrhage, mild to moderate tractional retinal detachment (TRD), and macular edema. All cases except one was performed using only retrobulbar anesthesia.

The mean operation time was significantly shorter in the 25-gauge group (37.9 minutes) than in the 20-gauge group (53.3 minutes). In both groups, visual acuity had notably improved at 3 and 6 months after surgery (P<.05). At both 1 week and 1 month after surgery, however, visual acuity was significantly better in the 25-gauge group, explaining faster visual recovery of the 25-gauge group. Postoperative complications were similar in both groups.
We concluded that, with advantages of a shorter operation time and the faster recovery of postoperative visual acuity, 25-gauge MIVS can be safely used for the treatment of the various stages of diabetic vitreoretinal complications.

**Surgery with 23 Gauge**

In order to solve some problems related to the small size of a 25-gauge cutter, such as overflexibility, slower cutting, and lack of control with dense tissue, the 23-gauge Accurus Surgical System was introduced in 2006.

The 23-gauge cutter has a stiffer shaft and the flow rate has been increased to a similar or better rate as on 20-gauge technology. In addition, and possibly most important, the port was brought closer to the tip of the probe. Table 1 compares the characteristics of the Alcon cutters according to gauge. Unlike 25-gauge, 23-gauge cutters are significantly better in terms of stiffness and aspiration flow rate.

Nearly every instrument and accessory for vitrectomy is now available in 23-gauge. The more recently available disposable 23-gauge Grieshaber DSP (Alcon Laboratories, Inc.) instruments provide excellent functional performance.

In early 2008, I began a prospective study comparing 23-gauge (with the Accurus Surgical System) and 25-gauge for the treatment of various vitreoretinal diseases to compare visual acuity outcomes and rates of complications. Eighty-five consecutive patients were randomized to either 23- or 25-gauge MIVS. Diagnoses included various macular surgeries and a significant number of diabetic vitreous hemorrhage, and mild to moderate TRD.

Although the amount of balanced salt solution used during surgery was significantly less in 25-gauge surgery, surgical time did not differ significantly between the two groups. Postoperative anterior segment changes were evaluated with a standardized grading system. At postoperative day 1 and week 1, 25-gauge eyes showed relatively less hyperemia and edema. Overall visual acuity improved 3 months after surgery ($P<.003$). Early postoperative visual acuity recovery (both at week 1 and month 1) after surgery were similar in both groups ($P=.439, .679$).

Complications were also comparable in both groups. Although the suture of sclerotomy and mild immediate postoperative hypotony seemed to be a little higher in 23 gauge, no serious complications, such as wound leakage, endophthalmitis, or retinal detachment occurred in either group.

We concluded that among the patients whose diagnoses fit the inclusion criteria, 23- or 25-gauge MIVS showed similar surgical outcomes and complication profiles.

**WHY 23 GAUGE?**

Based on the results of the above study, one might question the need for 23-gauge MIVS. In my opinion, 23-gauge MIVS is useful for expanding the indications of sutureless vitrectomy for more severe, advanced vitreoretinal complications, such as advanced diabetic TRD or RD with early PVR. A combination of recent advances in the 23-gauge system and preoperative antivascular endothelial growth factor therapy allows vitreoretinal surgeons to apply sutureless vitrectomy techniques to relatively advanced diabetic cases.

Figure 1 shows one of the first diabetic TRD cases for which I used bevacizumab (Avastin, Genentech) and the 23-gauge Accurus. The fundus photo on the left is pretreatment; the right is 1-week posttreatment with bevacizumab and shows a decrease in vitreous hemorrhage and neovascularization. Surgical manipulation with 23-gauge was easier posttreatment because there was less blood. Using a 23-gauge cutter results in a reduced need for other instruments.

**Surgical Preference for MIVS**

In conclusion, I prefer 25 gauge to 23 gauge for all macular surgeries (macular hole, pucker, vitreomacular traction, macular edema), relatively simple diabetic cases, less complicated vitreous hemorrhage, vitreous opacity, uveitis, vitreous biopsy, and retinal vascular surgery. I use 23-gauge for more advanced diabetic cases, thick vitreous hemorrhages, and complicated retinal detachments. I also use 23-gauge surgery for cases of lens dislocation, or where silicone oil tamponade is used.

