FIFTEEN YEARS OF MINIMALLY INVASIVE VITREORETINAL SURGERY


Advances have led to reliable 27-gauge instrumentation. Is there any need to go smaller?

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The evolution of systems for sutureless microincision vitrectomy surgery (MIVS) began approximately 25 years after Robert Machemer, MD, perfected 20-gauge closed pars plana vitrectomy (PPV) systems as the standard for vitreoretinal surgery.[1] Machemer, Anton Banko, and Jean Marie Parel, PhD, were the first to introduce the vitreous infusion suction cutter (VISC) with endoillumination and scissors technology.

By the late 1990s, innovators such as Eugene de Juan, MD, and Mark S. Humayun, MD, PhD, were developing smaller-gauge systems that could be used through sutureless self-sealing wounds. The efficacy of MIVS was initially described by Fujii and associates in 2002, with their introduction of 25-gauge transconjunctival sutureless vitrectomy.[2] Lakhanpal and associates subsequently described the clinical long-term outcomes of a consecutive case series using this technology.[3] In that series, the authors described the perceived advantages of MIVS over standard 20-gauge systems.

Innovations have continued over the past 15 years with the introduction of 23- and 27-gauge MIVS systems. As a result, sutureless MIVS is now the technique of choice for modern vitreoretinal surgeons for most indications, rather than traditional 20-gauge PPV. This article reviews how we got to where we are today and glances ahead to where we may be going.

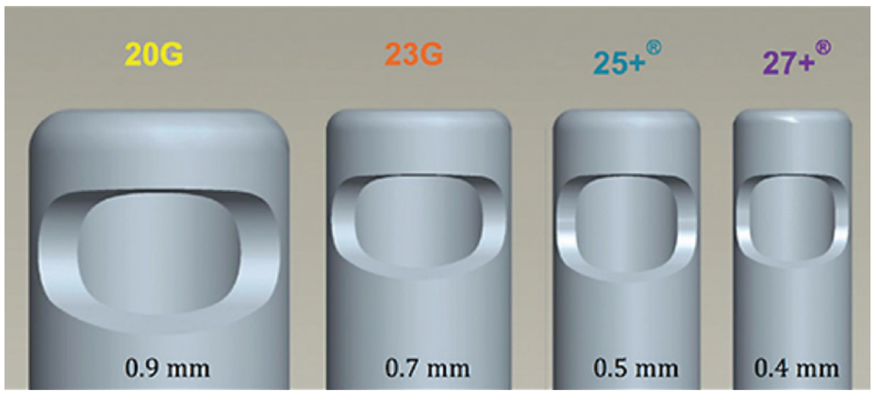

Figure 1. Comparison of vitrectomy handpiece sizes and designs. The 27-gauge vitrectomy handpiece is less than half the size of the 20-gauge handpiece, but the port diameter of the 27-gauge is 60% that of the 20-gauge probe, enhancing the fluidics of the smaller probe when combined with improved duty cycle and flow rates. The distance from port to tip of the vitrectomy handpiece is shorter with the 25- and 27-gauge instruments to permit more precise removal of preretinal tissue.

BENEFITS OF MIVS

In general, MIVS traded sutured conjunctival incisions and sclerotomies for transconjunctival trocar-cannula systems. These systems facilitated repeated insertion and removal of tools, resulting in improved self-sealing of wounds. This significantly reduced the necessity for sutures, thereby decreasing postoperative inflammation, promoting faster healing, and improving overall patient comfort.[3]

The initial 25-gauge MIVS technique demonstrated many advantages over 20-gauge sutured vitrectomy. MIVS allowed the use of microcannulas for three-port PPV. By reducing the diameter of the instruments (Figure 1) and the associated conjunctival damage, the MIVS procedure allowed wounds to self-seal without suturing. The cannula systems also eliminated much of the manipulation and disruption that occasioned the need for suturing, resulting in decreased postoperative inflammation.

Eliminating sutures had the collateral benefit of decreasing overall surgical times due to faster opening and closing.[3] Studies also showed faster healing times and increased patient comfort with MIVS, likely associated with the reduction of inflammation.[4] Ultimately, visual acuity improvement with MIVS was comparable to that achieved with 20-gauge PPV.[5]

SYSTEM IMPROVEMENTS

The original MIVS system was not flawless, however. Many concerns had to be addressed. First, the early

$$\text{Volume Flowrate} = \mathcal{F} = \frac{P_1 - P_2}{\mathcal{R}} = \frac{\pi(\text{Pressure difference})(\text{radius})^4}{8(\text{viscosity})(\text{length})}$$

$$\text{Resistance to Flow} \quad \mathcal{R} = \frac{8\eta L}{\pi r^4}$$

Figure 2. Poiseuille's law.

25-gauge instruments were undesirably flexible. Second, endoillumination was inadequate.[3] These problems were mitigated through the introduction of shortened instrument shafts that increased rigidity and chandelier lighting that provided improved illumination.

