Overview and new technology in cyclodestructive procedures

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When all medical and surgical measures have failed to lower intraocular pressure (IOP) in patients with severe and uncontrolled glaucoma, ophthalmologists must turn to cyclodestructive procedures to decrease aqueous production. Several months ago, the FDA (Food and Drug Administration) came through with an approval for a new technology in cyclophotocoagulation therapy. The IRIS Medical G-Probe™ used in conjunction with a semiconductor diode laser may be the superior alternative to previously available cyclodestructive techniques for which ophthalmologists have been searching.

Diode laser technology has progressed at a rapid pace since their first appearance about 10 years ago. Due to advancements in the telecommunications industry, companies like MCI® and Sprint® have developed durable and reliable lasers for their fiberoptic telephone lines which in turn have led to cost effective and dependable diode lasers for other purposes. Medical applications require a much higher power setting and in the last 5 years, diode lasers have become powerful enough for clinical functioning in the ophthalmic setting.

Diode lasers are compact and portable, about the size of a standard briefcase (Figure 1). They are powered by ordinary electrical wall current. In the future, batteries may even power upcoming models (Balles & Puliafito, 1990). They are highly efficient at converting electric energy to laser energy so little heat is produced. Therefore, no special plumbing or water cooling system is necessary. In addition, to being highly reliable and relatively inexpensive, they are easy to operate. From a nursing standpoint, diode lasers are an easy maintenance item. There are no gas pressures to regulate, water cooling systems to monitor, filters to change, or mirrors to go out of alignment.

Glaucoma
To describe how far patients and physicians must go before cyclodestructive procedures are recommended, first it is interesting to investigate the definition, incidence, and treatment of glaucoma. Glaucoma is present when IOP is at a level that is intolerable for the normal functioning of the optic nerve (Schuman & Puliafito, 1990). In the United States, glaucoma is one of the leading causes of blindness for the adult population, age 40 and older. African-Americans are 4 to 5 times more likely to acquire glaucoma than Caucasians. Prevent Blindness America currently estimates there are between 2 to 3 million Americans with glaucoma. Half of those with the disease are unaware they are afflicted. There are a staggering 89,000 to 120,000 Americans blind from glaucoma.

Medical and surgical treatments for glaucoma simply aim at affecting the balance between aqueous production and aqueous outflow to control IOP. Medical therapy used to lower IOP by increasing aqueous outflow are cholinergics (e.g. Pilocarpine, Carbachol, Phospholine Iodide). Beta blockers (e.g. Timoptic, Betoptic, Betagan) and carbonic anhydrase inhibitors (e.g. Diamox, Neptazane) are used to decrease aqueous production.

Some surgical procedures that lower IOP by increasing aqueous outflow include trabecuoplasty, filtration, goniotomy, trabeculotomy, and iridotomy (Schuman & Puliafito, 1990). Cyclodestructive procedures such as...
cyclocryotherapy and cyclophotocoagulation decrease aqueous production by partially eliminating the function of the ciliary processes (Shields, 1985).

**Cyclodestructive procedures**

Cyclodestructive therapy or ciliary ablation is usually reserved as treatment for those patients with uncontrolled glaucoma despite maximum medical and previous surgical interventions. For more than fifty years, ophthalmologists have been using ciliary ablation to slow the formation of aqueous production thereby reducing IOP in eyes with severe glaucoma. Methods to deliver this ablation energy to the eye have included coagulation with diathermy, beta-irradiation, chemicals, ultrasound, freezing, xenon light, and laser light (Gaasterland & Pollack, 1992).

The evolutionary path of cyclodestructive technology that led to the development of the G-Probe™ has had its ups and downs. Most of the early cyclodestructive methods proved disadvantageous. Cyclodiathermy, first introduced in 1933 had associated phthisis bulbi, uveitis, hemorrhage, and scleral necrosis (Alward, 1992). Beta-irradiation, used on rabbits in 1948, was damaging to the lens and therefore never adopted for clinical use (Shields, 1985). In 1949, a cycloelectrosynthesis method using a low frequency galvanic current that created a chemical reaction of sodium hydroxide which was caustic to the tissues within the ciliary body was attempted. It provided no advantage over cyclodiathermy and therefore was never clinically popular (Shields, 1985).

Using ultrasound for ciliary ablation began in 1964. By 1985, high-intensity focused ultrasonic technique showed that in addition to decreasing aqueous production by damaging the ciliary epithelium, aqueous outflow was also improved due to the separation of the sclera from the ciliary body (Shields, 1992). However, over time, patients presented with marked scleral thinning. Staphyloma—the condition when the uvea bulges into the thinned stretched sclera, and ectasia—the condition when uveal tissue is not included in the stretched scleral area were often reported.

Since 1950, freezing the ciliary processes to -80°C for at least 60 seconds was considered to be generally more predictable and less destructive than cyclodiathermy (Shields, 1992). Even though cyclocryotherapy is currently the most commonly performed cyclodestructive procedure, IOP control and visual acuity results remain unpredictable. There are many other reported problems associated with cyclocryotherapy, such as intense postoperative pain, IOP rise, inflammation, hypotony (Alward, 1992), and uveitis. Therefore, ophthalmologists have continued to search for a better method of cyclodestruction and cyclophotocoagulation is quickly becoming the cyclodestructive treatment of choice.

