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Diagnostic and surgical techniques

Endoscopic ophthalmic surgery of the anterior segment

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ABSTRACT

We summarize the uses of anterior segment endoscopic techniques and the basic science and technology of endoscopic cyclophotocoagulation (ECP) as compared with transscleral cyclophotocoagulation. This is followed by an analysis of patient selection for ECP, a description of surgical techniques, and clinical results. In addition, the ophthalmic endoscope has other uses in anterior segment surgeries. We discuss the techniques for these endoscope-assisted surgeries.

1. Introduction

The endoscopic ophthalmic surgical system gives a unique view of the interior structures of the eye and can be used for a wide variety of anterior and posterior segment surgeries. The system allows for visualization of structures that are not routinely accessible through standard viewing, such as the anterior chamber angle, the ciliary body and its processes, the ciliary sulcus space, and the anterior retina. It may also be useful in eyes with opaque media. Fibertech Co., Ltd. (Tokyo, Japan) produces two viewing only ophthalmic endoscope systems, the AS-611 and the MS-611, the latter having a higher resolution. Another viewing system is the Endognost Vitroptik Flex (Polydiagnost, Pfaffenhofen, Germany), which also has an endoscope and light source, but no laser. The only systems currently approved by the U.S. Food and Drug Administration for use in the United States are the E2 and E4 by Endooptiks, Inc. (Little Silver, NJ), first made available in

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1991. The E4 is an endoscope only. The E2 combines a diode laser with a light source, aiming beam, and fiberoptic camera. The most frequent indication for its use is the treatment of glaucoma with endoscopic cyclophotocoagulation (ECP).

Glaucoma is the most common cause of irreversible blindness worldwide.[36] Although the pathophysiology of glaucoma is multifactorial, the treatment strategy remains essentially one-dimensional: lowering of intraocular pressure (IOP). Medical management involves agents that either improve aqueous outflow or suppress inflow. When surgical intervention is required, the traditional treatment focuses on improving outflow. Procedures that reduce aqueous production have previously been reserved for refractory glaucoma. Recent technological advancements challenge this treatment paradigm, however.

The traditional gold standard for the surgical management of glaucoma has been trabeculectomy or guarded filtration surgery.[47] Such surgery is associated with postoperative complications, however, including over-filtering blebs, hypotony, and cataract.[8,16,18,19,47] Late complications such as bleb infection or endophthalmitis may occur years or even decades later. Aqueous drainage devices are a reasonable alternative to trabeculectomy, with less risk of infection or conjunctiva related complications, but tube shunts also subject patients to significant risks including diplopia, hypotony, corneal decompensation, and tube exposure.[11,18,39,47] More recently, angle-based glaucoma procedures have been introduced such as Schlemm canal stenting or trabecular meshwork ablation by internal approach in attempts to avoid some of these complications; ECP remains the only approach to reducing aqueous production, however.

When first introduced in the 1970s, cyclophotocoagulation was used as a last resort method to lower IOP. The procedure has evolved through much iteration, including both contact and non-contact transscleral delivery systems with various laser platforms. The transscleral approach to cyclophotocoagulation, although effective at lowering IOP, has an unacceptably high rate of chronic inflammation, hypotony, and phthisis, and therefore has limited use early in the disease process. More recently, a more targeted endoscopically guided technique has been introduced. ECP allows delivery of laser energy in a precise and efficient manner so that for many surgeons the indications for cyclophotocoagulation expand to include eyes with better visual potential. Moreover, given that the procedure may be performed through the same incision, many surgeons have used ECP as an adjunct to cataract surgery.[30] This inflow-reducing strategy may be more synergistic to the IOP lowering effect of phacoemulsification than procedures that completely bypass the trabecular meshwork such as trabeculectomy. Additionally, ECP spares the sclera and conjunctiva so that trabeculectomy or aqueous drainage procedure may be performed if needed in the future.[25,43]

ECP uses a diode laser with a wavelength of 810 nm, a 175 W xenon light source, a helium-neon aiming beam, and video imaging integrated into a fiberoptic system delivered through an 19–20 gauge probe. The laser delivery system allows the cilio-ablation to be performed under direct visualization, which helps to titrate the treatment better than the transscleral approach.[43]

2. Basic science and tissue effects of cyclophotocoagulation

Several modalities exist to reduce aqueous secretion, including the traditional method in which the ciliary body is frozen (cyclocryotherapy), transscleral cyclophotocoagulation, and endoscopic cyclophotocoagulation. Cyclocryotherapy sometimes induces severe pain and may be associated with the development of hypotony and phthisis. For this and other reasons, safer laser procedures have been developed for the ablation of ciliary body tissue in the treatment of recalcitrant glaucoma.

The Neodymium:Yttrium Aluminum Garnet (Nd:YAG) laser was originally developed to pass a beam of light ($\lambda = 1{,}120$ nm) from a slit lamp onto targeted ciliary body (CB) tissues by passing through the conjunctiva and sclera. The length of the beam's path was shortened subsequently by placing a fiber optic probe in contact with the conjunctiva and sclera and focusing the laser light onto the CB tissues. When used in ciliary body applications in continuous mode, the Nd:YAG laser causes a thermal disruption of structural molecules such as proteins that results in coagulation of the targeted tissues. The diode laser emits a beam of light ($\lambda = 810$ nm) that is well adsorbed by melanin chromophores in the CB tissues, generating sufficient thermal energy to coagulate them. The diode laser beam can be applied by either passing the laser light transsclerally (TCP) or directly onto the CB process by using the endoscopic delivery system (ECP).

The energy requirements for the laser procedures differ widely due to the distance and pathway from the light source to the targeted tissues (i.e., transscleral vs direct photocoagulation), and the wavelength of light applied (i.e., 1,120 vs 810 nm).[45] The lesions produced in the eyes of patients undergoing laser ablation may also mirror these differences in the energy levels applied. Histopathological analyses have been performed on the effects of these procedures in vivo and postmortem. The results range from contact and non-contact TCP to ECP diode in human and animal, living and enucleated eyes.

2.1. *Normal ciliary body architecture*

The ciliary body and processes form the pars plicata and consist of the non-pigmented (NPCE) and pigmented ciliary epithelium (PCE), which rest on a loose connective tissue, or stroma, that contains numerous capillaries and some fibrocytes and melanocytes. The NPCE is the monolayer of cuboidal cells located internally facing the posterior chamber, and the PCE is the monolayer of cells containing numerous melanin granules that is located more externally facing the ciliary body stroma. The two monolayers interact with each other along the apical surface and contain basement membranes along their basal surface. The NPCE and PCE work in concert in the aqueous formation process.

2.2. *Histopathology of transscleral cyclophotocoagulation*

McKelvie and Walland studied nine human eyes that had been treated with diode laser TCP in vivo and subsequently enucleated.[29] Damage to the pars plicata was evident in all cases and consisted of the destruction of PCE and NPCE and capillaries in the ciliary processes. They observed pigment clumping, coagulative necrosis, and extensive destruction of the ciliary muscle with moderate decreased vascularity. Unequal damage was seen around the circumference of treated areas, with some foci showing total loss of ciliary processes, but other foci with some sparing anteriorly, posteriorly, and centrally. Although some cases of mild recent treatment showed proliferation of NPCE, this was disorganized with no reconstitution of normal ciliary process architecture. There was pars plana injury in six of nine eyes, with loss of normal epithelium, pigment clumping, and destruction of muscle and most vessels. The adjacent iris root was damaged in three eyes, showing necrosis with loss of iris pigment, muscle, and vessels. The sclera in the path of the laser showed damage in three eyes, with scarring, increased fibroblast density, and vascularity.

Feldman et al describe an eye treated with contact diode TCP 3 days prior to death.[13] The patient had a blind, painful eye with a diagnosis of chronic angle-closure glaucoma and intraocular pressure of 44 mm Hg. The laser treatment was applied for 270° in 16 shots for 2 seconds at 1,180 mW. Gross examination confirmed the treatment spots approximately 0.5 mm posterior to the surgical limbus with gray-white lesions on the pars plicata internally. Microscopic examination showed sparse inflammatory infiltrate in the episclera. The sclera and ciliary body revealed coagulative necrosis without inflammatory cells and obliteration of the PCE and NPCE. There was a loss of cellular detail and external pigment disgorgement within the pars plicata. The untreated areas showed no changes.

