Endoscopic Vitrectomy in Children

Pediatric vitreoretinal surgery is complex, exemplified by variable surgical outcomes in a number of diseases. In stage-5 retinopathy of prematurity (ROP)—arguably one of the most surgically challenging vitreoretinal conditions—favorable anatomical outcome following vitrectomy varies widely, from 28%\(^1\) to 69%.\(^2\) Similarly, retinal reattachment rates following vitrectomy for traumatic retinal detachment (RD) in children with open-globe injuries range from 36%\(^3\) to 53%,\(^4,5\) although this is a more heterogeneous disease.

In the authors’ experience, endoscopy has some unique advantages over current contact and noncontact viewing systems, enabling surgical visualization and tissue access during vitrectomy invaluable in some of the more complex pediatric vitreoretinopathies.

Ophthalmic endoscopy dates back to the 1930s

In 1934, Thorpe developed a nonilluminating ophthalmic endoscope incorporating forceps for removal of nonmagnetic foreign bodies in the vitreous,\(^6\) followed later that year with a self-illuminating instrument measuring 6.5 mm in width.\(^7\) An eyepiece attached to the proximal end of the endoscope enabled direct monocural visualization. It was not until 1978 that Norris and Cleasby developed a significantly smaller 1.7-mm diameter endoscope for intraocular and orbital surgery.\(^8\) In 1990, a 20-gauge endoscope with image projection on an electronic monitor was described.\(^9\)

20- and 23-gauge endoscopes now in use

Current 20-gauge endoscopes incorporate up to 3 functions:

- A fiber optic video camera
- A xenon light source
- Endolaser

Recently, 23-gauge endoscopes became available.\(^10,11\) The field of view with 20-gauge endoscopes is approximately 110°, increasing to 160° with one of the current 23-gauge endoscopes. A resolution of 17,000 pixels is possible. In practical terms, this translates to being able resolve detail down to 20 μm at an optimum working distance of 3 to 4 mm. Straight and curved probes are available.

In the authors’ experience, curved probes can be more difficult to work with due to the additional axis of rotation of a curved vs a straight instrument. Nonetheless, it can be useful when access is required diametrically across the posterior pole of the lens to the vitreous base, ciliary body or posterior iris.

Endoscope offers an unmatched perspective

The endoscope has unique optical properties, conferring an advantage over conventional viewing systems in certain clinical scenarios. Visualization and dissection of the anterior hyaloid face and vitreous cortex are particularly relevant to anterior pediatric retinal pathology in conditions such as advanced ROP and familial exudative vitreoretinopathy (FEVR).
With conventional viewing systems, light from an endoilluminator in the vitreous cavity is partly transmitted through the anterior hyaloid face and pupil before being captured and visualized by the surgeon through an operating microscope. It can be difficult to make out the anterior hyaloid face using this technique.

The endoscope is unique in that the source of illumination and surgeon’s view of the resultant reflected light are coaxial. To illustrate this, Figure 1 uses lightly frosted cellophane tape to represent the anterior hyaloid face and vitreous. Visualization of what is an almost transparent anterior hyaloid face is evidently better with reflected light than transmitted light, as shown in Figure 2.

The endoscope also offers the surgeon a unique anatomical perspective. Visualization of posterior segment structures using conventional contact and noncontact viewing systems provides a bird’s-eye or face-on view through the pupil, with the most anteriorly visible structure being the vitreous base or pars plana. Even with deep scleral indentation, anterior structures are practically impossible to directly visualize and manipulate surgically.

The bird’s-eye view is an anatomical perspective comfortable to ophthalmologists, akin to that obtained through a direct or indirect ophthalmoscope. Instead, the endoscope enables a side-on perspective relative to the patient’s visual axis. Through a pars plana sclerotomy, the vitreous base, pars plana, ciliary body, posterior iris surface, and posterior lens surface can be directly visualized. This is advantageous in pediatric vitreoretinopathies, where relief of fibrovascular proliferation involving the aforementioned structures can be the difference between surgical success and failure.

