ABOUT THE AUTHORS

Flavio A. Rezende, MD, PhD

Dr. Flavio Rezende is a full Professor of Ophthalmology at the University of Montreal and Clinical Director at the Centre Universitaire d'Ophtalmologie, Maisonneuve-Rosemont Hospital. He completed fellowships in surgical retina, ocular oncology, and ophthalmic pathology at McGill University and earned a PhD from the University of São Paulo. His work focuses on complex vitreoretinal surgery, translational research, and surgical innovation.

Affiliations: Centre Universitaire d'Ophtalmologie, Hôpital Maisonneuve-Rosemont, Université de Montréal, Montréal, Québec, Canada

Thiago Machado Nogueira, MD

Dr. Thiago Nogueira is a retina fellow at the Université de Montréal, where he previously completed a fellowship in glaucoma. He completed his Ophthalmology residency at the University of São Paulo, Brazil, where he also served as chief resident. His clinical and research interests focus on the diagnosis and management of vision-threatening conditions, with particular emphasis on improving outcomes of both retinal pathologies and glaucoma.

Affiliations: Département d'ophtalmologie, Université de Montréal, Montréal, Québec, Canada

doi.org/10.58931/cect.2025.4152

Taking a Different Point of View: The Utility of Endoscopic Vitrectomy

Flavio A. Rezende, MD, PhD
Thiago Machado Nogueira, MD

Introduction

Pars plana vitrectomy (PPV), introduced by Dr. Robert Machemer in the 1970s, revolutionized the treatment of vitreoretinal diseases. Technological advancements, such as the development of small-gauge instrumentation and wide-angle viewing systems, have since enhanced the precision and safety of these procedures.[1] However, microscope-based visualization remains limited in scenarios involving limited anterior segment transparency, or when accessing anatomical areassuch as the anterior vitreous base, ciliary body, and retroirideal space.[2]

Endoscopic vitrectomy overcomes these limitations by offering direct intraocular imaging from the probe tip, bypassing anterior segment opacities, and yielding an unobstructed, distortion-free view of otherwise hidden structures[3-6] **(Figure 1)**. This technique allows for dynamic adjustment of perspective and orientation, enabling access to the peripheral retina, anterior vitreous base, and retroirideal structures not easily visualized with traditional top-down microscope-based views[7] **(Figure 2 and Table 1)**. Modern endoscopy systems combine miniaturized probes,[8] high-resolution video capture, coaxial illumination, and enhanced manoeuvrability, making them valuable tools in both routine and complex cases.[4,9]

This review explores the evolving role of endoscopic vitrectomy by examining its principles, instrumentation, clinical applications, surgical techniques, limitations, and future directions—demonstrating how a shift in visual perspective can broaden the capabilities of modern vitreoretinal surgery.

Principles and Instrumentation

Ophthalmic endoscopy was first employed by Thorpe in 1934 using a 6.5 mm probe to remove intraocular foreign bodies (IOFBs). The original device featured external illumination and integrated forceps. By 1978, Norris and Cleasby developed a 1.7 mm intraocular endoscope for use in orbital and intraocular procedures. A pivotal advancement occurred in the 1990s when Uram introduced fiberoptic endoscopes capable of transmitting real-time intraocular images to external monitors, achieving a resolution of up to 17,000 pixels.[10,11] These early instruments laid the groundwork for contemporary videoendoscopic systems that now feature substantial improvements in size, image quality, and functionality.

Contemporary systems use 19- to 25-gauge probes that integrate imaging, illumination, and optional laser photocoagulation capabilities.[2,3,5] Smaller gauges offer improved intraocular fluidics control but compromise resolution. These devices operate via coaxial light and image capture at the probe tip, allowing for a 360° panoramic visualization of the posterior segment independent of corneal clarity, lens status, or pupillary dilation. Unlike microscope-based systems, endoscopy employs coaxial lighting and captures reflected light directly from intraocular tissues, allowing enhanced visualization of otherwise transparent structures such as the vitreous - which appears more opaque in the endoscopic view.[12]

Both straight and curved endoscopy probes are available for intraocular surgery, each offering distinct advantages and limitations. Straight probes are generally favoured for their simplicity in orientation, reduced rotational complexity, and ease of use, particularly for surgeons who are new to endoscopic techniques. Their alignment with traditional instrument handling makes them more intuitive, thereby minimizing disorientation during surgery. However, straight probes may be limited in accessing anatomically challenging regions. In contrast, curved probes are designed to enhance manoeuvrability around intraocular structures, providing improved access and visualization in complex cases where angled views are essential.

Its curved tip, however, introduces an additional axis of rotation, which can complicate spatial orientation and contribute to a steeper learning curve[12] **(Figure 3)**.

The base unit of a typical endoscopic vitrectomy system currently includes a xenon or LED light source, digital image processing modules, a high-definition monitor, and an optional laser source, with the possibility of heads-up displays integration[10] **(Figure 4)**. Optical fibre bundles housed within protective sheaths run from the console to the intraocular probe, each bundle dedicated to a specific function—illumination, imaging, and laser transmission[13] **(Figure 3)**. Care should be taken while manipulating the probe as improper handling or excessive bending can lead to fibre breakage, resulting in a loss of resolution or black spots on the display.