Schlote et al evaluated changes in the vascular supply of the ciliary body histologically and by vascular casts after treating rabbit eyes in vivo with the diode TCP.[37] Two weeks after treatment, there was marked destruction of the ciliary processes with severe pigment dispersion and near complete destruction of the ciliary epithelium. At 6 weeks, there was atrophy of the ciliary body with flattening, fusion and shortening of the processes, with no regeneration seen at 6 or 12 weeks. In rabbits treated in the pars plana, similar effects were seen at 2 weeks, with destruction of the ciliary epithelium and pigment dispersion. After 12 weeks the pars plana was atrophic with no regeneration of the epithelium. The adjacent untreated ciliary body showed no effects.

The vascular casts showed rarefication, destruction, and obliteration of the vascular network with vessel break-up at the margin of the treatment zone. After 12 weeks, early neovascularization was seen at the margins of the laser treated areas. There was obliteration of the vascular supply in the treated pars plana areas.

van der Zypen et al observed similar vascular changes in rabbit eyes treated in vivo with Nd:YAG laser TCP.[44] Animals underwent vascular casting after laser treatment. As in the study of diode laser TCP by Schlote, there were marked defects in the capillary networks of the ciliary processes and incomplete regeneration of the vasculature.

Schuman reported the effects of contact TCP with the diode laser in rabbits and found coagulation necrosis of the PCE and NPCE, stroma, and vasculature in the ciliary processes and ciliary body in the acute phase.[38] Long-term effects included focal atrophy of ciliary processes with fibrosis of the ciliary epithelium and stroma.

Brancato compared contact TCP with the Nd:YAG and diode lasers in a human eye and found coagulative necrosis of the PCE and NPCE and stroma with vascular congestion and thrombosis.[6,7] He concluded that the diode laser caused more damage of epithelium at corresponding energy levels and that the energy required was half that needed with the Nd:YAG to produce similar threshold lesions.

2.3. *Histopathology of ECP diode*

Pantcheva et al compared the histological effects of ECP to TCP in human autopsy eyes.[33] The eye treated with TCP showed destruction of the PCE and NPCE and capillaries in the ciliary processes, with pigment clumping, coagulative damage, and stromal destruction. In contrast, the ECP-treated eye showed loss of the "lacy appearance" of the ciliary stroma with destruction of the non-pigmented epithelium and clumping of the pigmented epithelium, with little discernable effect outside the ciliary processes. Scanning electron microscopy showed shrinkage of the ciliary processes and effacement of the ciliary epithelium in the ECP eye.

Lin et al also compared ECP with TCP, studying histopathology and vascular effects in living rabbit eyes.[27] Twenty eyes of twenty rabbits were treated with each laser modality then imaged (along with five untreated controls) by endoscopic fluorescein angiography (EFA) immediately and a day, a week, and a month after treatment. EFA uses a blue filter fitted onto the endoscope probe and images the ciliary processes endoscopically after intravenous fluorescein injection.

Normal, untreated ciliary processes showed fluorescence within 10 seconds of injection. Both TCP and ECP showed severely reduced or lack of blood flow immediately and 1 day after treatment. At 1 month, the TCP eyes continued to show hypofluorescence, whereas the ECP eyes demonstrated partial reperfusion of the processes that was uniform, but of a lesser magnitude than untreated eyes.

Histopathologic analysis of the ECP treated eyes showed shrinkage, coagulative necrosis, and disorganization of the ciliary process architecture with loss of epithelium and shrinkage and avascularity of the ciliary stroma at 1 day. After a month, patency of the deeper ciliary vessels was evident. At 1 day the TCP treated eyes showed severe ciliary tissue damage, closure of many both large and small vessels, and stasis in the remaining vessels. Anatomical structures adjacent to the ciliary processes such as the pars plana, sclera, and iris also showed disorganization and damage. After a month, the TCP eyes showed continued sclerosis of stromal tissue, disorganization of normal epithelial architecture, and an exudative response.

Alvarado compared of the histopathology of ECP and TCP performed in living human eyes that were subsequently enucleated for unrelated pathology.[3] He analyzed two eyes treated with ECP 16 and 21 months prior and two eyes treated with Nd:YAG TCP 2 years prior to enucleation. The contact and non-contact Nd:YAG specimens showed obliteration of the ciliary muscle and replacement with collagenous scar tissue.

The stroma was also disrupted, and the two epithelial layers were absent at the lesion site, showing a paucity of blood vessels, fibrocytes, and melanocytes.

The histologic findings of the ECP-treated eyes contrasted with those of both the non-contact and contact TCP procedures. By transmission electron microscopy the epithelial bilayer showed no discontinuities, and the cells displayed a regular and uniform size as well as an intact cell membrane. In the ciliary process stroma, closure of the small blood vessels was evident with preservation of larger vessels. There was an absence of melanin granules within the pigmented ciliary epithelium along the crest of each process. Elsewhere in untreated areas or at the boundary of treated/untreated sites, melanin granules were present with a variable distribution.

2.4. *Discussion*

Studies of TCP, using both the Nd:YAG and diode lasers, show extensive damage to treated tissues, with coagulative necrosis, disorganization of normal ciliary process architecture, and replacement with fibrotic scar tissue. The vasculature is severely affected, with loss of capillaries in the stroma, and also variable loss or closure of larger vessels. These changes are concentrated in the areas of the laser burns, and in some cases miss the ciliary processes altogether.

In contrast, the studies of animal and human eyes after undergoing ECP show substantially less disruption of the ciliary body stroma or adjacent tissues. Although the architecture of the ciliary processes is modified—with evidence of tissue shrinkage, a reduction in the number and extent of blood vessels, and disruption of the ciliary epithelium—there may be regeneration of the epithelial bilayer as evidenced in the human eyes treated in vivo. Both the animal and human studies indicate that there is initial loss of vascular perfusion, with partial reperfusion over time. The disruption of tissues is markedly different from that observed in other cyclodestructive procedures that exhibit the permanent loss of both ciliary epithelial layers and extensive coagulative necrosis with permanent damage of some or all of the ciliary body structures, including its vasculature and musculature.

3. Endoscopic cyclophotocoagulation: patient selection

3.1. *Severity of glaucoma disease*

Patients with mild to moderate glaucomatous damage and preoperative IOP in the 18–30 mm Hg range on multiple glaucoma medications are good candidates for ECP. The target IOP should be in the mid-teen range, which is usually acceptable for patients with mild to moderate disease, but may not be adequate for those with advanced optic nerve damage.

ECP can also be performed at the same time as or after newer angle-based glaucoma surgeries such as canaloplasty (iScience, Menlo Park, CA), Trabectome (trabeculotomy internal approach, Neomedix, Tustin, CA), or iStent (canalicular bypass stent, Glaukos, Laguna Hills, CA). In cases where a target IOP is in the low teens and external filtration surgery is to be avoided, combining an internal filtering procedure and aqueous reduction procedure may achieve this goal.

Patients with advanced glaucomatous damage that have failed one or more external filtration surgeries are also candidates for ECP. These patients typically have a failed trabeculectomy, have one or more aqueous tube shunts already in place, and are on maximally tolerated medical therapy. ECP can be performed to lower aqueous production, working in concert with prior outflow procedures to maximally lower IOP. In these cases, the pars plana approach ("ECP plus") can be used.