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The exclusive perspective of the endoscope goes even farther. For example, in anterior tractional RD in ROP or FEVR, the surgeon can switch the position of the endoscope to visualize both above and below fibrovascular membranes. This is invaluable, enabling direct rather than indirect identification of a safe preretinal dissection plane, critical for surgical success in these zero-error-tolerance eyes. An iatrogenic retinal break in stage-5 ROP has been shown to lead to 100% failure in a series of 6 eyes.

However, there is a learning curve with endoscopic vitrectomy, as the nonstereoscopic view projected onto a monitor is dissociated from the surgeon’s manipulation of surgical instruments. This is unfamiliar and can be disorientating when coupled with the increased magnification. As with any new technique, additional surgical time is initially required. This is time well-invested, as the ability to directly visualize surgical planes in complex surgical solutions pays dividends in reduced complications and improved clinical outcomes.

**Applying endoscopy to clinical practice**

Endoscopic vitrectomy was first described in 1981. There is good evidence for its use in adults for traumatic RD, proliferative vitreoretinopathy (PVR), retained lens fragments, endophthalmitis, penetrating eye injury, sutured posterior-chamber intraocular lens placement, and rhegmatogenous RD. The authors utilize endoscopy as an adjunct to wide-angle viewing systems in almost all pediatric vitrectomies.

**When is endoscopy indicated?**

At the start of a case, endoscopy is helpful for directly visualizing sclerotomy placement if there are concerns over safe entry. In pediatric vitreoretinopathies such as traumatic RD, ROP, FEVR, and persistent fetal vasculature syndrome (PFVS), atypical anatomical landmarks are commonplace.

Endoscopy comes into its own when significant corneal haze is present, precluding the use of conventional viewing systems. While a keratopros thesis is an option, it is not without its challenges and complications. Pediatric vitrectomies can be performed exclusively with endoscopy.

In traumatic rhegmatogenous RD and PVR, the magnification and perspective of this technique facilitates better visualization and
thorough removal of preretal membranes and hypercellular vitreous. Inadequate clearance, particularly in the context of a hazy cornea, is an important cause of surgical failure and PVR in these children.

Surgical success in children with tractional RDs due to diseases such as ROP, FEVR, and PFVS is often limited by the adequacy of membrane dissection and removal in the area between the anterior retina and ciliary body. Visualization of these structures is often suboptimal with conventional wide-angle viewing systems, and at times impossible.

It is not widely appreciated that the quality of the surgical view with an endoscope is just as good, whether at the macula or pars plicata. Due to the anterior nature of the pathology in a significant proportion of complex pediatric vitreoretinopathies, the ability to maintain good visualization in difficult-to-access surgical spaces is particularly attractive. In addition, the spatial resolution of current 20- and 23-gauge endoscopy systems already exceeds that of conventional noncontact viewing systems.

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Conventional viewing systems in PFVS are adequate, but not necessarily ideal. With a bird’s-eye view, the surgeon sees the vertically oriented PFVS stalk from the top, through the native lens; this enables an accurate assessment of the size of the plaque adherent to the anterior hyaloid face or posterior capsular surface, and thus the degree of potential visual interference and need for surgery.

It is more difficult to assess the presence and amount of retina drawn up along the length of the stalk, as the surgeon’s visual perspective is almost parallel to it. Amputating the stalk too posteriorly risks incurring an iatrogenic retinal break and rhegmatogenous RD. With an endoscope, the stalk can be viewed perpendicularly, making it easier to identify any retinal vessels running through it.

Additional surgical maneuvers where the endoscope is useful include subretinal PVR membrane dissection and clearer identification of the interface between any combination of perfluorocarbon fluid, silicone oil, air, and balanced salt solution.

Looking ahead

As technology evolves, there are several potential developments. The most significant advance will probably be if stereoscopic visualization is made possible, whether with 3D glasses on a monitor, or piped into the eyepieces of the operating microscope. As the resolution of fiber optics increases and instrument size decreases, stereoscopic visualization may well become a reality.

The endoscope has a broad range of applications particularly relevant to pediatric vitrectomies. Its unique optical properties are complementary to conventional contact and noncontact viewing systems. Posterior-segment endoscopy has been a significant and indispensable addition to retina specialists’ surgical armamentarium.

References


Financial Disclosures