Review Article

# Intraocular endoscopy: A review

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Optimal visualization is one of the most challenging aspects of performing vitreoretinal surgery. In situations where conventional microscopic techniques provide poor posterior visualization, the adjunctive skill set of endoscopic visualization may be needed. This allows for by-passing the opaque anterior segment media and getting access to the posterior segment pathology. Endoscopic vitrectomy is a useful and unique adjunct to microincision vitreoretinal surgery. The optical set-up of endoscopy allows for clinical approaches that are impossible with regular microscope viewing systems. These include the ability to observe across optically significant anterior segment opacities and directly visualize the posterior segment of the eye. It also allows for visualizing the difficult-to-access retroirideal, retrolental, and anterior retinal structures. Surgical access to anatomic spaces like the pars plana, pars plicata, ciliary sulcus, ciliary body, and peripheral lens is tedious. This is made simpler by endoscopy. In this review, we summarize and review the usage of the intraocular endoscope as a diagnostic and therapeutic armamentarium across a wide spectrum of ocular pathologies.

**Key words:** Diagnostic endoscopy, endoscopic visualization, endoscopic vitrectomy, endoscopy, intraocular endoscopy

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Vitreoretinal surgeons often face complex clinical situations requiring astute surgical manipulation for optimal visual and anatomic outcomes. The necessity and dependence on a good surgical field visualization cannot be overemphasized in these situations.[1,2] Certain clinical conditions present with an operable posterior segment pathology with a compromised anterior segment visualization due to corneal scars, repaired corneal tears, dense pupillary membranes, and thick posterior capsular opacities. A recent increase in cases operated for keratoprosthesis also accounts for such cases with poor posterior segment visibility.

In many of these cases, the rapidity with which the treatment is initiated has a bearing on the final visual outcome.[3,4] Operating in suboptimal visualization provided by the conventional viewing systems may results in, missed breaks, incomplete laser incomplete vitreous clearance, or an incomplete tamponade fill. Using a temporary keratoprosthesis (TKpro) can help overcome these limitations to a certain extent. But a TKpro procedure is fraught with complications and also has an obligatory need for an immediate penetrating keratoplasty (PKP).[5-7] An ophthalmic endoscope allows for a far better surgical approach in these cases. It allows for a direct approach and visualization of the vitreous cavity, allows for a better and more thorough vitreous clearance and an assessment of retinal integrity and visual potential. Coexisting retinal breaks and holes can be picked up and timely treated. In the current communication, we present an extensive review of the usage of the ophthalmic endoscope for vitreoretinal procedures. Herein, we attempt to discuss and summarize case series and comparative literature on the usage of the endoscope in various clinical settings and report their results.

## Methods

We conducted a detailed review of the literature on PubMed using the search words endoscopic vitrectomy, ophthalmic endoscope, ocular endoscope, and endoscopy in vitreoretina. Additional articles were retrieved from the bibliography of the articles searched by the above key words. Non-English language works of literature were excluded.

## Instrumentation

The commonest instrumentation currently used for endoscopic vitrectomy is the E4 Endoscopy and Laser System (EndoOptiks, Inc., Little Silver, NJ, USA).[8] Herein, the EndoOptiks E4 Micro Probe™ is the principle component of the entire system. The complete hardware consists of the endo probe console, the footswitch, and the monitor. The camera selection and light intensity are controllable from the front panel while the rear panel consists of connectors to a video monitor, videocassette recorder, or video printer. A 175-W xenon light source is used to provide illumination. The intensity of the light source can be adjusted from the front panel or the footswitch. Through a 200-μm fiber-optic cable, the treatment laser can generate pulses from 0 to 1200 mW in power and 50 to 2000 ms in width. A charge-coupled device camera processes the image

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procured by the endo probe and displays it on the monitor for the operating surgical team. There are inter-gauge differences in the field of view and resolution. The inter-gauge differences are as follows: 19G—17,000 pixels, 140° Field of view (FOV); 20G—10,000 pixels, 110° FOV; and 23G—6000 pixels, 90° FOV.

FiberTech, Co, Tokyo, Japan also has an endoscopy platform (AS 611) available in 20G, 23G, and 25G.[9] Other commercially available endoscopes are sparsely used in ophthalmology.[10-12] Practically speaking, there are quite a few differences in the working of endoscopes vis-à-vis conventional operating microscopes [Table 1].

## Technique

Like any other unconventional surgical methodology, endoscopic vitrectomy has a large learning curve. Head posture is quite different as compared to what the surgeon is used to usually as this requires a head posture towards to display monitor. Often the head turn is exaggerated depending on the possible location of the camera monitor. Depth perception is nonexistent in endoscopic surgeries because of a lack of stereopsis and a two-dimensional visualization setup. As the light source and the camera are on the same axis, there is no shadowing. This eliminates the judgment of the instrument distance from the retina leading to high chances of possible tissue touch and retinal breaks, especially for the uninitiated surgeon. The overall view is a tunnel like, much different from the conventional panoramic view of the retina. Focusing the retina is not controlled on the table but has to be controlled by an assistant on the endoscope machine quite unlike the focusing of a binocular indirect ophthalmomicroscope lens. This is done by asking the circulating nurse to rotate a knob on the machine panel while the endoscopy probe is focused on a target like a conjunctival vessel. Rotation of the endoscope probe inadvertently causes rotation of the field of view which can again lead to errors of judgment. Judgmental errors are more common in the peripheral retinal maneuvering because easily identifiable landmarks like the foveal avascular zone and the optic disc are absent in the field of view. Thus, an imperative step is to ensure the orientation is correct before surgical maneuvering starts. In case of doubts, the probe can be retracted to allow for a greater field of vision and thus a better orientation. This may have to be repeated multiple times during surgery. An additional application of a chandelier illumination probe can be of great assistance as the added brightness of view gives a better orientation of the intraocular structures in the absence of thee dimensional view.

## Indications

The commonest indication of ophthalmic endoscopy is in anterior segment opacities which disallow adequately clear visualization of the posterior segment. When faced with posterior segment pathology requiring surgery in the presence of gross anterior segment opacities, the conventional approach is to manage the posterior segment pathology conservatively until the anterior segment opacities are treated or they get cleared. Another option is to use a TKpro to operate upon the posterior segment pathology. The disadvantage of waiting until the anterior segment problem is tackled is the potential progression of the posterior segment disease. Delay can lead to an overall reduction of visual potential. The disadvantage of using a TKpro is the obligatory requirement of corneal tissue to perform an immediate sequential keratoplasty. This can be especially difficult for many underdeveloped and developing countries that do not have adequate eye bank facilities.[13]

Another emerging application of endoscopic surgery is to diagnose and treat pathology related to the difficult to visualize areas of the eye like the ciliary body, ciliary sulcus, posterior iris epithelium, ora serrata and the peripheral retina especially laser cyclophotocoagulation for the treatment of intractable glaucoma.[14-16] As against artificially changed relative structural anatomy due to indentation and peripheral optical lens distortions, direct endoscopic visualization allows for understanding the actual *in-vivo* anatomy. A very important established indication is to prognosticate eyes that are due for an optical keratoprosthesis surgery.[17] The indications are summarized in Table 2.