The ability to rotate the probe and shift its position allows for real-time alterations in the field

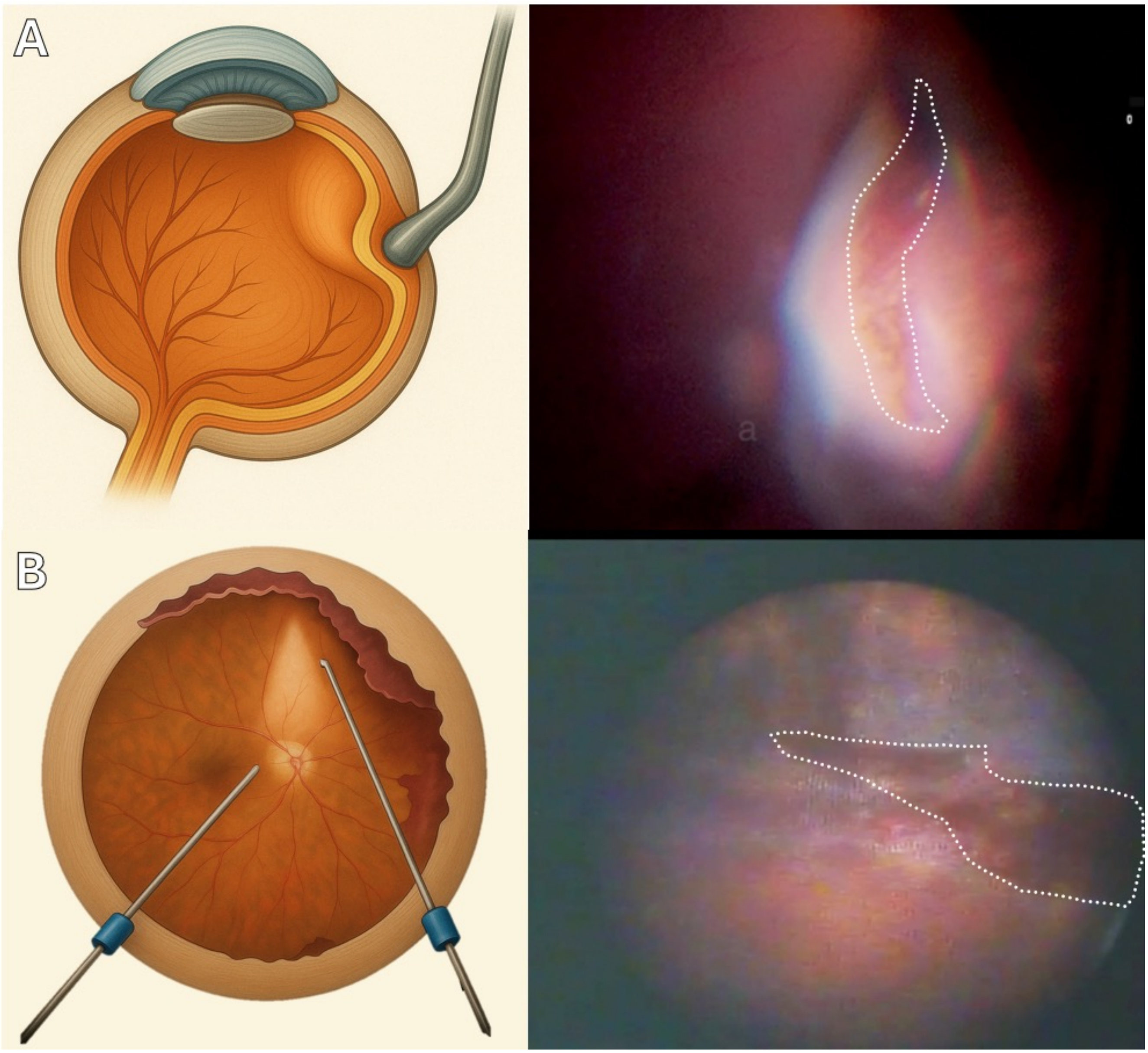

Figure 1. Comparison of the visualization of a large ora serrata break using a microscopic top down view with scleral depression (line A) versus an endoscopic view (line B). While the image at line A has a higher image resolution, scleral depression introduces structural distortions and prevents visualization of the vitreous and retroirideal structures anterior to the break. In contrast, line B demonstrates how endoscopy provides an undistorted view and enables more thorough shaving of the anterior vitreous base under direct visualization; *courtesy of Flavio A. Rezende, MD, PhD and Thiago Machado Nogueira, MD*

of view, enabling visualization of up to 90-140° at a time, depending on the calibre of the endoscope. Additionally, using two strategically positioned cannulas for small-gauge probes can provide a full 360° view.

Clinical Applications

Endoscopic vitrectomy serves two primary roles: endoscopy-guided PPV for eyes with anterior segment opacities where a top-down view with the microscope is not possible, and endoscopy-assisted PPV to enhance visualization of peripheral and retroirideal structures even in eyes with clear media.[14] This dual utility expands its indications significantly and enables earlier and more precise surgical intervention in complex cases **(Figure 5)**.

1. Anterior Segment Opacities:

In cases involving corneal edema, scarring, opacities, anterior chamber hemorrhage, or dense cataracts, endoscopic imaging provides direct visualization beyond opaque media. This approach eliminates the need for temporary or permanent keratoprosthesis or penetrating keratoplasty in situations where these interventions may be technically challenging or carry high risks. Endoscopy is particularly valuable in cases of severe fibrin formation, hyphema—which may be accompanied by corneal blood staining—and in procedures such as intraocular foreign body removal when conventional visualization is compromised. These advantages enable timely intervention, which is critical in urgent scenarios such as trauma, endophthalmitis, or retinal detachments with compromised anterior segment transparency.[2,5,15,16]

2. Ocular Trauma:

Endoscopy is invaluable for managing complex trauma involving IOFBs, retinal detachment, or endophthalmitis. In eyes with compromised corneas or anterior segments, endoscopy permits complete posterior segment evaluation and intervention. It also eliminates the need for scleral depression, which is contraindicated in cases of open-globe trauma.[4,11,17,18]