One important obstacle remained: Poiseuille's law (Figure 2). As instrument diameter shrank from 20 to 23 to 25 to 27 gauge, a reduction in flow rate was noted with each decrease. With the smaller diameters, decreased flow rates seemed inevitable, and these slowed down procedure times.[6] Accelerated cutters helped to balance the lower aspiration/cutting rates associated with decreased diameters.[3] The design of the twin-duty cycle (TDC) cutter, an innovation from Dutch Ophthalmic USA, increased cutting speed by using a large rectangular aperture with two sharp cutting edges. Double-cutting technology increases aspiration flow but reduces surge turbulence at the aspiration port. This technology also reduces traction on surrounding tissue, an advantage over single-motion cutters.

Other concerns with MIVS technology were similarly addressed. To decrease the risk of hypotony, the perpendicular incisions initially used were replaced by angled, two-step, beveled, self-sealing incisions.[7] The risk of hypotony also resulted in reports that MIVS was associated with an increased risk of endophthalmitis compared with 20-gauge PPV.[8]

Ultimately, improvements in 25-gauge instrumentation, endoillumination, cutting technology, and wound creation greatly improved outcomes and decreased surgeon concerns. Decreased inflammation after surgery, improved patient comfort, and faster healing times allowed 25-gauge technology to become the gold standard in vitreoretinal surgery. In the 2015 Preferences and Trends (PAT) survey conducted by the American Society of Retina Specialists (ASRS), more than 95% of responding vitreoretinal surgeons reported that they routinely use small gauge systems.[9]

FURTHER VARIATIONS

In 2007, Fine and associates published an introduction to 23-gauge sutureless MIVS, proposed as a compromise between the smaller 25-gauge and the larger 20-gauge instrumentation.[10] In theory, 23-gauge instrumentation would allow sutureless closure with angled, self-sealing incisions, similar to 25-gauge, but with stronger instruments, better endoillumination, and faster vitrectomy times, similar to 20-gauge. To facilitate self-sealing with the larger gauge wounds, Fine et al utilized angled tunnel incisions, and they noted that enhanced wound closure occurred with associated episcleral bleeding. This two-step wound creation technique lengthened opening times, but it has since become the standard incision approach used with 23-gauge and 25-gauge systems.[10]

Although there remained a slight flexibility to the instruments and a slower cutter rate with 23-gauge compared with 20-gauge, the 23-gauge approach allowed torquing and movement of the eye to the periphery when required.[11] The 23-gauge systems were usable in an increased number of indications because they were capable of performing complex maneuvers with greater ease.[12] Again, transient hypotony was encountered, but it resolved without reported complications.[10,12] Users of 23-gauge systems reported results similar to those with 25-gauge systems, including decreased postoperative inflammation, decreased operating times, and faster vision recovery.

The next step in the progression of MIVS was the creation of the 27-gauge system described by Oshima and associates in 2010.[13] Although it initially had limitations similar to those of early 25-gauge systems, with decreased endoillumination and slower infusion and aspiration rates, these issues have subsequently been addressed with alternative lighting sources and faster

AT A GLANCE

- All MIVS systems (23-, 25-, and 27-gauge) have been accepted as standards for use in vitreoretinal surgery, although opinions vary as to which is the best.
- Surgeon preference among these gauges should be based upon the surgeon's comfort level.
- With the learning curve, experience with MIVS often leads to improved patient outcomes over time, regardless of gauge.

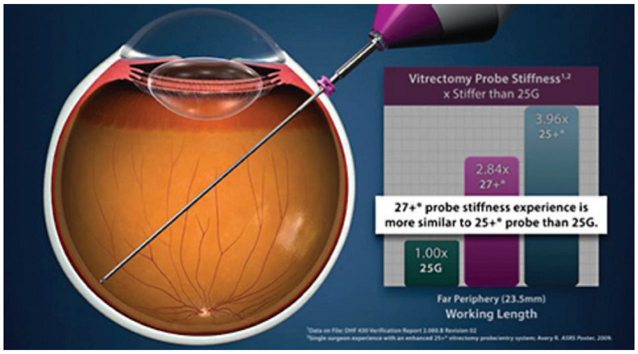

Figure 3. Comparison of vitrectomy probe stiffness for the Constellation platform. The manufacturer has used materials engineering to enhance vitrectomy probe staff stiffness, in addition to adding a 1-mm proximal stiffening sleeve. As a result, stability of the 27+ instruments is closer to the 25+ instruments than to the initial 25-gauge technology. Shaft stabilities are similar in the postequatorial retina.

rates.[6,13] The natural flexibility of the even narrower 27-gauge instruments has been corrected with the design of shorter, stiffer instruments such as those available for the Constellation Vision System (Alcon). With its minimal diameter, 27-gauge instrumentation allows the use of a perpendicular or straight incision technique, based on surgeon preference.[6]

Although the 27-gauge instruments are significantly smaller than 25- and 23-gauge instruments (Figure 3), early users reported outcomes and complication rates similar to those with the larger gauges; however, the 27-gauge system was not initially used for the most complex cases.[5] The smaller system has since been used in a broader range of indications with favorable outcomes.[14] A broad range of 27-gauge instrumentation is now available for the Constellation platform. The 27-gauge MIVS system, like earlier systems, facilitates faster visual recovery, decreased inflammation, and lessened conjunctival damage.[6,14]

DOES IT GET ANY BETTER THAN THIS?