## History

The first ophthalmic application of endoscopy was described in 1934 by Thorpe.[18] He used it for retrieving an intraocular foreign body. Norris *et al.*,[19] in 1978, described a lens and wave-guided viewing system surrounded by a wing of fibers for illumination lodged in a stainless steel sheath. This system gave a view of 70° and a magnification of 30×. In 1981, Norris *et al.*[20] described a series of 18 endoscopic vitrectomy procedures for removing retained foreign bodies and for persistent retinal detachments. They reported a good anatomical outcome with the only complication being a single case of iatrogenic retinal detachment. Volkov *et al.* in 1990 described the technical characteristics of flexible ophthalmic endoscopes for the first time and described a series of 23 patients operated with endoscopic vitrectomy with good results.[21,22]

**Table 1: Comparison of conventional operating microscope with ophthalmic intraocular endoscope**

| Attribute | Conventional operating microscope | Intraocular endoscope |
|---|---|---|
| Type of viewing | Fully stereoscopic | Non-stereoscopic |
| Judgment of tissue distances | Surgeon's steroacuity | Using non-stereo cues like size of objects, relative distance, shadows, and motion parallax |
| Field of view | Stable and wide-field | About 30-40° and can be increased by moving the endoscope either away or close |
| Magnification | Is changed by changing the focusing lens distances or by the in-built microscope magnification | Changed by moving the endoscope either away or close to the target tissue |
| Tissue resolution | Tissue detail is limited by optical aberrations in ocular media and ophthalmoscopic lens system and by ocular pathology that may interfere with media clarity | Details otherwise undetectable with conventional ophthalmoscopy can be imaged by moving the endoscope probe close to the target tissue |

**Table 2: Indications for intraocular endoscopic interventions**

| Diagnostic | Therapeutic* |
|---|---|
| Posterior segment evaluation for prognostication before keratoplasty or keratoprosthesis | Cyclophotocoagulation for intractable glaucoma |
| | Rhegmatogenous retinal detachment |
| | Retained intraocular foreign body |
| | Vitreous hemorrhage |
| | Endophthalmitis vitrectomy |
| | Dissecting ciliary membranes |
| | Sclera fixation of intraocular lens |
| | Vitrectomy with keratoprosthesis in situ |
| | Dissecting anterior proliferative vitreoretinopathy |
| | In severe fibrovascular membrane dissection in diabetic vitrectomy |

*Indications where the cornea is opaque

Around the same period, Eguchi *et al.*[23] from Japan described a system of an electronic video endoscope for ophthalmic usage. Uram *et al.* first described the use of laser ablation via an endoscope in cases of neovascular glaucoma for ciliary process photocoagulation and for retinal photocoagulation during endoscopic vitrectomies.[14,24] All cases were reported to have good outcomes with no serious adverse effect noted. A review of the various indications for which endoscopy has been used is discussed as follows.

## Applications of Endoscopy

### Anterior segment diseases

The current conventional viewing systems do not allow easy access to areas like the vitreous base, ciliary body, and the ciliary sulcus. Thus, pathologies related to these areas are difficult to access and may become unamenable to treatment. Heier described a series of cases with chronic uveitis due to retained lens matter in the ciliary sulcus.[25,26] The retained matter was removed endoscopically and that led to a resolution of the chronic inflammation.

Endoscopic procedures have a role in many angle procedures. Cyclodialysis cleft is a known occurrence after trauma or surgical procedures. Untreated, they can cause intractable hypotony. Caronia *et al.* described a novel endoscopic approach to visualize and treat a cyclodialysis cleft [Table 1].[27] The endoscope helped identify the cleft and also allowed for the application of laser to the ciliary body surfaces. Goniosynechiolysis is an angle maneuver used in cases with congenital glaucoma. A technique has been described wherein a goniosynechiolysis spatula is used to perform the same under the simultaneous visualization with an endoscope.[28] Their study reported a reduction of mean IOP from 42.9 ± 15.8 mmHg to 12.7 ± 3.5 mmHg post endoscopy-assisted goniosynechiolysis. Goniotomy is another surgical procedure performed for congenital glaucoma. Bayrakar *et al.* have described the use of endoscopy in goniotomy procedures.[29] They used a customized goniotomy blade that was attached to an endoscopy probe. In the follow-up period varying from 14.2 ± 9.7 months, the mean intraocular pressure (IOP) was decreased from 38.3 ± 6.9 mmHg to 17.6 ± 2.8 mmHg, with a reduction in glaucoma medications from 2.1 ± 0.3 to 0.3 ± 0.5. Joos and Shen reported a case of endoscopic goniotomy for congenital glaucoma in a 19-month-old infant.[30] Though in their report, the IOP did not reduce significantly enough, it still allowed for the adequate clearing of the cornea to allow conventional goniotomy.

Feltgen *et al.* have reported the technique of endoscopy assisted laser goniopuncture.[31] They used endoscope erbium: YAG laser system (Sklerotom 2.9, Endognost, Schwing, Germany) to perform laser goniopuncture combined with cataract extraction. A comparison with a control group of trabeculectomy with cataract extraction showed a similar IOP control over a 1-year follow-up with significantly fewer complications. Anterior chamber angle laser procedures also include excimer laser trabeculoplasty. Wilmsmeyer *et al.* presented a prospective case series of 69 patients treated with endoscopic laser therapy (ELT), and of 57 with combined ELT and phacoemulsification.[32] They noted a success rate of 66% with endoscopic ELT versus 46% with the control group. Repeat surgeries required were also fewer in the endoscopic ELT group (7% versus 28%).

Glaucoma valve surgeries are common place surgeries in the current era for complicated glaucomas. The success of the valve implant depends largely on an appropriate tube placement in the anterior chamber. On certain occasions, the cornea may be cloudy and the resultant corneal haze precludes an adequate visualization of the anterior chamber structures and does not allow judgment of the tube placement. In such situations, endoscopy in the anterior chamber can allow for appropriate visualization and tube placement. Tarantola *et al.* combined endoscope-assisted pars plana vitrectomy (PPV) and glaucoma tube shunt insertion in cases with chronic angle-closure glaucoma and corneal opacity.[33] In their series, 14 of 19 achieved complete or qualified success, with IOP <21 mmHg.