**Cyclophotocoagulation**

Cyclophotocoagulation uses laser energy to ablate the ciliary processes. Lasers emit light with photons in phase with each other in time and space which is referred to as coherent. These photons are also released in such a way that the resulting light is in a narrow range of wavelengths referred to as monochromatic (Shields, 1992). Laser-tissue interactions depend on laser light wavelength, power intensity (irradiance), and the composition of the target tissue (Balles & Puliafito, 1990). Laser surgery produces three types of tissue effects: photochemical, mechanical or ionized, and thermal.
In a photochemical laser-induced reaction, short-pulsed ultraviolet radiation is used to vaporize and condense target tissue. An example is the excimer laser which operates at a ultraviolet wavelength of 193 nm producing a photoablation reaction. Neodymium:yttrium aluminum garnet (Nd-YAG) producing an infrared wavelength of 1,064 nm is the most commonly used mechanical laser-induced reaction. Its action of very intense and extremely short pulse duration of laser light is referred to as photodisruption. Lasers producing visible wavelengths that cause thermal damage to target tissues are argon blue-green (488 nm and 514 nm), krypton red (647 nm), tunable organic dye (560 nm to 650 nm), and semiconductor diode lasers (780 nm to 850 nm) (Balles & Puliafito, 1990). For an illustration of laser wavelengths in relation to the light spectrum, see Figure 2. Referred to as photocoagulation, thermal effects to target tissue produce local inflammation and scarring (Shields, 1992).

Laser energy for cyclodestructive treatment can be delivered to the ciliary body through transpupillary cyclophotocoagulation, endophotocoagulation, or trans- scleral cyclophotocoagulation. The transpupillary approach is generally used when a clear cornea is present with a large pupil through which to distinctly view the ciliary processes. However, the posterior portion of the ciliary body can be difficult to destroy from this approach (Alward, 1992).

Endophotocoagulation is an involved, invasive procedure which requires a pars plana surgical incision approach for the laser probe. For patients who require a vitrectomy for other reasons, this method allows direct visualization of the ciliary processes for laser ablation (Shields, 1992), but is generally too risky to perform solely for cyclodestructive purposes.

Ciliary ablation using transscleral laser cyclophotocoagulation was first reported in 1972 using a ruby laser and in 1973 using the neodymium laser (Schuman & Puliafito, 1990). It is still the most popular approach today even though the laser currently being used is the semiconductor diode. The trans-scleral method can be performed either by a contact technique using a probe with the patient lying in a supine position or a non-contact technique through a slit lamp. With both techniques, laser energy is delivered through nonpigmented intact conjunctiva and sclera and is absorbed by the pigmented ciliary body. The contact technique is generally preferred over the non-contact method because there is more coagulative necrosis of the ciliary body without conjunctival blistering. This results in less pain, inflammation, and visual loss (Alward, 1992).

Currently, the advantages of using a semiconductor diode laser over the Nd-YAG laser are numerous. Mainly, the complications seen after cyclophotocoagulation are not so severe or harmful to the eye as those observed in cyclocryotherapy. Also, diode laser produces light in the near-infrared wavelength at 810 nm which is almost two times more effective for absorption of uveal melanin than Nd-YAG light at 1,064 nm (Gaasterland & Pollack, 1992), (Figure 3).

With the recent FDA approval for commercial use of the IRIS Medical G-Probe™ with the IRIS Oculight® SLx Diode Laser for the selective destruction of ciliary processes, patients are experiencing better results with fewer negative side effects. The G-Probe™ is a specially designed quartz glass fiberoptic noninvasive laser hand-piece with a tip that assures consistent location and spacing for treatment sites (IRIS Laser System Operator Manual). Its curved surface matches the anatomic curved surface of the scle-
ra (Figure 4). A protrusion of the fiber optic beyond the smooth curved surface on the tip of the probe accurately indents the scleral tissue to reproducible transmission depths ensuring repeatable results with no conjunctival burning at the treatment sites. Burns are then centered on the ciliary process with the laser energy directed parallel to the visual axis. Laser energy misses the equator of the lens making lens protection unnecessary.

Procedure
Patients are given a retrobulbar block and receive seventeen to nineteen laser applications for 2 seconds spaced half the width of the G-Probe™ apart at 1.5-2.0 Watts power for 270 degrees circumference, omitting 90 degrees temporally to avoid hypotony (Gaasterland & Pollack, 1992). It should be noted that dark colored irides will absorb more laser energy than those with less pigmentation and power settings should be adjusted accordingly. While the diode laser is in use with the G-Probe™, safety glasses must be worn by all persons in the treatment room, including the ophthalmologist.

It is important to keep the cornea moist throughout the laser procedure. The operator’s manual suggests providing moisture at least after every 4th laser application. The G-Probe™ is intended for one time use because build up of debris on the tip of the probe may cause localized tissue burning.

Postoperatively, the patient is patched for 4-6 hours to protect the eye until the retrobulbar injection has worn off. A long acting cycloplegic is prescribed twice a day (b.i.d.) and a steroid is used four times a day (q.i.d.). Both are tapered as inflammation subsides. All glaucoma medications used preoperatively are continued with the exception of miotics (Gaasterland & Pollack, 1992). Postoperative discomfort is mild but not as severe as in cyclocryotherapy. Ocular pain is rare but can typically be controlled using Tylenol with codeine and an ice pack. Patients return for an IOP check after twenty-four hours.

Summary
When management of glaucoma has exhausted all medical and surgical therapy and the ophthalmologist turns as a last resort to cyclophotocoagulation, the IRIS Medical G-Probe™ used in conjunction with the contact semiconductor diode laser offers a promising alternative for successful treatment for patients with severe glaucoma.

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References


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