3.2. *Types of glaucoma*

Glaucoma patients with aphakia or pseudophakia are candidates for ECP. Phakic patients can also be treated with ECP, using caution not to touch or violate the lens capsule. In addition, symptomatic cataract patients with uncontrolled glaucoma or controlled glaucoma with a desire to reduce medications are candidates for combined phacoemulsification cataract extraction and ECP (phaco-ECP). The potential population encompasses a large group of patients with primary or secondary, open or closed angle glaucoma. Those presenting with one of the following characteristics may be candidates for either ECP or phaco-ECP:

ECP alone:

- Pseudophakic or aphakic patients with uncontrolled glaucoma
- Patients post-tube or filtration surgery
- Patients with severe conjunctival scarring (i.e., post scleral-buckle, chemical burns) and failed filtration surgeries
- Patients who would otherwise be sub-optimal candidates for filtration surgeries due to:
  - Chronic ocular surface disease (i.e., ocular rosacea, pemphigoid, refractory blepharitis, severe dry eyes)
  - High risk for complications (i.e., aphakic eyes, vitrectomized eyes, history of suprachoroidal hemorrhage, history of trabeculectomy complications)

Combined phacoemulsification and ECP:

- Cataract and uncontrolled glaucoma
- Cataract and controlled glaucoma, but with a desire to reduce medication use due to compliance, cost, or side effects
- Cataract and narrow angle glaucoma, especially plateau iris[35]
- Cataract and high risk ocular hypertensive

3.3. *ECP in different settings*

Several factors enter into the decision-making process for combined phaco-ECP: 1) further reduction of IOP while not violating the conjunctiva and sclera; 2) management of patients with optic disk damage who would otherwise not be good candidates for filtration surgery due to advanced age, ocular surface disease, or conjunctival scarring, or likelihood of complications related to hypotony; 3) possibly increasing patient compliance by reducing the need for postoperative glaucoma medications; 4) offering the patient an alternative procedure to standard filtration surgery, especially with a history of complications from filtration surgery; and 5) the ability to avoid problems associated with discontinuing anticoagulants in high-risk cardiovascular and stroke patients.

3.3.1. *Eyes with narrow angles or shallow anterior chambers*

Patients with short axial lengths and narrow angles pose special intraoperative and postoperative hazards for ophthalmic surgeons. The trend is to move away from external filtration surgery in these cases because of the increased likelihood of aqueous misdirection (malignant glaucoma), choroidal effusions, and shallow anterior chambers. Instead of filtration surgery in these eyes, phaco-ECP affords several potential benefits. The lens extraction helps to deepen the anterior chamber and reduce IOP by increasing outflow. The ECP lowers IOP by reducing aqueous production. This procedure can also be employed in patients with chronic synechial angle closure, in whom angle-based procedures or aqueous tube shunts may be difficult.[10] ECP may help open the angle in patients with plateau iris syndrome by shrinking the ciliary body and its processes away from the posterior iris and angle structures.[1]

3.3.2. *In aphakic eyes*

Glaucoma in aphakic eyes may be refractory to traditional management, with a high rate of choroidal hemorrhage that may be exacerbated by prior vitrectomy. ECP by an anterior approach with an anterior chamber maintainer or by pars plana approach with infusion is a safer method of IOP reduction for these eyes. The procedure can be combined with a first stage aqueous tube shunt. Several weeks after surgery, after encapsulation of the plate, the tube may be inserted for better IOP control, decreasing the likelihood of hypotony associated with sudden opening of the ligature.

3.3.3. *In pseudophakic eyes*

Modern day cataract surgery typically involves placement of a posterior chamber intraocular lens (PCIOL) in the capsular bag, with a well-preserved posterior chamber. Excellent visibility of the ciliary body processes is achieved in these pseudophakic eyes, enabling thorough treatment. In eyes with advanced pseudoexfoliation; however, the white pseudoexfoliative material coating the zonules and ciliary processes creates difficulty in uptake for the laser. Thus, patients with advanced pseudoexfoliation glaucoma are not optimal candidates for ECP.

3.3.4. *Uncontrolled glaucoma in eyes status post failed drainage implant or filtration surgery*

Eyes with prior trabeculectomy and/or drainage implants are good candidates for ECP.[15] In most of these cases, the conjunctiva is badly scarred, and ECP is a good option to further lower IOP by reducing aqueous formation. This procedure can be performed either as a stand-alone surgery, or combined with cataract extraction, via an anterior limbal or pars plana approach.

3.3.5. *Eyes at high risk for complications following filtration surgery*

There is a distinct group of patients who are at high risk for complications after filtration surgery, and ECP offers the surgeon and patient a potential route to avoid complications. For example, patients with high myopia, long or short axial lengths, prior vitrectomy, bleeding diatheses, narrow-angle eyes prone to aqueous misdirection, severe conjunctival scarring after scleral buckling procedures, or on anticoagulants to prevent systemic thromboembolic disease may benefit from ECP. If the IOP is still not controlled, other procedures have not been precluded. Long-term disruption of the blood–aqueous barrier is not present post ECP and should not affect the efficacy of other future glaucoma procedures.[26]

3.3.6. *Contraindications and cautions*

As previously mentioned, patients with advanced pseudoexfoliation are not good candidates for ECP because of the white fibrillar material coating the ciliary processes that limits laser energy uptake. Patients with uveitis or neovascular glaucoma must be approached carefully, as they have a propensity for severe inflammation or hypotony postoperatively. A less aggressive approach is recommended for these patients-treating for 270° or less instead of 360° and reducing the energy applied. Aggressive perioperative and postoperative treatment to reduce inflammation may be warranted, such as intraocular preservative-free dexamethasone, intravenous steroids at the time of surgery, and oral prednisone after surgery.

Phakic patients can be treated if the anterior chamber is deep, but special care must be taken to avoid lens trauma. The pars plana approach cannot be used in a phakic patient. Patients with severe anterior segment scarring are usually best treated via a pars plana approach.

3.3.7. *Complications and adverse events*

Inflammation is commonly seen following ECP and may range from mild anterior chamber cells to severe inflammation and fibrin formation. The degree seen is likely dependent on the amount of energy used and the glaucoma diagnosis and ocular comorbidities. Inflammation may also lead to transient hypotony from ciliary body shut down, cystoid macular edema, or corneal transplant graft rejection episode in eyes with a prior penetrating keratoplasty. Rarer complications may occur as in any intraocular surgery, such as infection, bleeding, retinal detachment, and cataract formation.

4. Surgical techniques of ECP

4.1. Basic considerations

Anesthesia for ECP can range from intracameral infusion to general anesthesia, depending on the particular patient requirements. The ciliary processes are quite sensitive to manipulation or treatment and therefore topical anesthesia is not adequate. Intracameral injection of preservative-free lidocaine is popular, especially when combined with phacoemulsification cataract extraction; if more aggressive treatment is performed; however, peribulbar, subTenon's or retrobulbar anesthesia with lidocaine and bupivicaine is preferable.

The surgeon will typically sit at the superior or temporal position for the best surgical approach. The settings on the console should be a power of 0.25–0.4 W, with a continuous (surgeon-controlled) ablation time, and an aiming beam setting of 20–40. The intensity of the light source is varied depending on how far away the endoscope is from the target tissue.

4.2. *Anterior approach*

The incision, made adjacent to the limbus in clear cornea with a width of approximately 2 mm, should be large enough to facilitate entry of the probe without significant resistance. A watertight fit is not necessary as the eye is typically filled with viscoelastic. The anterior chamber is filled with viscoelastic, but not overfilled. Some viscoelastic products are not compatible with ECP as they form bubbles when the laser is activated. We recommend a cohesive viscoelastic such as sodium hyaluronate (Healon, Abbott Medical Optics, Santa Ana, CA), as it is does not form bubbles and is easily removed at the end of the procedure. The ciliary sulcus space is then expanded with viscoelastic to create space between the lens and the iris. The thicker form of hyaluronate (Healon GV, Abbott Medical Optics) is preferred by some surgeons because of its ability to maintain the ciliary sulcus space more readily. In an aphakic and vitrectomized eye, an anterior chamber maintainer with balanced salt solution is used to keep the eye pressurized.