### Ciliary sulcus disorders

One of the major bugbears among ciliary sulcus diseases is intractable chronic hypotony. The local pathogenesis causing hypotony includes ciliary process atrophy and thick membranes formed over the ciliary processes [Fig. 1]. Hammer and Grizzard in their report of 14 eyes have described the visualization and dissection of membranes over the ciliary body in cases of chronic hypotony.[34] They reported normalization of IOP in 78% of patients in the early postoperative period and 33% at last follow up.

Endoscopy has been employed to guide secondary intraocular lens (IOL) placement for assessing the capsular support and evaluating the ciliary sulcus in cases planned for scleral fixated IOLs. Olsen and Pribila have described a series of cases where endoscopy was used to evaluate the ciliary sulcus internally for the assessment of the suture pass in scleral fixation.[35] This potentially aided avoidance of vitreous hemorrhage as the pass into the ciliary body was under visualization.

### Endoscopic cyclophotocoagulation

Endoscopic cyclophotocoagulation is one of the commonest performed endoscopic procedures. It is performed either as an isolated procedure or combined with phacoemulsification. Ideal patients are those with previously failed surgeries for IOP control or those deemed unsuitable for filtering surgeries and having coexistent uncontrolled IOP, extensive conjunctival scarring, chronic ocular surface disease and eyes with a high

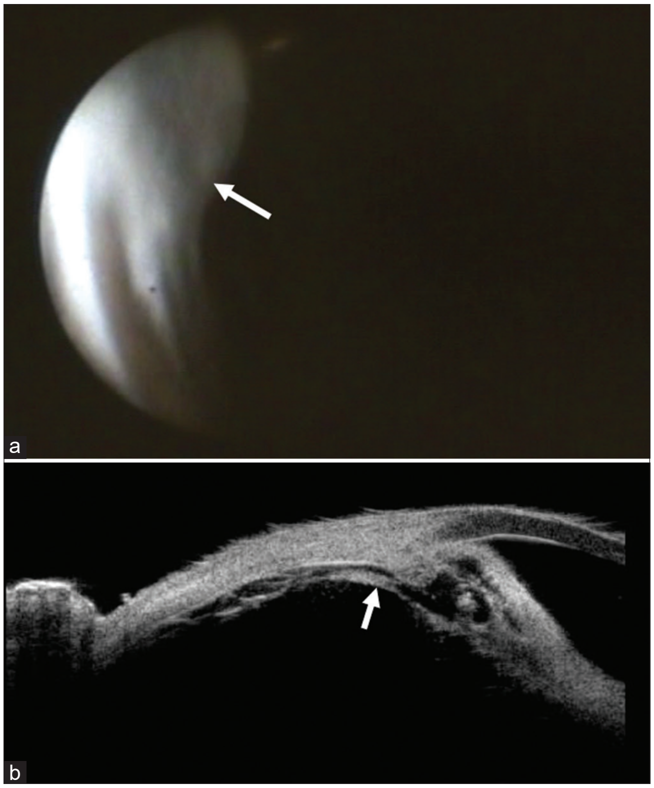


**Figure 1:** Panel showing peripheral ciliary body membrane (a) with the corresponding membrane on the ultrasound biomicroscopy (b)

risk of complications for incisional surgeries (vitrectomized eyes, eyes with a history of suprachoroidal hemorrhage).

Endocyclophotocoagulation (ECP) has demonstrated safety and efficacy in intractable glaucoma. Uram has shown the efficacy of ECP both by the pars plana and by the limbal route.[24,36] In the pars plana approach, 9/10 patients achieved IOP <21 mmHg at a 9-month follow-up. The mean pre ECP IOP recorded was 43.6 mmHg. In the limbal incision ECP group, the mean preoperative IOP of 31.4 mmHg had decreased to 13.5 mmHg at a follow-up of 19 months. A randomized control trial compared combined cataract surgery with ECP to cataract surgery and trabeculectomy.[37] At a 6-month follow-up visit, 32% of patients treated with ECP had IOP controlled (<21 mmHg) without medication and 45% with medications, as compared with 54% of patients treated with trabeculectomy without medications and 18% with medications. The IOP reduction was similar between the two groups and was noted to be 24.6 ± 6.2 mmHg at baseline with a reduction of 8.6 8.2 mmHg for the trabeculectomy group, and 24.8 ± 8.6 mm Hg at baseline with a reduction of 8.8 ± 9.6 mmHg for ECP group.

ECP has also been compared with Ahmed glaucoma valve (AGV). In a study conducted in Brazil, 68 patients with failed trabeculectomy were allocated to either an AGV implant or ECP.[38] In a mean follow-up of 20 months, both the groups showed a comparable reduction of IOP at the last follow-up, though the AGV group showed a greater reduction during the first week. The AGV group, however, required a higher number of postoperative visits and interventions in view of greater hypotony and higher postoperative early vision drop.

### Unique role of ECP in pediatric glaucoma

Pediatric eyes have an anatomy that is in a variant from that of an adult eye. ECP has a unique role to play in such eyes. In a case report published by Barkana *et al.*, the role is well elucidated.[39] They described a case of failed trans-scleral cyclophotocoagulation. On performing ECP, it was noted that the prior trans-scleral cyclophotocoagulation spots were received on the pars plana region, thus explaining the treatment failure. A similar experience was reported by Al-Haddad *et al*.[40] They reported 11 eyes of patients with Peter's anomaly with glaucoma treated with ECP who were previously treated with trans-scleral cyclophotocoagulation.

### Endoscopy for retinal detachment

Sclerotomies are also well visualized internally with an endoscopic approach. Vitreous incarceration at sclerotomies can be a nidus for external bacteria to gain access to the internal milieu and also can act as a scaffold for further fibrovascular proliferation especially in eyes with diabetic retinopathy. Endoscopy can allow easy access to these areas and facilitate the release of the incarcerated vitreous.[41]

The use of endoscopy in vitreoretinal procedures was first described way back in 1981.[20] Boscher *et al.* demonstrated the application of endoscopy combined with PPV in the management of retained lens fragments.[42] While the lens fragments in their study were primarily removed via conventional vitrectomy, endoscopy facilitated the localization of the lens fragments embedded in the vitreous base, enabled detection of anterior retinal breaks, and permitted resection of adhesions between the anterior hyaloid, lens capsule, and ciliary sulcus. They also reported identification and clearance of vitreous incarceration at the sclerotomies.