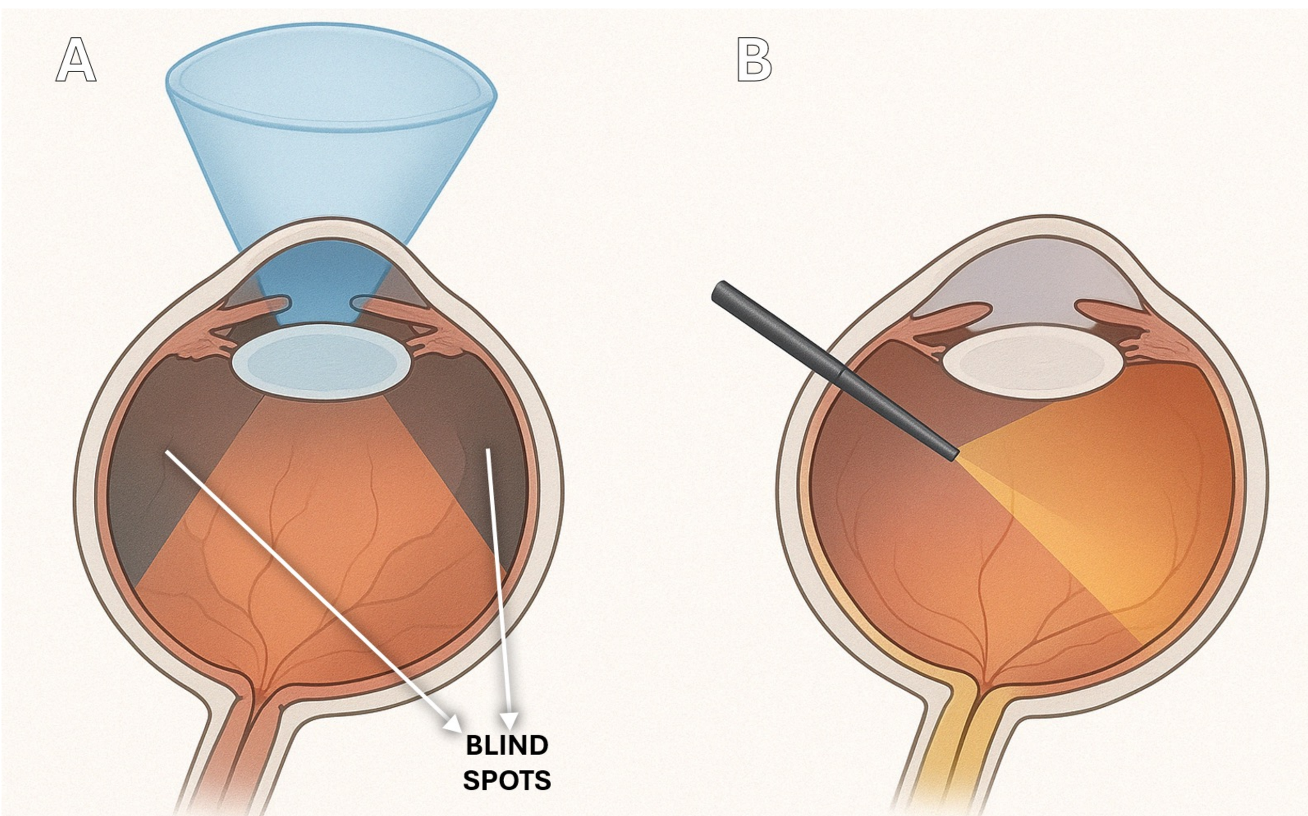

Figure 2. Comparison between the traditional top-down view using a surgical microscope (A) and the endoscopic view (B). Unlike the fixed microscopic perspective that obscures peripheral retroirideal structures in blind spots, endoscopy enables direct visualization of these otherwise inaccessible areas; *courtesy of Flavio A. Rezende, MD, PhD and Thiago Machado Nogueira, MD*

3. Retinal Detachment and Proliferative Vitreoretinopathy (PVR):

In cases of retinal detachments associated with anterior PVR, chronic hypotony, or ciliary body detachment, endoscopy enhances the identification and treatment of subtle pathology. It facilitates subretinal fluid drainage without posterior retinotomies and provides access to the anterior retina, vitreous base, ciliary body, and retroirideal space.[4,7,19-21]

4. Endophthalmitis:

Early vitrectomy in endophthalmitis improves outcomes, but dense media opacity can impede visualization. Endoscopy allows for timely removal of infectious material as well as visualization and assessment of posterior segment structures. This approach contributes to globe preservation and improved visual prognosis.[15,22]

5. Secondary Intraocular Lens (IOL) Fixation and IOL Complications:

Endoscopy enables accurate visualization of the ciliary sulcus and the assessment of the optic zone, haptics, and suture placement in scleral-fixated IOLs. By confirming optimal positioning, it minimizes complications such as IOL dislocation, hemorrhage, and uveitis-glaucoma-hyphema (UGH) syndrome. In postoperative evaluations, it aids in diagnosing and managing complications that are not visible through the standard microscope top-down view.[7,23]

Feature	Microscopy (Wide-angle Systems)	Endoscopy
Stereopsis	Present	Absent
Image Resolution	High (limited by surgeon's retina or camera resolution)	Variable; dependent on endoscope gauge and chip resolution
Field of View	Blind spots in retroirideal structures, partially compensated by scleral depression but prone to image deformations and lens border aberrations	90–140º at a time; 360º if two strategically positioned cannulas are used; independent of anterior segment clarity
Anterior Visulization	Limited to vitreous base	Extended up to iris, ciliary body, and retroirideal space
Access Through Opacities	Impaired by corneal/lens opacity or miosis	Unaffected by opacities or small pupils
Illumination	Transmitted through cornea and lens	Reflected light; coaxial illumination
Image Visualization	Direct through oculars or 3D monitor	On screen only; dissociation from surgeon's familiar line of sight with the microscope
Magnification	Optical zoom; may not enhance detail	Physical proximity allows enhanced detection of small lesions
Manipulation Axes	2 axes (horizontal and verticle)	3 axes (horizontal, vertical, rotational)
Learning Curve	Familiar to most vitreoretinal surgeons	Requires adaptation to 2D screen and lack of depth perception