The endoscope tip is wiped clean, and the view is focused and rotated by adjusting the camera probe where it enters into the laser console. Any blood at the incision must be removed as it may obscure the view. The tip is introduced into the anterior chamber and advanced until it reaches the pupillary margin. At this point, the surgeon looks towards the monitor and orients him/herself to the position within the eye. The probe is advanced towards the ciliary sulcus until about 6 to 8 ciliary processes are visible on the screen. This is the optimal distance for laser energy tissue absorption. The aiming beam is centered over a process, and the laser is activated by depressing the foot pedal. The duration and location of treatment is determined by visual feedback of tissue reaction. The ciliary process will shrink and whiten when treated properly. It is important to treat the entire visible ciliary process from anterior to posterior. The amount of energy delivered is determined by the duration of the treatment and also by the proximity to the target tissue. In order to avoid overtreating, the power or amount of ablation should be decreased when the processes are closer to the endoscope. The aiming beam is then centered on the adjacent process and the procedure repeated until the probe has reached its full range. At this point, we recommend retreating as the probe is rotated back to the entry position to ensure adequate energy absorption. This also enables the surgeon to treat the areas of ciliary epithelium between the processes. When the midpoint is again reached, a curved probe must be rotated 180°, along with the camera, and the process is repeated in the other direction.

Once 180° have been treated, the probe is withdrawn and cleaned, and another incision is made to allow treatment of the remaining processes. At the end of the procedure, special care must be taken to remove all of the viscoelastic either by automated or manual irrigation and aspiration or by flushing the anterior chamber and sulcus with balanced salt solution while distorting the corneal incision to allow it to exit. If not adequately removed, retained viscoelastic may cause a postoperative IOP spike.

4.3. *Combined with cataract extraction*

ECP combined with phacoemulsification cataract surgery is one of the most common indications for the procedure. The steps are essentially the same as that described in the anterior approach, with a few modifications. The cataract extraction is performed first, and the viscoelastic is removed from the capsular bag with irrigation/aspiration following intraocular lens implantation. The anterior chamber and ciliary sulcus are expanded with viscoelastic, and ECP follows as described earlier. Typically, one can treat up to 270° of ciliary processes from the temporal incision. In order to treat the remaining processes, a paracentesis may be pre-placed 90° from the temporal incision and then enlarged to accommodate the ECP probe.

4.4. *Pars plana approach and "ECP plus"*

The pars plana approach may be used for more aggressive treatment and is also useful in eyes with anterior chamber pathology that prevents a clear pathway for the endoscope probe (Fig. 1). This approach is appropriate in pseudophakic or aphakic eyes, but cannot be used in phakic patients and affords the best view of the ciliary processes to facilitates more complete treatment. A conjunctival peritomy is made nasally and temporally, and a sclerotomy is made approximately 3 mm posterior to the limbus with a 20-gauge MVR blade. The procedure can be performed with a standard 3-port or 2-port vitrectomy technique. A full or limited posterior vitrectomy is performed prior to ECP. In the 2-port approach, the infusion is placed as an anterior chamber maintainer, or in one sclerotomy and the ECP probe in the other. The vitrectomy can be performed under endoscopic guidance. In the 3-port approach, the infusion is left in the inferior sclerotomy and one port is plugged or used to hold the vitrector.

The ECP probe is placed through one of the sclerotomies and advanced across the globe until the ciliary processes are visible. They are then treated in the same fashion as in the anterior approach. The posterior approach, however, allows the surgeon to treat the entire ciliary process. Thus, one must titrate the number of degrees treated to avoid hypotony, especially in neovascular and uveitic glaucoma.

In recalcitrant glaucoma, one can use the ECP plus technique, in which the entire circumference of ciliary processes are treated, as well as 1 to 2 mm of laser extending into the pars plana. This treatment can result in profound

Fig. 1 – Endoscopic cyclophotocoagulation and pars plana treatment (ECP-plus). This endoscopic view shows the ECP-plus procedure. Note the ciliary processes above that are already treated and the pars plana to the lower right currently undergoing laser photocoagulation.

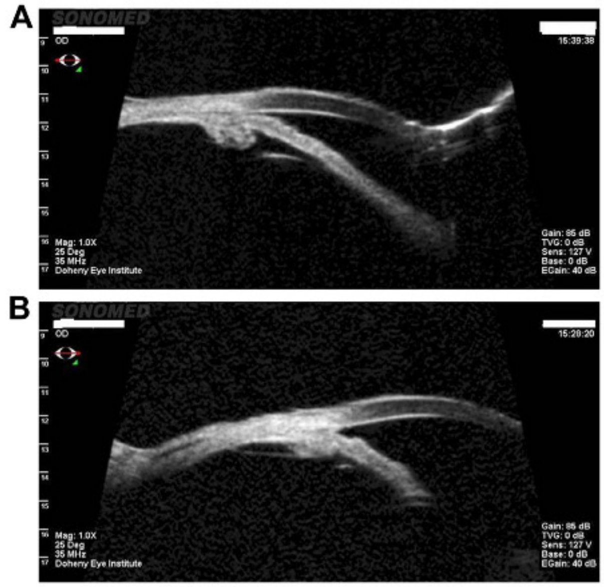

Fig. 2 – Endoscopic cilioplasty for plateau iris syndrome. A: The ultrasound biomicroscopy image shows the preoperative appearance of severe plateau iris with appositional angle closure caused by large and anteriorly rotated ciliary processes pushing the peripheral iris anteriorly. B: Following ECPL and lens extraction, the angle is wide open and the ciliary processes are flattened and shrunken.

IOP reductions and should be used with caution to avoid hypotony.

4.5. *Endoscopic cilioplasty for plateau IRIS syndrome*

Plateau iris syndrome is characterized by a narrow peripheral anterior chamber angle caused by large and anteriorly rotated ciliary processes. In a minority of cases, peripheral iridotomy and laser iridoplasty are inadequate to open the angle. In these patients cataract extraction with IOL may be combined with endoscopic laser treatment to change the shape and size of the ciliary processes and thus reconfigure the angle anatomy (Fig. 2A, 2B). In this procedure, the ciliary processes are treated in a similar fashion to ECP, but with less laser energy and no treatment of the spaces in between (unless IOP reduction is also desired). In addition, the processes are typically treated from posterior forward, in order to cause the anterior portion of the processes to shrink posteriorly, away from the iris.

Ahmed et al's ultrasound biomicroscopy data[1] show that the angle is opened widely after lens extraction and endoscopic cilioplasty, but that the angle is still narrow in the quadrant untreated with endoscopic cilioplasty in the same eye.

4.6. *Surgical pearls*

Scleral depression can facilitate treatment of the ciliary processes via an anterior or posterior approach. This maneuver will splay out the processes and allow more complete treatment of the processes and the areas in between.

Steroids are helpful in preventing inflammations the most common complication of ECP. Intensive topical steroids, subconjunctival injection, intracameral injection of preservative-free steroid, postoperative oral steroids, or peri-operative intravenous steroids can be used alone or in combination. Corticosteroid use can sometimes mask IOP lowering because of steroid response. Therefore, once inflammation is controlled, we recommend tapering of the steroids and re-evaluation of IOP if the desired lowering has not yet been achieved.

In certain cases, anterior segment pathology is encountered that makes ECP challenging. If severe, consider the pars plana approach. Anterior and posterior synechiae can generally be severed to enable access to the ciliary sulcus. In some cases, residual lens material or posterior synechiae are encountered. These can be removed if necessary, but often can be circumvented by manipulation of the probe. This generally results in the probe tip being in close proximity to the ciliary processes, which requires adjustment of the power.

4.7. *ECP with opaque media*

One of the advantages of ECP is that it can be used in eyes with anterior segment pathology that precludes the use of external filtering surgery because of severe conjunctival scarring. This presents challenges, however, because of the coexistence of media opacity, which can affect the anterior approach. In order to inflate the ciliary sulcus, the surgeon should first inject viscoelastic into the anterior chamber and then into the ciliary sulcus under endoscopic guidance. Once this space is expanded, the remainder of the procedure is performed with the endoscopic view.

5. Clinical results of ECP: efficacy and safety

ECP, used as a stand alone procedure or as an adjunct to standard external filtration surgery, has demonstrated clinical efficacy and safety in several studies, even for severe refractory and pediatric glaucoma. In a series of 10 patients with neovascular glaucoma, Uram used the pars plana approach,[41] treating between 90° and 180° of ciliary processes. After almost 9 months of follow up, 9 out of 10 eyes were able to achieve IOP < 21 mm Hg, despite a mean preoperative IOP of 43.6 mm Hg. More recently, he reported a case series of 10 patients where 180° of ECP through a limbal incision was combined with phacoemulsification.[42] After 19.2 months, the mean preoperative IOP of 31.4 mmHg had decreased to 13.5 mmHg, and all patients reducted the number of glaucoma medications.