Ciardella *et al.* described the usage of the endoscope in diabetic vitrectomies.[43] They described six cases where endoscopy was used due to inadequate conventional visualization. The causes for the inadequate visualization included small pupil, hyphema, pseudophakic fibrotic posterior capsule, and pars plana neovascularization with anterior tractional retinal detachment. They concluded that the endoscopic approach allowed for adequate visualization of the ora Serrata, the pars plana, facilitated laser photocoagulation of pars plana neovascularization, and release of anterior traction at the pars plana and ciliary sulcus. Only one case has a complication in the form of an iatrogenic retinal tear which was managed by an appropriate laser.

Endoscopic vitrectomy has been described as a useful modality to treat complex retinal detachments with poor anterior segment visualization [Fig. 2]. de Smet *et al.* described nine cases with rhegmatogenous retinal detachment with anterior segment opacities which were treated by endoscopic vitrectomy.[44] All patients showed a significant improvement of vision over a 6–22 month follow-up. They also reported a decrease in the overall surgical time in view of avoidance of unnecessary extra surgical steps. There was no occurrence of any iatrogenic breaks but in phakic patients, the authors reported the possibility of posterior lens capsule touch. Faude *et al.* reported the observations of the peripheral retina and ciliary body in cases with large retinectomies in severe anterior proliferative vitreoretinopathy (PVR).[44] Yokoyama *et al.* reported the results of 127 cases of rhegmatogenous retinal detachments that underwent endoscopic repair.[45] The

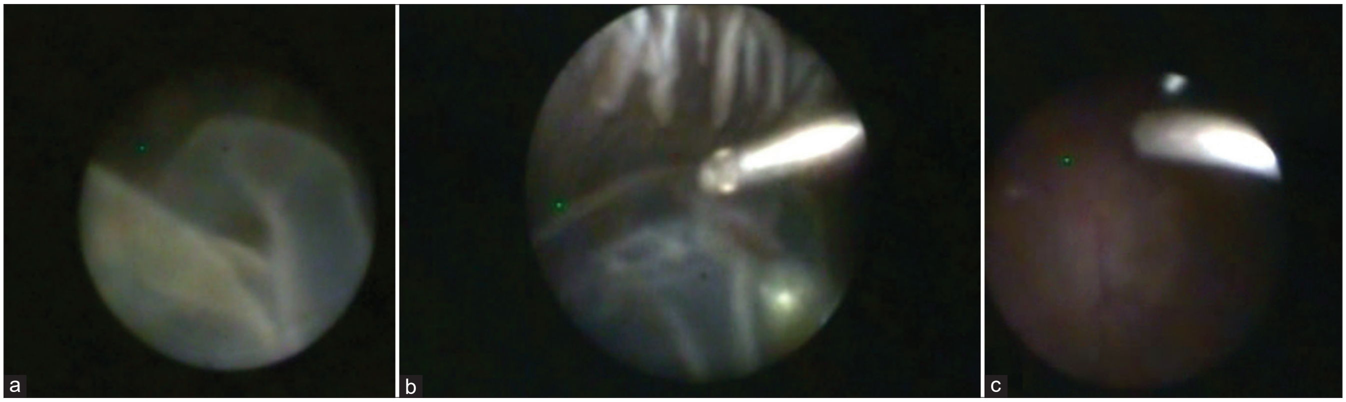

**Figure 2:** Panel showing an endoscopic view of rhegmatogenous retinal detachment (a), peripheral proliferative vitreoretinopathy dissection (b) and finally an attached retina (c)

primary and final success rate reported was 98.4% (125/127) and 100% (127/127), respectively, while the mean surgical time was 59.6 ± 26.3 min. The limitation of their study, however, was that they had excluded cases that had advanced PVR.

Sonoda *et al.* described a novel usage of endoscopy wherein the endoscope was used to drain subretinal fluid from the peripheral primary break.[46] This avoided the necessity of making a posterior drainage retinotomy and also circumvented the difficulty in visualizing the peripherally located breaks by conventional microscope examination. Kita *et al.* conducted a study to demonstrate the efficacy of endoscope-assisted PPV in patients with rhegmatogenous retinal detachment where no retinal breaks were detected preoperatively.[47] In their series of 20 eyes, in 19 eyes, retinal breaks were noted on the table with the help of the endoscope. The authors proposed the advantages of an endoscopic approach to be able to observe the peripheral retina, vitreous base, and pars plana without excessive globe manipulation or indentation. This would reduce the incidence of post-operative inflammation and proliferation.

The endoscopic approach has been described to have an important role in dissecting PVR in cases with PVR-related retinal detachments with poor corneal visibility. Kita *et al.* reported a series of four cases with severe corneal opacity with rhegmatogenous retinal detachment where there was no transpupillary visibility.[48] All cases achieved successful retinal reattachment on the table at the first attempt. A subsequent endoscopic fundus examination performed a few months after the first endoscopic vitrectomy confirmed the reattachment of the retina under the silicone oil in three eyes. Uram had also stressed the advantages of an endoscopic approach in advanced PVR.[49] He described 10 cases where endoscopy allowed for better access and manipulation at the ora serrata, pars plana, and the ciliary body. At a mean follow-up of 8.2 months, he achieved retinal reattachment in 6/10 cases.

## Endoscopy in scleral fixation of IOL

Sasahara *et al.* reported the advantages of endoscopy in the scleral fixation of IOLs by comparing two groups.[50] One group underwent scleral fixation without endoscopy assistance while one underwent endoscopy assistance. In the group with endoscopy assistance, the internal point of penetration of the proline needle was under observation by an endoscope and was suitably adjusted wherever deemed necessary. The groups had 95 eyes in the without endoscopy group and 26 eyes in the endoscopy group. In a mean follow-up of 3 months, they noted a significant reduction in IOL dislocation in the endoscopy group as compared to the non-endoscopy group (0% vs 23%). Other complications like high astigmatism, ocular hypertension, vitreous hemorrhage, cystoid macular edema, and retinal detachment were also lesser in the endoscopy group. Manabe *et al.* used ultrasound biomicroscopy to study eyes in which the IOL was sutured by the ab-external method and found that only 37% of the haptics were located adequately in the ciliary sulcus.[51] This explains the limitation of blind needle-penetration for precise suturing in the ciliary sulcus and may explain why the rates of IOL dislocation were so different between the two groups.