All MIVS systems (23-, 25-, and 27-gauge) have been accepted as standards for use in vitreoretinal surgery, although opinions vary as to which is the best. Surgeon preference should be based upon the surgeon's comfort level with the following parameters, among others: degree of endoillumination, cut rates and duty cycle, degree of instrument flexibility, and incidence of hypotony.[11,12] Due to the learning curve, experience with MIVS often leads to improved patient outcomes over time, regardless of gauge.

MIVS was a natural progression from 20-gauge systems, just as laparoscopy was a progression from large open wounds in general surgery. A small incision that self-seals is an attractive concept. Initial setbacks were subsequently addressed with improved two-step entry, improved endoillumination, faster cut rates, and decreased flexibility of instrumentation. As a result, surgical results improved and complications decreased. Thus, surgeon comfort levels have increased dramatically, and MIVS platforms are now the most widely used in vitreoretinal surgery. Smaller is better if the gauge of the instruments is adequate for the indication at hand.

Will there be a need for sub–27-gauge instrumentation? There will be numerous obstacles to this goal. Poiseuille's law dictates a further substantial reduction in flow rates. Perhaps a TDC cutter or another innovation could mitigate that concern. Instrument flexibility would again be an engineering challenge.

But the more practical question is: Would there be a need for such instrumentation? What indications would necessitate an even smaller cutting instrument? The 27-gauge vitrector serves as an excellent pick and cutting instrument that can fit into narrow spaces in tractional retinal detachments. Would a 30-gauge cutter be a further improvement? Will surgical companies be willing to invest in the research and development for a smaller gauge? The authors consider this to be unlikely. More probably, current technologies will continue to be the gold standard for vitreoretinal surgery. ■

1. Machemer R, Parel JM, Norton EW. Vitrectomy: a pars plana approach. Technical improvements and further results. *Trans Am Acad Ophthalmol Otolaryngol*. 1972;76(2):462-466.
2. Fujii GY, De Juan E Jr, Humayun MS, et al. A new 25-gauge instrument system for transconjunctival sutureless vitrectomy surgery. *Ophthalmology*. 2002;109(10):1807-1812; discussion 1813. Erratum in: *Ophthalmology*. 2003;110(1):9.
3. Lakhanpal RR, Humayun MS, de Juan E Jr, et al. Outcomes of 140 consecutive cases of 25-gauge transconjunctival surgery for posterior segment disease. *Ophthalmology*. 2005;112(5):817-824.
4. Rizzo S, Genovesi-Ebert F, Murri S, et al. 25-gauge, sutureless vitrectomy and standard 20-gauge pars plana vitrectomy in idiopathic epiretinal membrane surgery: a comparative pilot study. *Graefes Arch Clin Exp Ophthalmol*. 2006;244(4):472-479.
5. Ibarra MS, Hermel M, Prenner JL, Hassan TS. Longer-term outcomes of transconjunctival sutureless 25-gauge vitrectomy. *Am J Ophthalmol*. 2005;139(5):831-836.
6. Khan MA, Kuley A, Riemann CD, et al. Long-term visual outcomes and safety profile of 27-gauge pars plana vitrectomy for posterior segment disease [published online ahead of print November 13, 2017]. *Ophthalmology*.
7. Mohamed S, Claes C, Tsang CW. Review of small gauge vitrectomy: progress and innovations. *J Ophthalmol*. 2017;2017:6285869.
8. Scott IU, Flynn HW Jr, Dev S, et al. Endophthalmitis after 25-gauge and 20-gauge pars plana vitrectomy: incidence and outcomes. *Retina*. 2008;28(1):138-142.
9. Stone T. 17th Annual Preferences and Trends Survey. Poster presented at: American Society of Retina Specialists 33rd Annual Meeting; July 11-14, 2015; Vienna, Austria.
10. Fine HF, Iranmanesh R, Iturralde D, Spaide RF. Outcomes of 77 consecutive cases of 23-gauge transconjunctival vitrectomy surgery for posterior segment disease. *Ophthalmology*. 2007;114(6):1197-1200.
11. Eckardt C. Transconjunctival sutureless 23-gauge vitrectomy. *Retina*. 2005;25(2):208-211.
12. Schweitzer C, Delyfer MN, Colin J, Korobelnik JF. 23-gauge transconjunctival sutureless pars plana vitrectomy: results of a prospective study. *Eye (Lond)*. 2009;23(12):2206-2214.
13. Oshima Y, Wakabayashi T, Sato T, Ohji M, Tano Y. A 27-gauge instrument system for transconjunctival sutureless microincision vitrectomy surgery. *Ophthalmology*. 2010;117(1):93-102.e2.
14. Khan MA, Shahlaee A, Toussaint B, et al. Outcomes of 27 gauge microincision vitrectomy surgery for posterior segment disease. *Am J Ophthalmol*. 2016;161:36-43.e1-2.

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