Chen et al described a retrospective case series of 68 ECP procedures in refractory glaucoma cases including primary open-angle, congenital, chronic angle-closure, uveitic, exfoliative, neovascular, and angle-recession glaucoma. The procedure was performed both with and without phacoemulsification surgery, through either a limbal or pars plana incision, in children and adults.[10] All had failed maximal medical therapy and prior filtration surgery, and some had failed prior transscleral cyclophotocoagulation. After a mean follow-up of over 1 year, IOP decreased from 27.7 ± 10.3 mm Hg to 17.0 ± 6.7 mm Hg, with a reduction in glaucoma medications from 3.0 ± 1.3 to 2.0 ± 1.3. At 1 year, 94% of patients achieved IOP < 21 mm Hg, with 82% at 2 years, without any incidences of hypotony or phthisis bulbi.

In a retrospective study, Kahook et al compared the results between 15 patients treated with one-site corneal incision ECP (240°–300°) and 25 patients treated with two-site corneal incision ECP (360°).[22] Both procedures were combined with phacoemulsification and intraocular lens implant surgery. After 6 months of follow up, postoperative mean IOP was significantly lower in the group treated with two-site ECP (mean 13 mm Hg) versus the group treated with one-site ECP (mean 16 mm Hg) without any higher incidence of complications related to the procedure. This indicates that it may be more effective to treat as much of the ciliary body as possible.

Gayton et al compared combined cataract surgery with ECP to cataract surgery with trabeculectomy in a randomized trial.[17] Fifty-eight patients were randomized to each procedure, and the primary end point was at 6 months. Cataract surgery with ECP performed through a limbal cataract incision produced significantly less postoperative inflammation than cataract surgery combined with trabeculectomy. In those followed for at least 6 months after treatment, 32% of patients treated with ECP had IOP controlled (>21 mm Hg) 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: 24.6 ± 6.2 mm Hg at baseline with a reduction of 8.6 ± 8.2 mm Hg for trabeculectomy, and 24.8 ± 8.6 mm Hg at baseline with a reduction of 8.8 ± 9.6 mm Hg for ECP.

Lima et al studied ECP compared with the Ahmed drainage implant in refractory glaucoma.[24] In that study, 68 Brazilian pseudophakic patients who had failed trabeculectomy with antimetabolite underwent either ECP or Ahmed drainage implant in alternating allocation. Patients were followed for an average of 20 months (range 2–24 months). Both procedures were effective and similar in lowering the IOP, though the Ahmed drainage implant resulted in statistically lower IOP in the first week after surgery. The mean preoperative IOP was quite high in both groups (41.2 mm Hg Ahmed, 41.6 mm Hg ECP), and was similar at the 2-year follow up (14.7 and 14.1 mm Hg, respectively). The group that underwent Ahmed drainage implant surgery, however, had a higher rate of decrease in visual acuity and early postoperative hypotony, requiring additional postoperative visits.

ECP has also been shown to be moderately effective in cases of pediatric glaucoma. Neely and Plager reported a study of 36 pediatric patient eyes treated with single-incision limbal ECP over 6 years, with a minimum of 6 months of follow-up.[31,34] Patient ages ranged from 0.4 to 15 years of age, with a mean of 4.9 years, and the study included both phakic and aphakic eyes. Thirty-four percent were successfully controlled after the procedure with a mean follow-up of 10 months. Sixty-six percent were not successfully controlled after ECP and went on to require further treatment. In nine eyes on which repeat ECP was performed, three eyes demonstrated a favorable response, whereas six eyes did not receive any further benefit from the procedure and required additional surgical procedures such as aqueous tube shunts, trabeculectomy, or cryotherapy.

An advantage of ECP in the pediatric population where anatomy is likely to be abnormal was demonstrated by Barkana et al.[4] In that case report, prior transscleral cyclophotocoagulation was unsuccessful, and at the time of endoscopic cyclophotocoagulation, it was discovered that the laser burns had been placed in the pars plana. Similarly, Al-Haddad et al reported a case series of 12 eyes of 11 pediatric patients with corneal opacities (Peters anomaly, anterior segment dysgenesis, corneal scar, or micophthalmos) who were treated with ECP.[2] Ten eyes had previously received transscleral cyclophotocoagulation and/or cyclocryotherapy, and six eyes had previous penetrating keratoplasties; only two eyes (17%), however, had successful IOP control after the first ECP procedure, with a mean time to failure of 7.8 months.

ECP can also be performed after outflow procedures. Francis et al[15] reported a prospective case series of 25 eyes of 25 patients with uncontrolled IOP after prior Baerveldt Glaucoma Implant 350 (AMO, Santa Ana, CA) aqueous tube shunt. The follow-up was 6 months to 2 years, with the main outcome measures of IOP and medication reduction at 1 year. Success was defined as a reduction of IOP of 3 mm Hg or greater or a discontinuation of oral carbonic anhydrase inhibitor medications, with IOP < 21. Failure was defined as uncontrolled IOP, increase in glaucoma medications, loss of light perception, or additional glaucoma surgery. At 1 year, the mean IOP decreased from 24.0 to 15.4 mm Hg, and medications from 3.2 to 1.5, with a success rate of 88%.

In summary, endoscopic cyclophotocoagulation is a useful tool for glaucoma surgeons that can be combined with a standard phacoemulsification and intraocular lens implant surgery and has been shown to be comparable to other filtering or shunting procedures in control of intraocular pressure, with perhaps with fewer complications.[17,24] It can be used to effectively treat refractory glaucomas which have failed other forms of treatment.[25] As an aqueous suppressant surgery, it can be added to outflow procedures. In pediatric patients, outcomes have been less favorable. This may be due to the degree of abnormality of the eye structures often present in congenital glaucomas, especially those associated with other anterior segment pathologies, or the increased ability for tissue regeneration in children.

6. Ophthalmic endoscopy: anterior segment surgery

The camera portion of the ophthalmic endoscope allows an excellent view of the anterior and posterior chambers of the eye as well as the anterior vitreous. Therefore, it can be used to assist in a wide variety of intraocular procedures that require a detailed view of the interior of the eye or have dense opacities blocking the view.

6.1. *Angle procedures*

6.1.1. *Identification and treatment of cyclodialysis clefts*

Cyclodialysis cleft (Fig. 3A–3C), a disruption of the ciliary body muscle insertion from the scleral spur, may be caused by blunt trauma or appear as an iatrogenic outcome from intraocular surgery.[28] Diagnosis and repair of cyclodialysis cleft is critical to treat persistent hypotony and its sequelae, but the operating microscope with a goniosurgical lens may provide a limited view in the shallow anterior chamber. Accurate appraisal of the size of the cleft is important, as this determines management. Generally, if the cleft is larger than two clock hours, the endoscopic camera can aid in identifying the exact location and size of the cleft for surgical intervention by direct cyclopexy through a scleral window or by passing the suture across the anterior chamber. If the cleft is less than two clock hours, it may be identified and closed with endoscopic laser to the cleft site.

Caronia et al have reported a novel technique using an endoscopic laser to successfully visualize and treat a 2.5 clock-hour cyclodialysis cleft in an 8-year-old with refractory hypotony following trabeculectomy and trabeculotomy procedures.[9] The endoscope was used to identify the cleft and to apply laser to both the internal and external ciliary body surfaces within the depths of the cleft. They noted normalization of the IOP 3 weeks after surgery.

6.1.2. *Goniosynechialysis*

Patients with angle-closure glaucoma may benefit from goniosynechialysis (GSL), which removes the peripheral anterior synechiae (PAS) from the outflow structures (Fig. 4). A two-handed technique involving the use of the endoscope to visualize the chamber angle while using a goniosynechialysis spatula or forceps to peel the iris from the meshwork is a very sophisticated method of reopening the chamber angle.