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As innovation in microincisional vitrectomy surgery (MIVS) has progressed, 23-gauge technology was introduced to answer many of the objections that vitreoretinal surgeons had regarding the overflexibility of 25-gauge MIVS instrumentation. Twenty-three-gauge surgery, however, is seen as a compromise to some surgeons because the wound and the cannula are slightly larger, and if applied incorrectly, wound leakage can occur.

We all are familiar with the reasons for moving towards MIVS. To all of us who have performed MIVS, there is no doubt in our minds about the increased patient comfort and the improved postoperative recovery. Are we, however, compromising intraoperative safety and risking postoperative complications for these aforementioned benefits? This article will address these concerns and present my case for why 23-gauge surgery is not a compromise in MIVS and why it is safe and efficient for patients.

WHY SMALL-GAUGE VITRECTOMY?

The impetus to MIVS has involved several factors. First, the number of vitreoretinal surgeries that are being performed for macular diseases has increased. The number of vitreoretinal surgeries that we performed at the Singapore National Eye Center, for example, reflect a steady increase of surgery for macular diseases from 2000 to 2006 (Figure 1). Second, we have a better understanding of the pathogenesis of vitreoretinal conditions such as macular holes. Third, additional technological improvements have taken place that have reduced the need for manipulation during surgery, including wide-angle viewing technology, enhanced illumination, and staining techniques for the epiretinal membrane and internal limiting membrane. Finally, surgeons are beginning to appreciate the benefits of combined phaco-vitrectomy, particularly in Asia, where cost is a significant issue.

The issues that surgeons initially had with 25-gauge instrumentation are widely known and include overflexibility and the effect on stability. The Accurus (Alcon Laboratories, Inc., Fort Worth, TX) 25-gauge vitrectomy system represents the newer generation of 25 gauge, which is more stable than the older generation.

Figure 1. Vitreoretinal surgeries for macular diseases has increased steadily from 2000 to 2006 at the Singapore National Eye Center.

The American Society of Retina Specialists’ 2006 Patterns and Trends Survey reported that 80% of retina surgeons have tried 25-gauge surgery at least once and that 31% used 25-gauge technology frequently. The main concerns cited by survey respondents included increased rates of retinal detachment and endophthalmitis. Hypotony is also frequently cited as a significant concern with smaller-gauge surgery, with some reports citing a 20% increase in incidence with 25-gauge surgery. The rate of retinal detachment was cited in one study as being 3.4% for 25-gauge vitrectomy vs 0.6% for 20-gauge vitrectomy. Kaiser et al reported endophthalmitis in 0.23% cases with 25-gauge surgery vs 0.018% in 20-gauge surgery.

There is no information currently on how many surgeons are using 23-gauge surgery.

TWENTY-THREE-GAUGE TECHNOLOGY

A discussion on the development of 23-gauge surgery cannot exclude the contributions of Klaus Eckardt, who introduced reusable, trocar and microcannula instrumentation for 23-gauge vitrectomy (Dutch Ophthalmic Research Center, Zuidland, The Netherlands). The system required a two-step process for insertion of the microcannula with a disposable microvitreoretinal blade, and had some limitations in cut rates—up to 1,200 cpm with suctions up to 500 mm Hg—but...
achieved these with fairly rigid instrumentation.

The 23-gauge Accurus has improved on the previous generation for entry with incision and entry in a single step. The trocar blade and cannulas are preloaded in Total Plus Paks, similar to 25-gauge Total Plus Paks. Additionally, the metal cannulas are easier to insert into the incision, resulting in reduced cannula-to-instrument friction, and lead to increased positional accuracy when the surgeon is working closely to the retina. The single most significant improvement that I find with the 23-gauge Accurus system is the low insertion force required to make the entry wound through the sclera.

The orange plastic hub of the cannula enhances visibility, signifies 23-gauge size and is easy to use with calipers and forceps. The large funnel shape of the trocar enables instrument entry without a microscope.

The trocar is excellent in most cases. I have had very few cases where the cannula dislodged; however, this is a risk for patients with high myopia or thin/weak scleras and the risk may be enhanced by repeated entry of the vitrector.

The learning curve with 23-gauge surgery is that unlike the "straight-in" wound made for 25-gauge surgery, an angled incision is required. Slight rotation can make entry easier if resistance is encountered. To avoid subretinal infusion it is important to check that the infusion cannula is in the vitreous cavity before turning the infusion on. Finally, I always keep the eye pressurized before final exit, but even so, I have found that conjunctival ballooning with fluid or air is not infrequent and can pose problems if suturing. I find that I can overcome this by using a cotton tip applicator to massage the wound.