Jurgens *et al.* described a unique technique of SFIOL using the endoscope.[52] In their technique, an intraocular microendoscope with an 18G probe was used for direct sulcus observation and assessment of the needle position. The straight needle of a 10-0 polypropylene suture and the tip of the probe were placed in a 16G silicone rubber tube to hold them together. Fixing the needle to the endoscope allowed a direct view of its tip and required only one hand. The other hand was used to grasp the tip of the needle when it comes out under the scleral flap after passing through the sulcus. Assessment of needle position with an endoscope avoided surgically induced iris root or ciliary body damage. Olsen *et al.* reported their series of 74 eyes that received a scleral fixated IOL done under endoscopic guidance.[35] They described the advantages of this technique as excellent visualization and haptic localization, optimal lens centration, buried knots, broad scleral imbrication, and minimal vitreous- and hemorrhage-related complications. The disadvantages were a large learning curve, increased operative time, long-term suture stability issues, and limited availability and training in usage of intraocular endoscopes. Endoscopy can also be applied for explantation of posteriorly dislocated IOLs in cases with the opaque cornea [Fig. 3].

## Endoscopy in trauma

Endoscopy has a definite value in the management of penetrating eye trauma with posterior segment pathology with poor corneal visibility. Morishita *et al.* described a case where a traumatic retinal detachment was managed by a 23G sutureless vitrectomy, assisted by endoscopic visualization.[53] The primary reattachment of the retina was achieved by a tamponade of SF6 gas. After 5 months of the vitrectomy, PKP was performed successfully with visual improvement. Endoscopy can also be

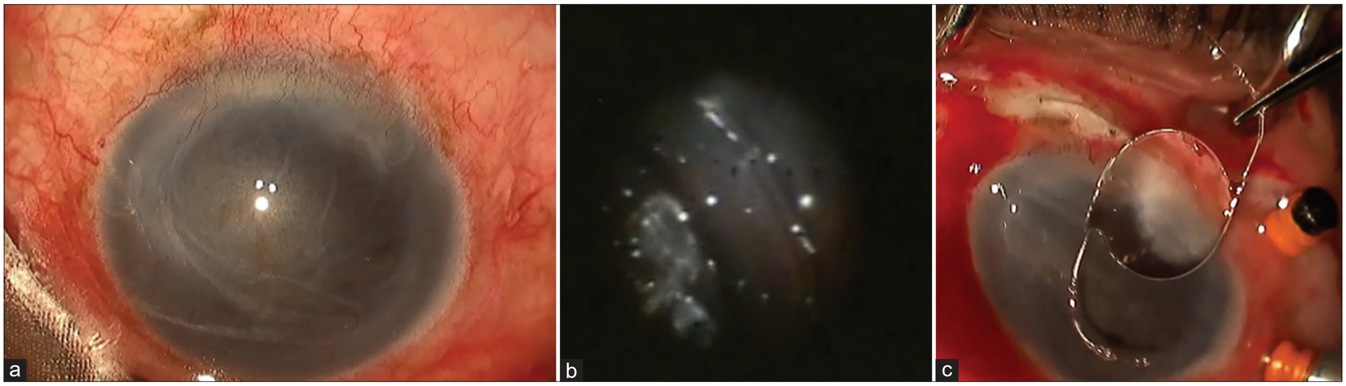


**Figure 3:** Panel showing hazy cornea with no anterior chamber view (a), endoscopic evaluation showing a dropped intraocular lens (b) and the explanted intraocular lens (c)

applied successfully to approach retained intraocular foreign bodies with the concurrent opaque cornea [Fig. 4].

Sabti *et al.* reported their cases of endoscopy-assisted management of severe ocular trauma.[54] In their series, they reported the outcomes of 50 cases where PPV was necessary but was not possible by conventional wide-angle viewing system due to media haze and/or a disorganized anterior segment. In cases with open-globe injury, they reported a visual improvement in 83.7% cases. In the subset with endophthalmitis, 5/7 eyes (71.4%) showed visual improvement. The authors also opined that the complexity of the surgery, intraoperative manipulations, postoperative inflammation, and silicone oil use in such cases may be the incriminating factors for the compromised graft clarity in case a PKP is done at the primary sitting. These problems can be circumvented if an endoscope is used for the primary vitrectomy, and PKP is done at a later stage when the eye is stable, ocular inflammation has subsided, and silicone oil is removed.

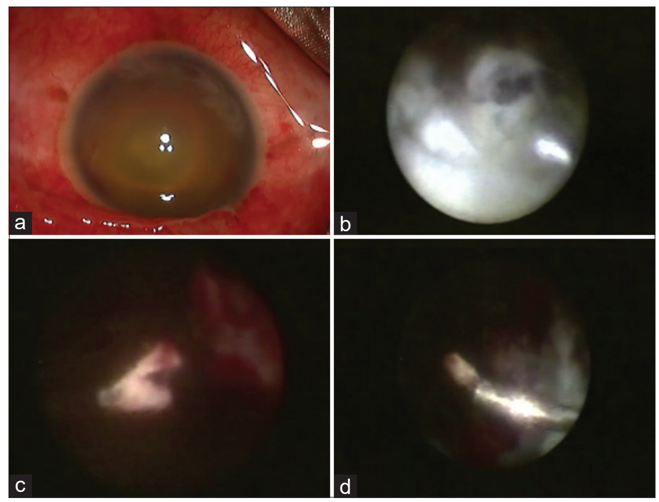


**Figure 4:** Panel showing endophthalmitis with hazy anterior segment view (a), necrotic retina (b), intraocular foreign body (c), and foreign body being removed by an intraocular magnet (d)

## Endoscopy in endophthalmitis

In the acute setting, surgery for endophthalmitis is complicated by poor visibility. The use of an ophthalmic endoscope allows for by-passing this limitation and ensures a controlled and adequate vitrectomy [Figs. 5 and 6]. De Smet *et al.* reported their series of 15 eyes with endophthalmitis with an opaque cornea that was managed with an endoscopic approach.[55] In their series, eight patients retained useful vision. Six of eight patients without retinal necrosis by endoscopic examination had improved vision, with final visual acuity ranging from counting fingers to 20/20. The authors described endoscopy in their series to have helped diagnose and define the extent of retinal affection and retinal necrosis in their series.

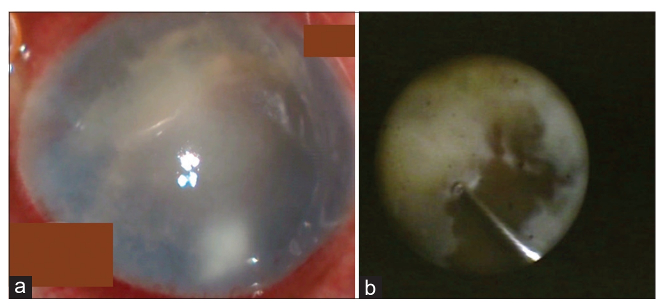


**Figure 5:** Panel showing endophthalmitis with hazy anterior segment view (a) and dense exudates in the vitreous cavity with necrotic retina (b)

Pan *et al.* reported their series of severe *Bacillus cereus* endophthalmitis which was managed with endoscopic vitrectomy.[56] They divided the patients into two groups: endoscopy-assisted vitrectomy (5 eyes) and conventional vitrectomy (10 eyes). Their main outcome measure was the need for enucleation. They found no difference in the enucleation rate between the two groups. There was also no difference between the two groups with respect to the final visual outcome. They, thus, suggested that endoscopy is an acceptable alternative approach to conventional surgery in these cases.