Fang et al have reported a novel technique of endoscopic GSL that enables the surgeon to better visualize the angle without needing to reposition the patient's head and use bridle sutures.[12] They studied 12 eyes of 12 patients with synechial angle closure due to either acute angle-closure glaucoma with PAS or flat anterior chamber post-trabeculectomy. The procedure utilized the Endognost (Vitroptik Flex, Polydiagnost, Germany), which has an endoscope and light source, but no laser. Viscoelastic was used to break the PAS in most cases, with some requiring blunt dissection with an iris repositor instrument. The synechiae were treated for their total extent, some for 360°. They reported a reduction of mean IOP from 42.9 ± 15.8 mm Hg to 12.7 ± 3.5 mm Hg.

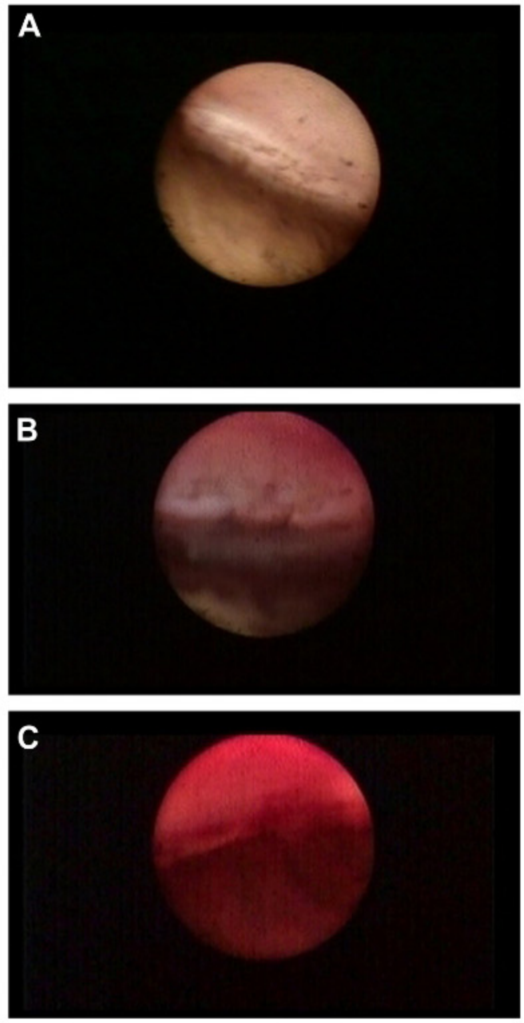

Fig. 3 – Cyclodialysis cleft. *A*: This is an endoscopic view of the cyclodialysis cleft, enabling full evaluation of the size and extent of the cleft to plan repair. *B*: This image was taken after direct suturing of the ciliary body to the sclera, and shows that a significant portion of the cleft remains anteriorly. *C*: Further repair was performed and resulted in complete cleft closure, confirmed by the endoscope.

6.1.3. *Goniotomy in pediatric glaucoma*

Bayrakar and Koseoglu describe a series of 12 eyes of 7 patients with congenital glaucoma treated with endoscopically guided goniotomy using the Endooptiks system.[5] A 20 gauge MVR blade incision was made in clear

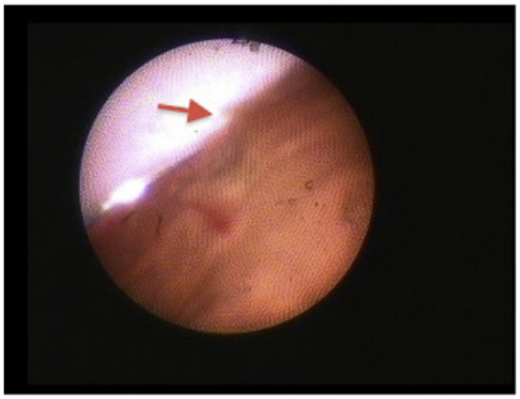

Fig. 4 – Goniosynechialysis. This endoscopic view of the angle shows the extent of peripheral synechiae, and enables controlled lysis of goniosynechiae. The cannula performs blunt and viscoelastic dissection of the synechiae. The arrow points to the end of the viscoelastic cannula and the demarcation between treated synechiae to the left and existing synechiae to the right. An alternative procedure involves pulling the iris with a microforceps to break the synechiae.

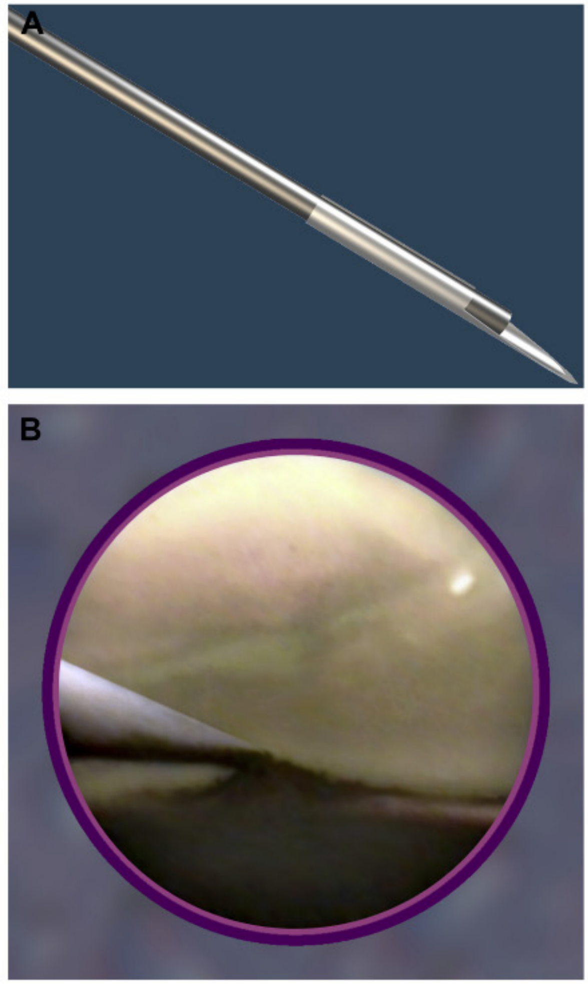

Fig. 5 – Goniotomy in congenital glaucoma. *A*: Photograph of the endoscope probe with the attached goniotomy blade for endoscopic goniotomy. *B*: Endoscopic view of the procedure showing the blade cutting through the abnormal tissue covering the trabecular meshwork. To the right of the blade is the treated angle, and to the left is the untreated angle.

cornea, and an anterior chamber maintainer inserted. They used both 2-port and 3-port approaches (Fig. 5A, 5B). In the 2-port technique, a specially designed goniotomy blade (Endooptiks, Inc.) is attached to the endoscope probe and advanced across the anterior chamber. The blade is then used under endoscopic guidance to perform a superficial cut to the trabecular meshwork until a whitish band is clearly seen by the endoscope. In the 3-port technique, another corneal incision is made, and a 20-gauge MVR blade makes the goniotomy incision while being viewing through the endoscope. The inferior and superior angle is treated for at least 240°. At a follow up period of 14.2 ± 9.7 months, the mean intraocular pressure was decreased from 38.3 ± 6.9 mm Hg to 17.6 ± 2.8 mm Hg, with a reduction in glaucoma medications from 2.1 ± 0.3 to 0.3 ± 0.5. Complete success was defined as IOP <17 mm Hg without medications, qualified success as IOP between 18 and 21 mm Hg without medications, and failure as IOP > 22 mm Hg without medications. Using these criteria, there were seven complete and three qualified successes, and two failures.

Kulkami et al reported on 14 eyes of eight patients with primary congenital or developmental glaucomas with opaque corneas treated with endosocopic goniotomy.[23] The IOP was reduced 16.7 ± 16.7 mm Hg from baseline, with a success rate of 43% overall, and 50% in primary congenital glaucoma cases. Success was defined as IOP < 21 mm Hg with or without medications and no further surgical interventions. Similarly, Joos and Shen present a case of endoscopic goniotomy in a 19-month-old with congenital glaucoma with a poor view due to corneal haze.[21] The procedure used the same coaxial technique using the endoscope probe with goniotomy blade attachment. The intraocular pressure did not lower significantly after the procedure, but allowed clearing of the cornea for standard goniotomy.