Table 1. Comparing features of microscopy and endoscopy; *courtesy of Flavio A. Rezende, MD, PhD and Thiago Machado Nogueira, MD*

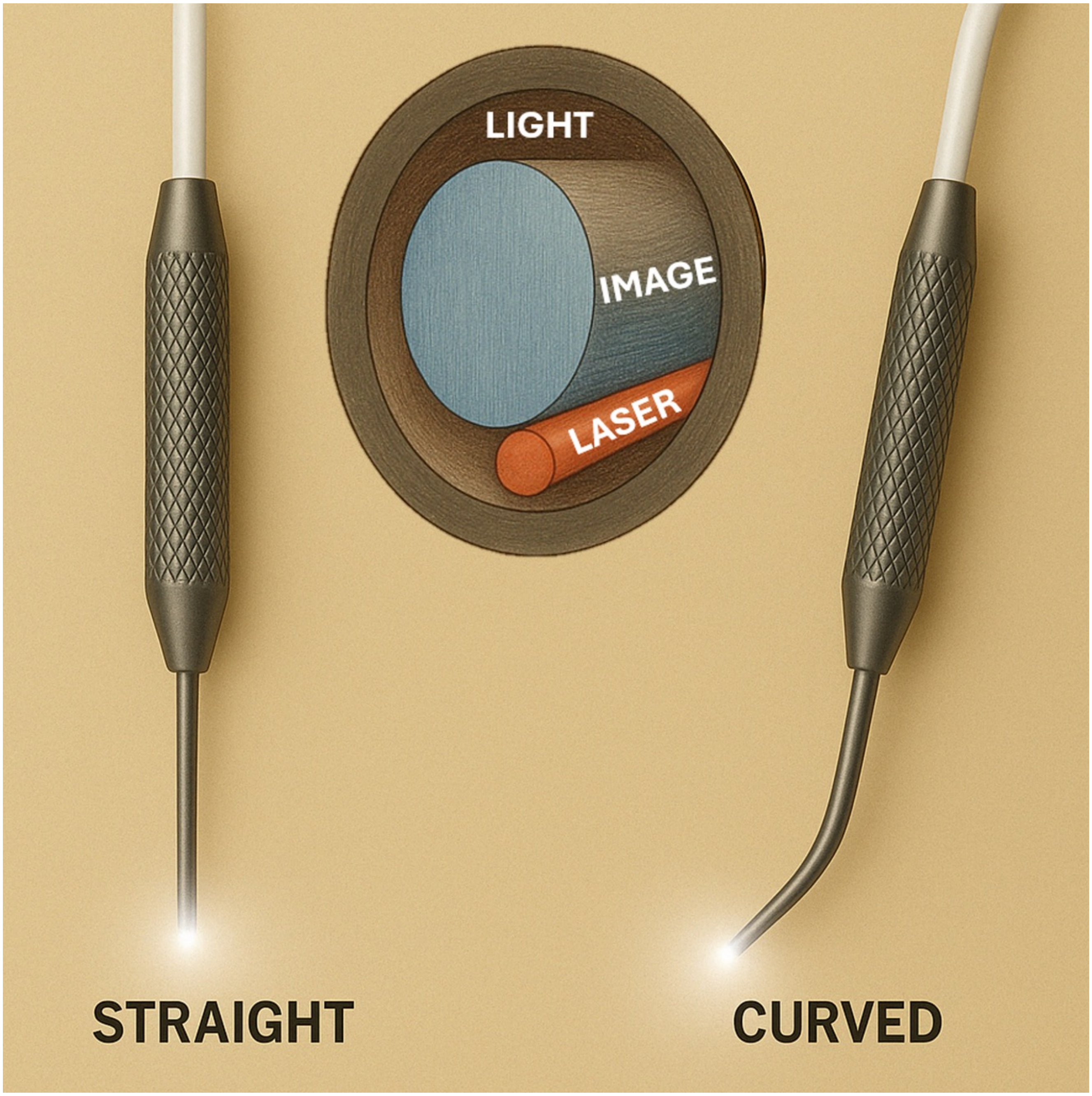

Figure 3. Endoscopic vitrectomy probes are available in straight and curved designs. Straight probes offer intuitive handling and simplified orientation, while curved probes enhance access to anterior structures that may be difficult to visualize in certain surgical contexts. Each probe incorporates dedicated fibre bundles for illumination, imaging, and laser delivery, enabling coaxial illumination/visualization and laser application regardless of corneal clarity or pupil size. When stationary, the probe provides a field of view ranging from 90° to 140°, depending on its calibre. Complete visualization of the posterior segment can be achieved by manipulating the probe and using two well-positioned cannulas for optimal access; *courtesy of Flavio A. Rezende, MD, PhD and Thiago Machado Nogueira, MD*

6. Glaucoma Surgery:

Endoscopy facilitates the placement of pars plana tube shunts by allowing a more complete shaving of the anterior vitreous and ensuring proper positioning of the implant through the pars plana. This reduces the risks of blockage and other postoperative complications.[24] It also enables comprehensive 360° endocyclophotocoagulation (ECP).[25] This method is superior to transpupillary approaches, which can only treat up to 9 clock hours of the ciliary body. It is particularly useful in refractory cases, including neovascular or pediatric glaucoma. In malignant glaucoma, it enhances visualization and dissection of the anterior hyaloid, guaranteeing the patency of the communication between the anterior and posterior segments with Irido-Zonulo-Hyaloido-Vitrectomy.