Ren *et al.* described their series of cases with endophthalmitis that was managed with endoscopy.[57] They described a series of 21 cases that underwent endoscopic vitrectomy for endophthalmitis with retinal detachment. In the postoperative period, the visual acuity of three patients ranged from 2/100 to 20/100 (14.3%), two of the patients had finger counting (9.5%), eight had hand motions (38.1%), six had light perception (28.6%), and two required evisceration (9.5%). In their study, they concluded that the endoscopic approach reduces the risk of evisceration significantly.

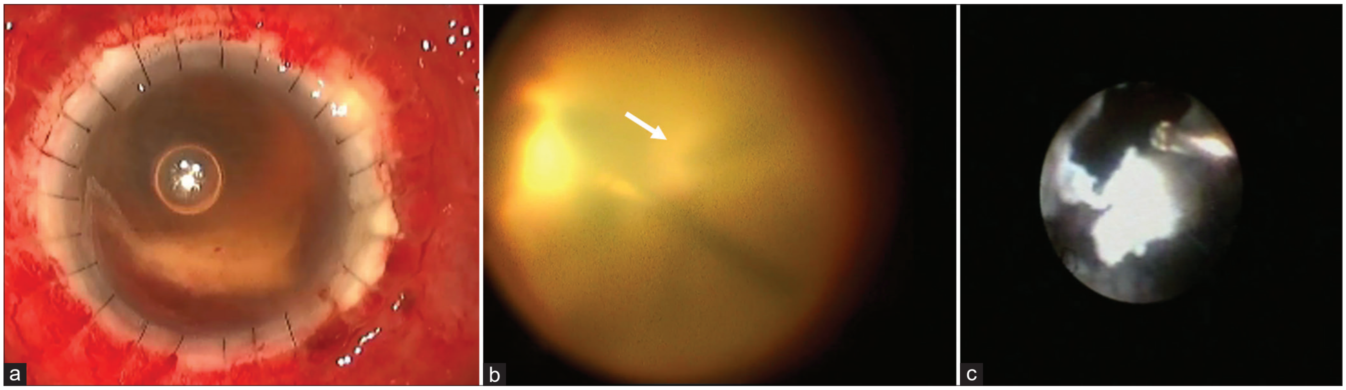

**Figure 6:** Panel showing post keratoplasty eye with endophthalmitis (a), conventional view showing a very hazy vitreous cavity with poorly visible retinal detachment (b, arrow) and endoscopic view clearly showing the detachment and a peripheral necrotic break (c)

Dave *et al.* described a series of 33 cases with endophthalmitis and concurrent corneal opacity that were managed with endoscopic vitrectomy.[58] In their series, 24 eyes (72.72%) had a favorable anatomic outcome at the last visit, and five eyes (15.15%) had a favorable visual outcome. Of those with an unfavorable visual outcome, 10 eyes had further visual potential. Evisceration was required only in one eye (3.03%). They too concluded that an endoscopic approach allows for a quicker and a greater clearance of exudates from the vitreous cavity thus allowing for a reduction in the overall evisceration rates.

### Diagnostic endoscopy

While an ultrasound B scan provides adequate information regarding the retinal morphology and position in cases with an opaque anterior segment, it does not provide any valuable information regarding the retinal vasculature and the optic nerve head health [Fig. 7]. In cases with complex corneal diseases, necessitating keratoprosthesis or keratoplasties, a preoperative endoscopy can have diagnostic value, giving adequate information about the abovementioned factors which leads to a greater prognostication accuracy.

Farias *et al.* described the use of a videoendoscope for the preoperative evaluation of eyes scheduled for keratoprosthesis surgery to assess visual potential.[59] They reported 10 cases that underwent diagnostic endoscopy. Of the 10 cases, three cases were deemed to be suitable candidates for keratoprosthesis surgery. All cases operated had a significant visual improvement post keratoprosthesis. The authors proposed intraocular diagnostic endoscopy as a part of the preoperative decision making algorithm in cases due to keratoprosthesis surgery where the visual potential is questionable.

Tyagi *et al.* also reported their results of diagnostic endoscopy in posterior segment evaluation for prognostication in eyes with corneal opacification.[17] In their series, the principle outcome measure was the determination of whether diagnostic endoscopy helped in the final management plan or not. They published their results of 64 eyes. Of these, in 62 eyes, the diagnostic endoscopy helped in the final management plan. In eyes with an attached retina on B scan endoscopy helped in the diagnosis of a glaucomatous disc in 10 eyes. The endoscopic evaluation helped in identifying poor visual prognosis in 30/64 eyes (46.8%) thus avoiding unnecessary complex procedures in them and saving time and resources. The authors concluded that diagnostic endoscopy helps in better prognostication

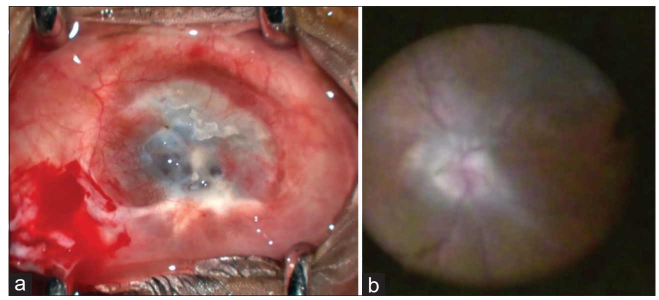

**Figure 7:** Panel demonstrating diagnostic endoscopy prior to keratoprosthesis surgery. Vascularized thinned out cornea seen (a) and endoscopic view reveals attached viable retina with mild disc pallor (b)

before a definitive anterior segment procedure in eyes with corneal opacity and helps reserve further therapy for eyes with a favorable visual prognosis.

Table 3 summarizes the published literature and provides details of indications for endoscopic surgery, methods and outcome.