6.1.4. *Goniopuncture or trabeculotomy in adult open-angle glaucoma*

Goniopuncture performed with the erbium:YAG laser via an endoscopic approach and combined with cataract extraction was evaluated by Feltgen et al.[14] The procedure is performed with an endoscope erbium:YAG laser system (Sklerotom 2.9, Endognost, Schwing, Germany). The trabecular meshwork was treated for 180° with 18 laser pulses (Fig. 6). They compared the procedure prospectively to retrospective controls with combined cataract and trabeculectomy. In 24 eyes reaching 1 year follow up, they found a decrease in IOP from 23.4 ± 3.7 mm Hg to 16.3 ± 6 mm Hg and a decrease from 22.7 ± 3.3 mm Hg to 15.1 ± 3.8 mm Hg in controls. The number of glaucoma medications decrease in both groups. Postoperative complications were found more frequently in the control group, but postoperative visual acuity was lower in the control group.

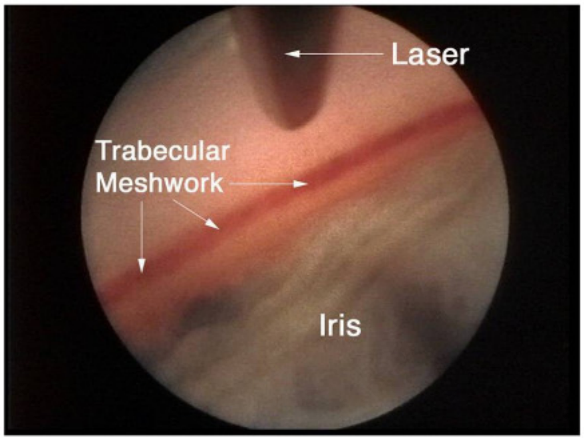

Fig. 6 – Laser goniopuncture or trabeculotomy. This endoscopic view shows the trabecular meshwork view prior to excimer laser trabeculotomy (ELT). The trabecular meshwork is clearly visible and is the target for placement of the laser probe, seen in the superior aspect of the figure. Images courtesy of J. Funk, MD, University of Freiberg, Germany.

Excimer laser trabeculotomy (ELT) is another angle-based glaucoma surgery in which small perforations are made through the trabecular meshwork to allow flow of aqueous into Schlemm canal. The procedure can be performed by viewing through a surgical goniolens or an ophthalmic endoscope. Wilmsmeyer et al present a prospective case series of 69 patients treated with endoscopic ELT, and of 57 with combined ELT and phacoemulsification.[46] At 1 year follow-up, IOP was reduced from a baseline of 24.1 ± 0.7 mm Hg to 18.8 ± 0.8 (n = 37) and a success rate of 46% (IOP < 21 mm Hg and reduced 20%). However, 28% of the eyes needed repeat surgery due to insufficient IOP reduction. Combined phacoemulsification plus ELT reduced the IOP from 22.4 ± 0.6 mm Hg to 16.4 ± 0.4 ± (n = 35), with a success rate of 66% and only 7% of the eyes requiring repeat surgery due to insufficient IOP reduction. The number of glaucoma medications was similar before and after surgery for both groups.

6.2. *Anterior segment and ciliary sulcus procedures*

6.2.1. *Hypotony evaluation and treatment*

Ophthalmic endoscopic surgery has proven useful in evaluating the ciliary body in eyes with hypotony (Fig. 7A–7C). The ciliary body and processes can be viewed with the endoscope to assess degree of ciliary atrophy, presence of ciliary body detachment or effusion, and especially the presence of tractional circumferential bands of the ciliary body. The latter can be dissected under endoscopic viewing to release traction on the ciliary body and allow reattachment and resumption of aqueous production.

Using endoscopic evaluation and surgical dissection of the ciliary body in 14 eyes, Hammer and Grizzard visualized clinical findings associated with ocular hypotony, including "whitecaps," or white surface changes with brush-like texture in ciliary processes and "traction elongations" of ciliary processes in the majority of the eyes.[20] Membrane dissection from the ciliary body resulted in normalization of IOP in 78% of patients in the early postoperative period and 33% at last follow up. The return of hypotony in some patients may be caused by the reformation of fibrous membranes over the ciliary body. These novel findings may provide early structural cues for management and pathophysiology of ocular hypotony.

6.2.2. *Tube placement*

In the majority of cases, aqueous tube shunt placement is routine. It is critical for the long-term health of the eye for the tube to be in perfect position between the iris and cornea. Occasionally, when the cornea is cloudy, and there is no view of the anterior segment anatomy, it is difficult to see the position of the tube. The ophthalmic endoscope may be inserted into the anterior or posterior chamber or the anterior vitreous, in order to assist in the exact positioning of the tube. The endoscope is positioned 180° away from the tube site, and the 23-gauge needle is easily seen as it enters the anterior segment, verifying where the tube will go. Then the tube is inserted and its position verified with the endoscope.

In 19 consecutive eyes with uncontrolled chronic angle-closure glaucoma and corneal opacity or pupil fibrosis, Tarantola et al combined endoscope-assisted pars plana vitrectomy and glaucoma tube shunt insertion.[40] The mean IOP decreased from 31.3 ± 10.5 mm Hg on 3.4 ± 1.0 glaucoma medications to 11.4 ± 2.9 mm Hg on 1.3 ± 1.2 medications at last follow-up. Based on the predetermined criteria, 14 of 19 achieved complete or qualified success, with intraocular pressure < 21 mm Hg, whereas 5 of 19 were classified as failure because of phthisis, loss of light perception, or requirement for additional intervention to control glaucoma.

6.2.3. *Verification of IOL position and capsular support*

The endoscope can be used to assess the amount of capsular support remaining to plan IOL placement during a complicated cataract extraction with capsular trauma (Fig. 8). In addition, if the surgeon is unsure if one haptic might be out of the capsular bag, this is instantly identified with the endoscope. Thus, endoscopy allows the surgeon to determine if a PCIOL placed in the capsule, a sulcus placed posterior chamber IOL, a scleral or iris suture fixated IOL, or an anterior chamber IOL is most appropriate.

The endoscope is helpful to better understand anterior segment anatomy in eyes with malpositioned IOLs, especially haptic location. Usually the location of a subluxated IOL haptic can be visualized, along with the cause of the lens dislocation. It can also be used to view the extreme periphery of the capsule, including zonular support, which may not be visible through the pupil.

6.2.4. *Secondary IOL implantation*

Similarly, secondary IOL implantation may be guided by endoscopy (Fig. 9). As stated earlier, the capsule and zonular support can be assessed thoroughly. Placement of a posterior chamber scleral-fixated IOL can be improved with endoscopic guidance. In a retrospective case series of 74 eyes of 71 patients, Olsen and Pribila described a technique of pars plana vitrectomy and scleral suture fixation of a PC IOL.[32] The preoperative diagnoses were trauma (42%), lack of capsular