7. Pediatric Vitreoretinal Diseases:

Pediatric eyes, due to their small size and unique anatomy, present additional challenges. In conditions such as retinopathy of prematurity, persistent fetal vasculature, and familial exudative vitreoretinopathy, endoscopy improves tissue dissection and visualization near the lens and pars plicata.[8] This technique enhances surgical precision, reduces iatrogenic damage, and supports visual outcomes in otherwise inoperable cases.[8,9]

8. Subretinal Procedures:

Endoscopy permits precise membrane removal under the detached retina, avoiding the need for posterior retinotomies. This is particularly valuable in subretinal PVR cases where standard visualization is limited.[26]

9. Keratoprosthesis Planning and Management:

Preoperative endoscopy allows for the evaluation of the posterior segment before keratoprosthesis placement. Postoperatively, it

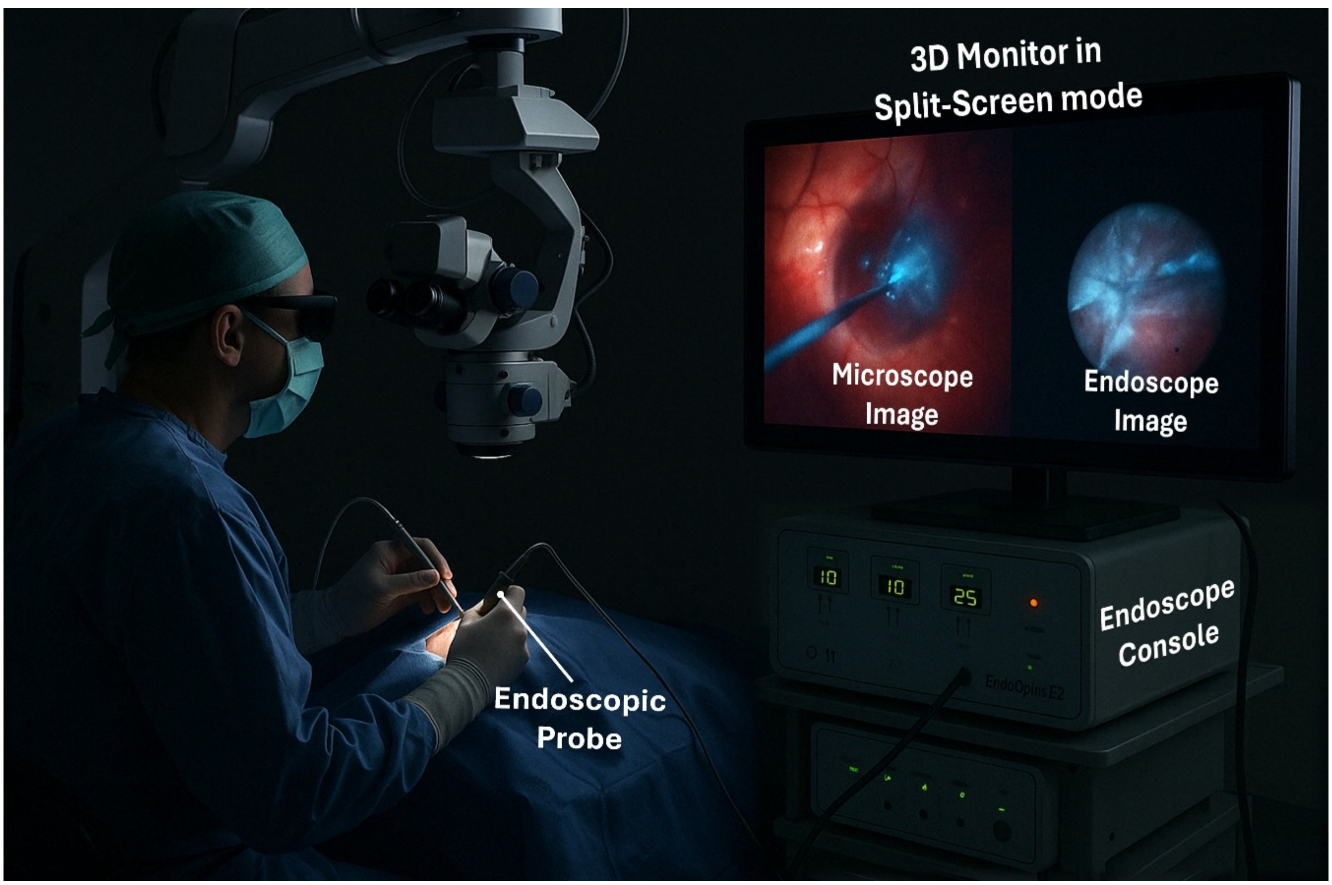

Figure 4. Set-up of an integrated endoscopic view within a three-dimensional (3D) visualization system. The split screen configuration enables a simultaneous display of both microscopic and endoscopic images, improving spatial orientation and eliminating the need to alternate between separate microscopes (or a 3D display) and endoscopy monitors. This configuration enhances ergonomics and provides greater comfort for the surgeon throughout the procedure; *courtesy of Flavio A. Rezende, MD, PhD and Thiago Machado Nogueira, MD*

supports interventions such as retinal detachment repair, endophthalmitis surgical treatment, retroprosthetic membranectomy, and ECP.[27,28]

10. Panretinal Photocoagulation (PRP):

PRP can be delivered through the pars plana using endoscopic visualization in ischemic retinopathies where standard views are obscured.[16] This method allows for complete peripheral treatment, potentially reducing recurrence or progression.