**INDICATIONS FOR 23-GAUGE VITRECTOMY**

Ideal cases for 23-gauge vitrectomy are the same as what we are used to for 25-gauge surgery and include macular pucker, macular holes, vitreomacular traction, vitreous hemorrhage in patients with diabetes, and even some cases of endophthalmitis where limited vitrectomy is required. I would use 23-gauge vitrectomy for rhegmatogenous retinal detachment where primary vitrectomy is performed without the need to incise the conjunctiva. More complicated cases that can be performed with 23-gauge surgery include diabetic vitrectomy, giant retinal tear, trauma and small intraocular foreign body, and proliferative vitreoretinopathy. It is also simple to use 23-gauge technology for redo cases where revision of vitrectomy, internal fluid/gas exchange, or vitreous washout is required. Twenty-three gauge can also be used in cases in which silicone oil, specifically, 1000 centistoke, is utilized. The silicone oil infusion mode (VFC; Viscous Fluid Controller) on the Accurus works well with 23 gauge directly from the syringe at maximal infusion pressure of approximately 80 mm Hg—and without the need to enlarge the sclerotomy.

**PERFORMANCE OF 23-GAUGE TECHNOLOGY**

There is little difference in the performance of 23-gauge technology when compared to 20-gauge flow rates through the port at equivalent cut speeds (Figure 2), making the learning curve and transition within these parameters easy. In fact, at cut rates above 1,700 cpm, the 23-gauge flow is better than 20 gauge. Alternatively, the flow rate is much slower with 25-gauge.
A direct comparison between 20-, 23-, and 25-gauge Alcon vitrectomy probes can be seen in Figure 3. The 23-gauge probe is much stiffer and the distance of the port to the tip is closer than both 20 and 25 gauge (50% closer than 20 gauge, as seen in Figure 4), which makes a significant difference when working on membranes close to the retina. The close proximity of the port to the tip on the 23-gauge probe is actually achieved in the manufacturing process of the probe. The tip is spun-closed rather than welded separately, allowing the opening to be much closer on the 23-gauge instrument.

CONCLUSIONS

With proper case selection and awareness of potential complications, the advantages to MIVS are clear. There are, however, specific cost issues that need to be addressed and although the instinctive reaction may be to move toward disposables. Because most cases can be successfully performed with 23-gauge surgery, I find it infrequent that I require 20-gauge technology.

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1. 2006 Patterns and Trends Survey. Posters presented at the annual meeting of the American Society of Retina Specialists; September 2006; Cannes, France.

Outcomes With Combined Sutureless Surgery

This procedure has proved to be safe and effective.

DR. JONY CHENG-JONG CHANG

Phaco surgeons have worked toward the smallest possible sutureless incision because it reduces trauma to the eye and enables fast postoperative recovery. Now that retina surgeons have access to sutureless vitrectomy, we are able to strive for the same goals. For retina, smaller incisions translate to faster surgical times, minimal trauma to the eye, decreased postoperative inflammation, less discomfort for the patient, and a fast recovery.

My first experiences with 25-gauge surgery was with the Millenium TSV-25 Vitrectomy System (Bausch & Lomb, Rochester, NY). We have dubbed our combined cataract and vitrectomy cases combined sutureless surgery (CSS). We have more recently been performing CSS with the Alcon 23- and 25-gauge Accurus vitrectomy systems (Alcon Laboratories, Inc., Fort Worth, TX).

CLINICAL OUTCOMES WITH CSS

We have compiled data on CSS in our surgery center in Taipei, Taiwan, which we published in 2005. We performed CSS on 150 eyes of 131 patients who had various vitreoretinal abnormalities, including diabetic retinopathy with vitreous hemorrhage, pucker, macular hole, non-diabetic vitreous hemorrhage, and vitreous macular tractional syndrome, along with significant cataract. All patients included in this study underwent surgery using CSS and IOL implantation. We measured outcomes based on preoperative vs postoperative best-corrected visual acuity (BCVA), intraocular pressure (IOP), and intra- and postoperative complications.