## Newer Advances

The current ocular endoscopic technology is a 2 dimensional (2D) entity, hence, the absence of stereoscopic visualization. Other systemic disciplines line urology, otolaryngology, and gynecology have to some extent applied stereoscopic endoscopy.[60-62] Historically, in ophthalmology, an 18G stereo-endoscope was proposed by did not find favor.[63] Potential facilitation of 3D endoscopic visualization would require replacing optical fiber image guides with video microchips mounted on the distal end of endoscope probes ("chip-on-the-tip" sensor elements instead of optical cores correspond to video monitor pixels).[64]

Ophthalmic endoscopes currently use rigid straight or rigid curved probes. Flexible and sterilizable endoscopes are used in other surgical disciplines where larger diameter endoscopes accommodate channels for illumination, imaging, instrumentation, and tip-bending guide wires.[65,66] Single-use illumination and laser probes are now available for conventional vitrectomy using fiber-optic bundles that curve when extended from a rigid casing. This, if achieved for intraocular endoscopy, would be ideal. Another restriction of intraocular endoscopy is the limited field of vision. A way to improve the endoscopic

**Table 3: Summary of the articles reviewed with indications for endoscopic surgery, methods and outcome**

| Authors | Type of study | Number of eyes | Brief methods | Salient outcomes |
|---|---|---|---|---|
| Caronia *et al*.[27] | Case report | 1 | Describes treatment of a cyclo-dialysis cleft by means of endolaser photocoagulation with a diode laser | Laser microendoscope probe was used and laser was applied to both the internal scleral and external ciliary body surfaces within the depths of the cleft. Within 3 weeks after treatment, IOP increased to 15 mmHg |
| Fang *et al*.[28] | Prospective noncontrolled clinical trial | 12 | Patients who had acute angle-closure glaucoma with peripheral anterior synechiae or patients with flat anterior chamber after trabeculectomy underwent endoscopically controlled goniosynechiolysis | The absolute success rate (IOP <21 mmHg without medication) was 8 of 10. Visual acuity improved in 11 of 12 patients (91.7%). No significant intraoperative complications occurred |
| Bayrakar *et al*.[29] | Prospective case series | 12 | Cases of congenital glaucoma treated with endoscopically guided goniotomy. The inferior and superior angle was treated for at least 240 deg. | Seven complete successes, three qualified successes, and two failures in a follow-up period of 14.2±9.7 months |
| Joos *et al*.[30] | Case report | 1 | The goniotomy blade was used under endoscopic guidance to perform a superficial cut to the trabecular meshwork until a whitish band was clearly seen by the endoscope. | The IOP did not lower significantly after the procedure, but allowed clearing of the cornea for standard goniotomy. |
| Feltgen *et al*.[31] | Prospective-retrospective comparative study | 59 | Patients with coexistent cataract were treated by phacoemulsification and endoscopic Er: YAG goniopuncture in a combined fashion and was compared to a retrospective inclusion-matched control group treated by trabeculectomy and cataract surgery in a single procedure. | Combined Er: YAG goniopuncture and cataract surgery lowered the IOP to an extent comparable to combined trabeculectomy and cataract surgery with fewer complications. |
| Tarantola *et al*. [32] | Retrospective case series | 19 | Uncontrolled chronic angle-closure glaucoma associated with corneal opacification or fibrosed pupils underwent endoscope-assisted PPV with Baerveldt tube shunt placement | IOP was significantly reduced at each postoperative time point examined. Postoperatively, best-attained visual acuity improved in 14 of 19 eyes, remained unchanged in 4 of 19 eyes, and was reduced in 1 of 19 eyes. |
| Hammer *et al*.[34] | Retrospective case series | 14 | Videotapes and charts were reviewed retrospectively to correlate the appearance of the ciliary body and to analyze the clinical findings and surgical results. Video endoscopic surgery to remove fibrous tissue from the ciliary processes was per-formed in nine eyes. | The evaluation and management of hypotony was enhanced by the use of intraocular videoendoscopy. The endoscope facilitated surgery for dissection and removal of fibrous tissue over the ciliary processes. |
| Olsen *et al*.[35] | Retrospective case series | 74 | A novel method for placement of a sulcus-fixated, sutured posterior chamber intraocular lens using endoscopic guidance during PPV surgery | Advantages of this technique include: excellent visualization and haptic localization, optimal lens centration, buried knots, broad scleral imbrication, and minimal vitreous and hemorrhage-related complications. Disadvantages included the learning curve, increased operative time, long-term suture stability issues, and limited availability of intraocular endoscopes |
| Gayton *et al*.[37] | Prospective randomized trial | 58 | Comparison of endoscopic laser cycloablation performed through a cataract incision during phacoemulsification versus standard combined procedure | Endoscopic laser cycloablation performed through a cataract incision was a reasonably safe and effective alternative to combined phaco-trabeculectomy |
| Lima *et al*.[38] | Prospective comparative trial | 68 | Sixty-eight eyes with refractory glaucoma were prospectively assigned to either endoscopic cyclophotocoagulation or Ahmed tube shunt implantation. Kaplan-Meier survival curve analysis showed a probability of success at 24 months of 70.59% and 73.53%for the Ahmed and ECP groups, respectively ($P$=0.7) | There was no difference in the success rate between the Ahmed glaucoma valve and ECP in refractory glaucoma. The eyes that underwent Ahmed tube shunt implantation had more complications than those treated with ECP |