11. Sclerotomy-associated Complications:

Endoscopy allows for intraocular analysis of sclerotomy sites, which is useful for identifying vitreous and retinal incarceration as well as pinpointing the source of intraoperative or postoperative hemorrhages.[29]

12. Diagnostic Endoscopy:

When conventional imaging is inconclusive, diagnostic endoscopy provides direct intraocular visualization. This technique is useful in cases of trauma, opaque cornea, and preoperative planning for keratoplasty. It aids in surgical decision-making, prognostication, and patient counselling.[3,7,11]

Surgical Technique

Endoscopic vitrectomy typically complements standard PPV. Proper planning of trocar placement is essential to accommodate probe angulation and allow full quadrant access.[11]

Intraoperative technique involves dynamic manipulation of the endoscope, requiring adaptation to two-dimensional imaging without stereopsis. Surgeons must rely on visual depth cues and tactile feedback to infer spatial relationships.[29] Changes in probe orientation significantly alter the field of view, which may be unintuitive for those accustomed to the fixed top-down perspective of a microscope rather than the side-on view provided by endoscopy.[12]

While traditional endoscopy systems are costly and cumbersome, recent advances include portable units and modified high-resolution digital

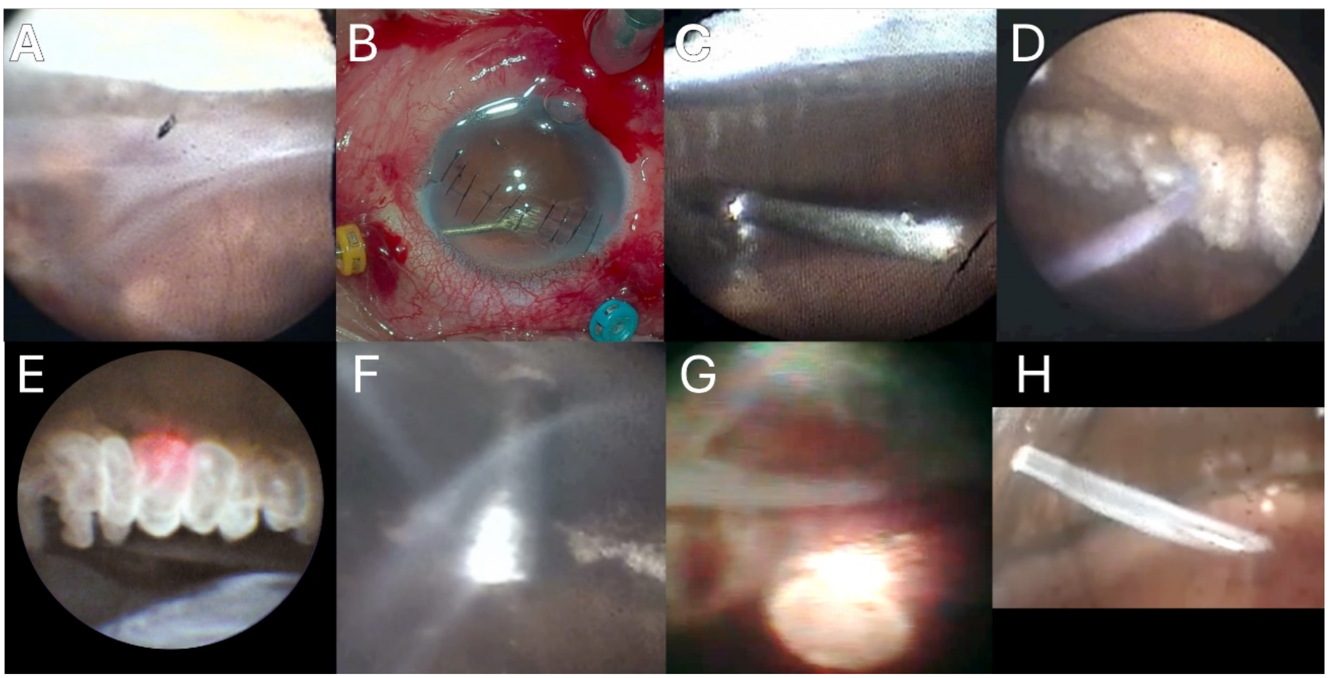

Figure 5. Representative surgical images illustrating key indications and applications of endoscopy. **A:** Dissection of anterior proliferative vitreoretinopathy (PVR); **B:** Vitrectomy in an eye with limited anterior segment transparency; **C:** Shaving of the retroirideal vitreous and anterior hyaloid. **D:** Evaluation of a scleral-fixated intraocular lens (IOL) - this image reveals a haptic piercing a ciliary process, which accounts for the recurrent postoperative vitreous hemorrhage; **E:** Endocyclophotocoagulation (ECP) of the ciliary processes; **F:** Identification of vitreous incarceration within a cannula; **G:** Confirmation of patency of the communication between anterior and posterior segments during Irido-Zonulo-Hyaloido-Vitrectomy for malignant glaucoma; **H:** Intraoperative positioning of a pars plana tube shunt; *courtesy of Flavio A. Rezende, MD, PhD and Thiago Machado Nogueira, MD*

cameras, expanding accessibility.[30] The integration of heads-up displays and digital overlays improves ergonomics, decreases learning curve length, and reduces physical strain during lengthy procedures.

Endoscopy enables high-precision manoeuvres such as dissection of anterior PVR,[20] identification of subtle peripheral breaks,[6] and direct delivery of endolaser photocoagulation or endodiathermy. It enhances safety during fluid-air exchange and facilitates secure tamponade, even in compromised eyes.[31]

Limitations and Challenges

Despite its advantages, endoscopic vitrectomy faces barriers that limit its widespread adoption. One significant challenge is cost and accessibility; acquisition and maintenance are expensive, limiting availability in many centres.[12] Additionally, there is a training deficit, as few training programs offer structured exposure to endoscopy, resulting in underutilization.[10]

The absence of stereopsis is also a limitation. The two-dimensional image requires adaptation to pseudostereopsis, increasing the learning curve.[18] Ergonomic fatigue also poses a challenge, as maintaining orientation and adjusting hand position increases surgeon fatigue, especially during lengthy cases.[32]

There are also trade-offs between resolution and field of view. Smaller-gauge probes provide less detailed images, a smaller field of view, and reduced illumination, while larger calibre probes are less manoeuvrable.[9] The need to operate the endoscope with one hand precludes the use of standard bimanual surgical techniques, further complicating the procedure.[11]

Postoperative visualization presents another challenge. In persistently opaque anterior segments, traditional fundus exams are not feasible, requiring ultrasonography or repeat endoscopy in the postoperative period.[7] Addressing these challenges requires ongoing development in miniaturization, three-dimensional visualization, and simulation-based training. Wider adoption may be facilitated by the development of standardized curricula and evidence-based protocols.