The first step in CSS is to apply topical and subconjunctival anesthesia. The microcannula system maintains the alignment between the conjunctival and the scleral entry site so that no conjunctival dissection is required. I insert three to four trocar microcannulas transconjunctivally in different quadrants with the microcannulas for alignment left in place. One of the microcannulas is connected to an infusion line while the others are closed with plugs. To prevent low pressure and wound leakage, a watertight clear corneal incision is essential. Further, oblique insertion for microcannulas improves the self-sealing capability of sclerotomies.

In a typical case, 25-gauge vitrectomy was performed...
Complications were infrequent postoperatively.

Figure 1. Visual acuity improvement by diagnosis.

using a high-speed vitrectomy cutter, light pipe, microforceps, diathermy, and laser probe under a wide-angle viewing system. A posterior chamber IOL was implanted through a 2.5 to 2.8 mm corneal incision. At the end of all procedures, the microcannulas were removed without any suturing. A miotic agent was injected into the anterior chamber to constrict the pupil and prophylactic antibiotics and corticosteroid were given at the end of the procedures.

The preoperative visual acuity ranged from 20/30 to light perception and the postoperative visual acuity ranged from 20/20 to counting fingers. Eighty-two percent of eyes undergoing CSS and IOL implantation experienced an improvement in visual acuity postoperatively. 13% did not have a change in visual acuity, and 5% of eyes had worse vision preoperatively, largely because of underlying diabetes. The visual acuity improvement by initial diagnosis is seen in Figure 1.

In our study, we concluded that CSS does not significantly increase the risk of intra- and postoperative complications and found it to be safe and effective for selected cases.

**CCS FOR RESCUE CASES**

In the past 5 years as we developed the technique of CCS, we were faced with many cases of phaco with ruptured capsule and subsequent vitreous loss. The sutureless technique has been useful to manage these difficult cases. We published our results in 2006.²

There are five key steps when operating this rescue procedure. First, we inject triamcinolone into the anterior chamber to visualize prolapsed vitreous. Upon recognition of posterior capsule rupture, captured triamcinolone particles are injected into the anterior chamber. Tramcinolone particles become trapped on the vitreous gel, making it clearly visible in the anterior chamber and corneal wound.

The second step is to establish a 25-gauge trocar microcannula system. Under local anesthesia, IOP is maintained by anterior chamber infusion. The first microcannula is introduced nasally through the pars plana. The infusion line is transferred to the first microcannula. A wet cotton tip is then applied to the corneal incision to prevent wound leakage. The second microcannula is inserted in the temporal side.

The third step is to perform partial core vitrectomy with a high-speed vitrectomy cutter introduced temporally through the microcannula. Vitrectomy is performed to debulk the prolapsing vitreous. The IOP is adjusted by the height of the infusion bottle. The corneal wound is cleared by sweeping the vitreous away from the wound with an iris spatula introduced through the side port. Residual cortical and epinucleus matter are removed simultaneously with the vitrectomy cutter through the posterior capsular opening.

On completion of the vitrectomy, a foldable IOL is implanted. In cases with small area of rupture, partial posterior CCC is performed, and the foldable single piece posterior chamber IOL is then implanted into the capsular bag under the safeguard of vitreous cutter, posteriorly.

In cases with significant rupture, the foldable three-piece posterior chamber IOL is implanted and dialed into the sulcus above the CCC opening by the support of vitreous cutter posteriorly. If the posterior capsular rupture is found after IOL implantation, the stained vitreous is removed through the posterior capsular opening. The IOL can be dialed into the sulcus under the safeguard of vitreous cutter. The viscoelastic material is completely removed after the procedure is complete and a miotic agent is injected to constrict the pupil. The microcannulas are closed with plugs and removed without suture. Prophylactic antibiotic injections are given at the end of the procedures.

We have performed 21 cases using this rescue procedure and have found that CSS combined with triamcinolone stain is a safe, reliable adjunct for managing vitreous loss during phaco, leading to rapid visual recovery. So totally we have 21 cases who received this type of rescue procedure.

There are, however, challenges for a surgeon performing this type of combined procedure. For example, the foot pedals can be cumbersome. Alcon has a 23-gauge combined Total Plus PAK with one cassette for phaco and vitrectomy.

**SUMMARY**

In conclusion, combined sutureless surgery with IOL is safe and effective in treating selected vitreoretinal abnormalities coexisting with cataract. As technology for 23-gauge and 25-gauge surgery continues to improve, such procedures are sure to become more widespread.

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