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**Table 3: Contd...**

| Authors | Type of study | Number of eyes | Brief methods | Salient outcomes |
|---|---|---|---|---|
| Barkana *et al.*[39] | Case report | 1 | Reported the control of intraocular pressure with endoscopic cyclophotocoagulation after repeated failure of trans-scleral diode-laser cyclophotocoagulation | Using direct endoscopic visualization of the ciliary body, precise, confluent burns were applied to the ciliary body. The direct visualization during the endoscopic procedure is advantageous. |
| Boscher *et al.*[42] | Case series | 30 | An endoscopic probe incorporating a video channel, a fiber-optic light source, and a diode laser was used for visualization | Endoscopy facilitated and shortened the surgical maneuvers required during removal of the lens fragments |
| Ciardella *et al.*[43] | Case series | 8 | Evaluated the indication for endoscopic vitreoretinal surgery in proliferative diabetic retinopathy | The surgical indications were small pupil (3), hyphema (3), pseudophakia with fibrotic posterior capsule (1), and pars plana neovascularization with anterior tractional retinal detachment (6). |
| Faude *et al.*[44] | Case series | 5 | The peripheral retina and the ciliary body of 5 patients with anterior proliferative vitreoretinopathy after large retinectomies (>180◦) were visualized endoscopically | The cause of the postoperative hypotony after large retinectomies is mainly related to fibrosis and detachment of the ciliary body. Surgeons can expect a postoperative hypotony if fibrosis and a large detachment of the ciliary body is seen during surgery with the help of an endoscope. |
| Yokoyama *et al.*[45] | Case series | 127 | Study included 127 eyes from consecutive patients who underwent repair of RRD by 23- or 25G endoscope-assisted vitrectomy, with a minimum follow-up of 3 months | Primary and final success rate was 98.4% (125/127) and 100% (127/127), respectively, Surgery time was 59.6±26.3 min. It demonstrated the efficacy of endoscope-assisted vitrectomy for patients with uncomplicated RRD. |
| Sonoda *et al.*[46] | Prospective case series | 10 | Study was to assess the usefulness of endoscopy-guided SRF drainage in for RRD. SRF was drained through a primary retinal break guided by an endoscope. No drainage retinotomy was made. | Endoscopy-guided SRF drainage is the safe and effective procedure in PPV for RRD. |
| Kita *et al.*[47] | Case series | 20 | Purpose was to demonstrate the efficacy of endoscope-assisted PPV in treating patients with retinal detachments with no retinal breaks detected preoperatively. In 19 of 20 eyes, breaks were identified with the help of an endoscope during surgery. | Endoscope-assisted vitrectomy is useful in the management of pseudo-phakic and aphakic retinal detachments with undetected retinal breaks preoperatively. |
| Sasahara *et al.*[50] | Retrospective case series | 26 | Purpose was to compare the rates of surgical complications between patients in the non-endoscope-assisted and endoscope-assisted groups. | In the endoscope-assisted group the complications were markedly decreased. Using an endoscope for trans-scleral sulcus suturing of an IOL can be an effective technique to reduce surgical complications, especially postoperative IOL dislocation. |
| Morishita *et al.*[53] | Case report | 1 | Report of a case of traumatic retinal detachment in an eye with severe corneal opacity that was successfully treated using 23G transconjunctival vitrectomy assisted by endoscope and a wide-angle viewing system. Endoscopy revealed a retinal detachment in the inferior quadrant with tiny retinal breaks. | 23G vitrectomy assisted by combined endoscopy and a wide-angle viewing system could be advantageous in managing visualization constraints due to penetrating trauma. |
| Sabti *et al.*[54] | Case series | 50 | The study reported the results of PPV assisted by ophthalmic endoscope in severe ocular trauma cases which are unsuitable for vitrectomy due to media haze | Endoscopy provided a clear view to conduct PPV in select trauma cases where delay in surgery due to hazy media or due to nonavailability of donor cornea for simultaneous penetrating keratoplasty can lead to severe proliferative vitreoretinopathy change |

*Contd...*

**Table 3: Contd...**

| Authors | Type of study | Number of eyes | Brief methods | Salient outcomes |
|---|---|---|---|---|
| De Smet *et al*.[55] | Case series | 15 | Study was to demonstrate the value of ophthalmic endoscopy in treating patients with severe vision-threatening endophthalmitis in whom visualization through the anterior ocular structures is compromised. | Eight patients retained useful vision. The ophthalmic endoscope aids in performing safe, diagnostic, and therapeutic vitrectomy in endophthalmitis. |
| Ren H *et al*.[57] | Case series | 21 | Study was to evaluate surgical outcomes using an intraocular videoendoscope for vitrectomy in patients with severe endophthalmitis with retinal detachment. | Intraocular infections got controlled in 19 of the 21 patients. Evisceration rate was 9.5%. Endoscopic approach reduces evisceration rates |
| Dave VP *et al*.[58] | Case series | 33 | Study evaluated the outcomes of endoscopy in cases of endophthalmitis with concurrent infectious keratitis | Study indicated a drastic reduction of evisceration rates and resultant globe salvage due to prompt endoscopic intervention |

IOL=Intraocular lens, IOP=Intraocular pressure, RRD=Rhegmatogenous retinal detachment, PPV=Pars plana vitrectomy, SRF=Subretinal fluid

field of view is by incorporating a prism into the objective lens system at the distal end of a rigid, straight intraocular probe. The prismatic effect would give a larger field of vision akin to the conventional microscope viewing system.

Currently, 3D heads up viewing during vitreoretinal surgeries is getting popular. Morishita *et al.* described a novel way of performing endoscopic surgeries called vitrectomy assisted by a combined endoscope and wide-angle viewing system.[53] This was simply a combined usage and a seamless interchange between conventional vitrectomy and the endoscopic system. The same group further described the concept of "hybrid vitrectomy."[67] This was a hybrid wide-angle viewing-endoscopic vitrectomy procedure that used a 3D visualization system. Images of the fundus on the 3D visualization system monitor were obtained through either a RESIGHT wide-angle viewing system (Carl Zeiss Meditec) or an ocular endoscope system consisting of a high definition camera FC-304 (10K pixels in resolution), light-emitting diode (LED) unit FL-301 used as a supplemental intraocular illumination, 25 G fiber Previt, and image processer FI-302 (Fiber Tech, Tokyo, Japan), or by using both systems as the need was felt clinically. Largely, the posterior pole dissection was done using the 3D visualization and conventional vitrectomy while the peripheral maneuvers were done better with the endoscope. They reported a single-center, retrospective, consecutive surgical case series of 113 eyes with good outcomes. They, recently in 2019, reported a new 3D endoscope system for vitrectomy.[68] Herein, they described a single-center, retrospective, consecutive surgical case series of 391 eyes that underwent 25G hybrid vitrectomy. To create 3D endoscopic images, a 3D converter was connected to a monocular endoscopic system. The Constellation Vision System (Alcon Laboratories, Fort Worth, TX, USA) was used in this study to perform all of the 25G vitrectomy procedures. The NGENUITY 3D visualization system (Alcon Laboratories) was attached to a VISU 210 microscope (Carl Zeiss Meditec, Jena, Germany) and used to observe the surgeries. The 2D endoscopic images of the fundus were obtained through an ocular endoscope system consisting of an HD camera FC-304 (Fiber Tech, Tokyo, Japan), LED light unit FL-301 (Fiber Tech), 25G fiber Previt (Fiber Tech), and image processor FI-302, which could change the size and contrast of the images. To create 3D endoscopic images, a 3D converter NOVEL HD-3D-A (Shinko Optical, Tokyo, Japan) was connected to a monocular endoscopic system. The processed images were directly sent to a 3D display, which was 26 in in size and positioned to the front and right of the surgeon at a distance of 1 m.

## Conclusion

In conclusion, the intraocular endoscope does have its limitations. The biggest among them is the large learning curve. Vitreoretinal surgery in itself is a complex surgery. Endoscopy with its limited field of view and 2D visualization makes it difficult for the uninitiated surgeon. With adequate exposure though, it forms an indispensable tool in the armamentarium of the vitreoretinal surgeon.

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### Conflicts of interest

There are no conflicts of interest.

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