Future Directions

Advances in endoscopic vitrectomy are expected to enhance its usability and clinical integration. One notable development is the combination with three-dimensional visualization systems. Integrating endoscopic views into heads-up display systems improves the surgeon's spatial awareness and ergonomics by eliminating the need to alternate between separate monitors. Additionally, the colour filters available in these systems can enhance endoscopic visualization in a split-screen setting.[5]

Digital enhancements also play a crucial role in image quality. High-resolution microcameras and real-time contrast modulation improve image quality.[33]

Emerging technologies, including chip-on-tip designs,[2] proximity sensors,[34] depth-sensing technologies,[7] three-dimensional ocular endoscopy,[35] and robotic endoscope holders,[36] promise enhanced visualization.

Furthermore, dedicated training in vitreoretinal surgery fellowships would improve adoption and proficiency among new users.

As clinical familiarity grows and technology advances, endoscopy will evolve from a niche tool to a standard adjunct in complex cases.

Conclusion

Endoscopic vitrectomy represents a transformative approach in vitreoretinal surgery that extends visualization beyond the limits of traditional microscopy. Its ability to bypass opaque media and access retroirideal structures makes it extremely valuable in complex vitreoretinal conditions. While technical challenges remain, surgeons can adapt through structured training and experience.

By complementing wide-angle systems, endoscopy reduces surgical blind spots, enhances precision, and broadens the therapeutic reach. As technology advances and clinical evidence grows, endoscopy will play an increasingly central role in the modern vitreoretinal surgeon's armamentarium. It provides a different point of view that reshapes intraoperative decision-making and enhances patient outcomes.

Correspondence

Flavio A. Rezende, MD, PhD
Email: frezendef@gmail.com

Financial Disclosures

F.R.: None declared.
T.N.: None declared.