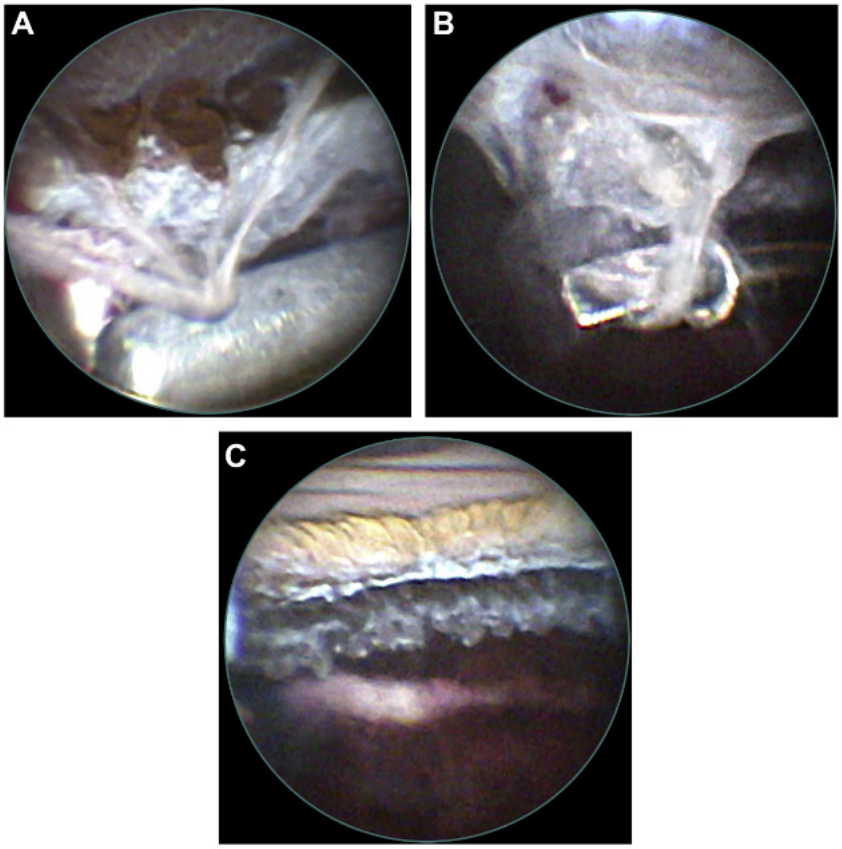

Fig. 7 – Hypotony evaluation and treatment. *A:* This endoscope image shows the ciliary body and processes in a case of severe hypotony following complicated retinal detachment repair surgeries. The ciliary body is detached by a cyclitic membrane seen as a band of fibrotic tissue. *B:* The endoscope aids in identifying the pathology, releasing the traction and removing the membrane with the vitrector. *C:* Image of the ciliary body after membrane removal.

support with IOL subluxation (24%), uveitis (15%), congenital cataract (11%), fans or ectopia lentis (6%), and other (2%). The endoscope (GRIN solid rod endoscope, Insight Inc., Stuart, FL) was used to visualize the ab interno suture pass into the ciliary sulcus and out through the sclera, thus avoiding hemorrhage from the ciliary body. They concluded that the advantages of the technique are excellent visualization and haptic localization, optimal lens centration, buried knots, broad scleral imbrication, and minimal vitreous hemorrhage. The disadvantages are learning curve, increased operative time, suture stability issues long term, and limited endoscope availability.

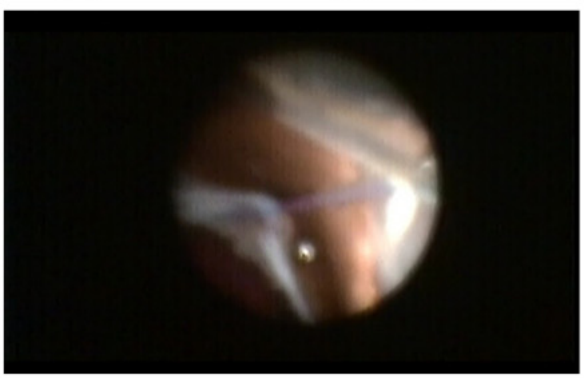

Fig. 8 – Verification of intraocular lens (IOL) position and capsular support. The endosocopic view shows a patient with a subluxated IOL undergoing repositioning of the implant. The patient has a compromised posterior capsule, and a sulcus placed IOL was the desired placement. However, in the endoscopic view, the inferior haptic is identified to be posterior to the anterior capsule, and therefore in the compromised capsular bag, predisposing to further subluxation. The haptic was retrieved and placed in the sulcus, anterior to the capsule.

6.2.5. *Uveitis glaucoma hyphema syndrome*

Uveitis glaucoma hyphema syndrome (UGH), a syndrome manifesting as chronic, intermittent and recurrent episodes of hyphema, ocular inflammation, and often elevation of IOP, is typically caused by the contact of an intraocular device such as an IOL or tube with sensitive uveal tissue such as the iris or ciliary body. The endoscope can be used in these circumstances to search for the cause and, if abnormal blood vessels are seen, to photocoagulate them. In the example shown in Figure 10, a patient with recurrent uveitis, hyphema, and secondary glaucoma was examined intraoperatively with the endoscope. The IOL was not completely within the capsular bag, with one haptic in the sulcus. The endoscope enabled viewing of this malpositioned haptic, as well as evidence of trauma to the posterior iris anterior to the haptic, and pigmented uveal tissue on the haptic surface. In this case, the IOL

Fig. 9 – Secondary IOL implantation. This patient had a subluxated IOL, and was undergoing surgery to either reposition or replace the lens. With the endocope, the cause of the subluxation was identified as severe zonular dialysis in the inferior angle. Although the capsule was largely intact, a repositioned sulcus placed IOL would likely still slip inferiorly as there is no peripheral support for the IOL haptic. Because of this finding, a scleral suture fixated IOL was placed.

was left in place, but the haptic was amputated to prevent any further iris trauma.

7. Conclusion

Ciliary body ablation procedures remain an effective tool in glaucoma management. Methods of laser cycloablation include the transscleral route (TCP), which includes contact and non-contact approaches using either the Nd:YAG or semiconductor diode lasers and the endoscopic route using the diode laser. Whereas cycloablative surgeries were traditionally used for refractory glaucoma or as a surgery of last resort, recent technological advancements in endoscopic surgery allow it to be used safely and effectively earlier in the surgical management of glaucoma, especially when compared to glaucoma filtration surgery. Further research is required to define better the long-term complications and outcomes of ECP. A comparative study between ECP and other newer surgical modalities in treating glaucoma will help guide surgical management of glaucoma.

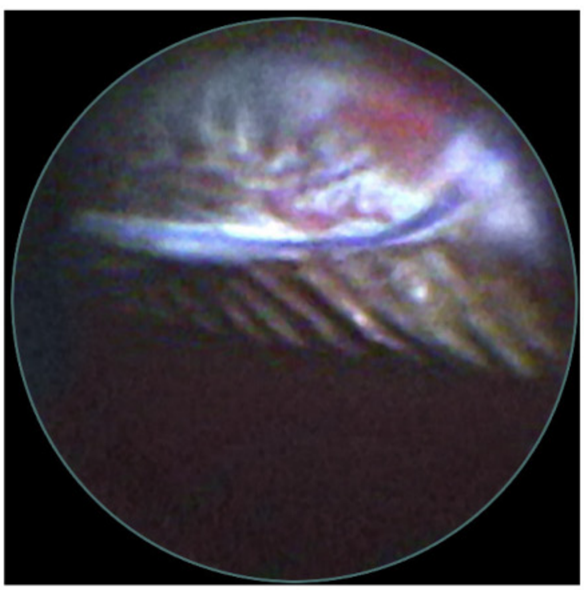

Fig. 10 – Uveitis glaucoma hyphema syndrome. This endoscopic view shows a patient with UGH syndrome caused by an intraocular lens haptic in the sulcus traumatizing the posterior surface of the iris. A hemorrhage is visible anterior to the IOL haptic.

We have discussed the expanding uses of endoscopy for ophthalmic surgeries in the anterior segment, ranging from treatment of cyclodialysis clefts to assistance in tube placement in opaque media or eyes with disorganized internal anatomy. We limit this review to endoscopic methods in the anterior segment, but plan a survey of novel endoscopic techniques in retinal surgery in the future.

8. Method of literature search

This literature search was conducted using the PubMed database and Google search engine. The search words used included *endoscopic, cyclophotocoagulation, cycloablation, cyclodiode, transscleral cyclophotocoagulation,* ECP, *endoscope* or *endoscopic* and *laser, ocular, eye, ophthalmic, lens, cornea, intraocular,* IOL, *glaucoma, ciliary, sulcus, tube,* or *angle.* The years searched were 1980 to 2012. Both English and non-English articles were searched, but only those with an English abstract were included. All articles that included the use of an endoscope in anterior segment ophthalmic surgery were included. Articles describing the use of the endoscope in posterior segment surgery were excluded, as they will be the subject of a separate review paper.

9. Disclosures

BF, RF, RN, TS, JB, and HJ are consultants for Endooptiks, Inc (Little Silver, NJ), the makers of the ECP instrumentation; JK has no financial disclosures; MU is the inventor of the E2 and E4 endosocope and is Chairman of Endooptiks, Inc.

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