References

1. Scott MN, Weng CY. The Evolution of pars plana vitrectomy to 27-G microincision vitrectomy surgery. Int Ophthalmol Clin. 2016;56(4):97-111. doi:10.1097/iio.0000000000000131
2. Dave VP, Tyagi M, Narayanan R, Pappuru RR. Intraocular endoscopy: a review. Indian J Ophthalmol. 2021;69(1):14-25. doi:10.4103/ijo.IJO_1029_20
3. Yu YZ, Jian LL, Chen WX, Peng LH, Zou YP, Pang L, et al. Endoscopy-assisted vitrectomy for severe ocular penetrating trauma with corneal opacity. Int J Ophthalmol. 2024;17(12):2256-2264. doi:10.18240/ijo.2024.12.14
4. Rezende FA, Vila N, Rampakakis E. Endoscopy-assisted vitrectomy vs. vitrectomy alone: comparative study in complex retinal detachment with proliferative vitreoretinopathy. Int J Retina Vitreous. 2020;6:34. doi:10.1186/s40942-020-00238-9
5. Baldwin G, Miller JB. Heads-up 3-dimensional visualization to enhance video endoscopy during vitreoretinal surgery. J Vitreoretin Dis. 2024;8(4):428-434. doi:10.1177/24741264241249527
6. Kita M, Yoshimura N. Endoscope-assisted vitrectomy in the management of pseudophakic and aphakic retinal detachments with undetected retinal breaks. Retina. 2011;31(7):1347-1351. doi:10.1097/IAE.0b013e3182003c93
7. Lai FHP, Wong EWN, Lam WC, Lee TC, Wong SC, Nagiel A, et al. Endoscopic vitreoretinal surgery: review of current applications and future trends. Surv Ophthalmol. 2021;66(2):198-212. doi:10.1016/j.survophthal.2020.11.004
8. Yeo DCM, Nagiel A, Yang U, Lee TC, Wong SC. Endoscopy for pediatric retinal disease. Asia Pac J Ophthalmol (Phila). 2018;7(3):200-207. doi:10.22608/apo.2018154
9. Nagiel A, Yang U, Reid MW, Anulao KJ, Say EAT, Wong SC, et al. Visual and anatomic outcomes of pediatric endoscopic vitrectomy in 326 cases. Retina. 2020;40(11):2083-2090. doi:10.1097/iae.0000000000002746
10. Ajlan RS, Desai AA, Mainster MA. Endoscopic vitreoretinal surgery: principles, applications and new directions. Int J Retina Vitreous. 2019;5:15. doi:10.1186/s40942-019-0165-z
11. Yonekawa Y, Papakostas TD, Marra KV, Arroyo JG. Endoscopic pars plana vitrectomy for the management of severe ocular trauma. Int Ophthalmol Clin. 2013;53(4):139-148. doi:10.1097/IIO.0b013e3182a12b1f
12. Wong SC, Lee TC, Heier JS, Ho AC. Endoscopic vitrectomy. Curr Opin Ophthalmol. 2014;25(3):195-206. doi:10.1097/icu.0000000000000052
13. Kawashima S, Kawashima M, Tsubota K. Endoscopy-guided vitreoretinal surgery. Expert Rev Med Devices. 2014;11(2):163-168. doi:10.1586/17434440.2014.882226
14. Rezende F, Vila N. New era in endoscopic vitreoretinal surgery. Graefes Arch Clin Exp Ophthalmol. 2019;257(12):2797-2798. doi:10.1007/s00417-019-04468-y
15. Dave VP, Pappuru RR, Tyagi M, Pathengay A, Das T. Endoscopic vitrectomy in endophthalmitis: initial experience of 33 cases at a tertiary eye care center. Clin Ophthalmol. 2019;13:243-251. doi:10.2147/opth.S185716
16. Marra KV, Yonekawa Y, Papakostas TD, Arroyo JG. Indications and techniques of endoscope assisted vitrectomy. J Ophthalmic Vis Res. 2013;8(3):282-290.
17. Yu YZ, Zou XL, Chen XG, Zhang C, Yu YY, Zhang MY, et al. Chronic hypotony management using endoscopy-assisted vitrectomy after severe ocular trauma or vitrectomy. Int J Ophthalmol. 2023;16(6):947-954. doi:10.18240/ijo.2023.06.18
18. Boscher C, Kuhn F. Endoscopic evaluation and dissection of the anterior vitreous base. Ophthalmic Res. 2015;53(2):90-99. doi:10.1159/000370032
19. Lee GD, Goldberg RA, Heier JS. Endoscopy-assisted vitrectomy and membrane dissection of anterior proliferative vitreoretinopathy for chronic hypotony after previous retinal detachment repair. Retina. 2016;36(6):1058-1063. doi:10.1097/iae.0000000000000838
20. Ajlan RS, Pfannenstiel M, Kam Y, Sciulli H. Endoscopy-assisted pars plana vitrectomy in retinal detachments associated with anterior proliferative vitreoretinopathy and epiciliary membranes. BMC Ophthalmol. 2023;23(1):376. doi:10.1186/s12886-023-03120-y
21. Yu YZ, Zou YP, Zou XL. Endoscopy-assisted vitrectomy in the anterior vitreous. Int J Ophthalmol. 2018;11(3):506-511. doi:10.18240/ijo.2018.03.23
22. Diaz JD, Arroyo JG. Modern clinical applications of endoscopic pars plana vitrectomy in vitreoretinal surgery. Int Ophthalmol Clin. 2020;60(1):25-33. doi:10.1097/iio.0000000000000295
23. Sugiura T, Kaji Y, Tanaka Y. Anatomy of the ciliary sulcus and the optimum site of needle passage for intraocular lens suture fixation in the living eye. J Cataract Refract Surg. 2018;44(10):1247-1253. doi:10.1016/j.jcrs.2018.07.017
24. Shaikh AH, Khatana AK, Zink JM, Miller DM, Petersen MR, Correa ZM, et al. Combined endoscopic vitrectomy with pars plana tube shunt procedure. Br J Ophthalmol. 2014;98(11):1547-1550. doi:10.1136/bjophthalmol-2013-304283
25. Marra KV, Wagley S, Omar A, Kinoshita T, Kovacs KD, Silva P, et al. Case-matched comparison of vitrectomy, peripheral retinal endolaser, and endocyclophotocoagulation versus standard care in neovascular glaucoma. Retina. 2015;35(6):1072-1083. doi:10.1097/iae.0000000000000449
26. Kaga T, Yokoyama S, Kojima T, Mitamura H, Mori T, Matsuda T, et al. Novel endoscope-assisted vitreous surgery combined with atmospheric endoscopic technique and/or subretinal endoscopic technique for rhegmatogenous retinal detachment with grade c proliferative vitreoretinopathy. Retina. 2019;39(6):1066-1075. doi:10.1097/iae.0000000000002121
27. Farias CC, Ozturk HE, Albini TA, Berrocal AM, Amescua G, Betancurt C, et al. Use of intraocular video endoscopic examination in the preoperative evaluation of keratoprosthesis surgery to assess visual potential. Am J Ophthalmol. 2014;158(1):80-86.e82. doi:10.1016/j.ajo.2014.02.043
28. Geoffrion D, Mullie GA, Arej N, Rhéaume MA,

Harissi-Dagher M. Endoscopy-assisted total pars plana vitrectomy during Boston keratoprosthesis type 1 implantation. Can J Ophthalmol. 2023;58(5):e209-e211. doi:10.1016/j.jcjo.2023.03.010
29. Cheng YS, Hsiao CH, Hsia WP, Chen HJ, Chang CJ. Endoscopic vitrectomy combined with 3D heads-up viewing system in treating traumatic ocular injury. J Ophthalmol. 2024;2024:9294165. doi:10.1155/2024/9294165
30. Sturzeneker G, Pereira RR, Nakaghi RO, Maia A. Modified portable camera endoscope for posterior segment surgery. Retina. 2021;41(1):228-229. doi:10.1097/iae.0000000000002973
31. Vila N, Rampakakis E, Rezende F. Endoscopy-assisted vitrectomy outcomes during silicone oil removal after complex retinal detachment repair. Journal of VitreoRetinal Diseases. 2019;3(6):445-451. doi:10.1177/2474126419861850
32. Kita M, Mori Y, Hama S. Hybrid wide-angle viewing-endoscopic vitrectomy using a 3D visualization system. Clin Ophthalmol. 2018;12:313-317. doi:10.2147/opth.S156497
33. Xia W, Chen ECS, Peters T. Endoscopic image enhancement with noise suppression. Healthc Technol Lett. 2018;5(5):154-157. doi:10.1049/htl.2018.5067
34. Mori T, Kaga T, Yoshida N, Sato H, Kojima T, Matsuda T, et al. Usefulness of the proximity endoscope in vitrectomy for proliferative diabetic retinopathy. Retina. 2020;40(12):2424-2426. doi:10.1097/iae.0000000000002937
35. Kita M, Kusaka M, Yamada H, Hama S. Three-dimensional ocular endoscope system for vitrectomy. Clin Ophthalmol. 2019;13:1641-1643. doi:10.2147/opth.S221197
36. Zhou, D. et al. Eye Explorer: A robotic endoscope holder for eye surgery. *International Journal of Medical Robotics and Computer Assisted Surgery* 17, 1–13 (2021).