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Laser Peripheral Iridotomy for Pupillary-block Glaucoma

American Academy of Ophthalmology

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Introduction

Over the last decade, laser surgery has supplanted incisional surgery as the preferred method for creating an opening in the iris for the treatment of angle-closure glaucoma caused by pupillary block. Laser surgery permits the ophthalmologist to create an opening inside the eye without performing an ocular incision. The vastly improved safety of laser iridotomy when performed by a skilled ophthalmologist has made laser surgery the primary treatment for pupillary-block (angle-closure) glaucoma.

The term "iridotomy" refers to the creation of a hole in the iris. Through common usage the laser procedure for doing this has become known as "laser iridotomy," or, less commonly, as "laser iridectomy," and the incisional technique as "surgical iridectomy." The terms laser iridotomy and incisional iridectomy are used in this report, though both are surgical techniques.

This document reviews these procedures. The techniques of incisional iridectomy and laser iridotomy are described and compared with regard to efficacy, skill required, safety, complications, and necessary follow-up care. The impact of laser iridotomy on the overall quality of care delivered to patients is also assessed.

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Historical Development of Surgical Iridectomy

Albrecht von Graefe reported the first use of incisional iridectomy as an effective treatment for glaucoma in 1857.[1] A small iridectomy located in the peripheral iris was reported to be effective in treating glaucoma in 1890.[2] At the time, it was not fully understood why an iridectomy was effective in some cases and not in others, since the difference between open-angle and angle-closure glaucoma was unknown.

The mechanism of pupillary block as the precipitating cause of angle-closure glaucoma and its resolution after peripheral iridectomy was first explained by Curran in 1920.[3] This led to the more specific application of peripheral incisional iridectomy for relief of pupillary-block glaucoma rather than to all forms of glaucoma. Laser peripheral iridotomy also allows relief of pupillary-block before it leads to actual angle-closure glaucoma.

Historical Development of Laser Iridotomy

Meyer-Schwickerath used the xenon arc photocoagulator to create iridotomies in human eyes in 1956.[4] However, the high incidence of corneal and lens opacities with the xenon arc photocoagulator limited its use. Several studies showed encouraging results using the ruby laser to perform iridotomies.[5–7] Although the rate of success was high with brown irides, the results were inconsistent with blue irides.[7]

A major advance in applying laser technology to glaucoma therapy occurred when the continuous-wave argon laser was adapted to the slit lamp biomicroscope; this application made laser technology available at most large ophthalmic referral centers. The argon laser was used successfully by many pioneering investigators in the 1970s to create peripheral iridotomies in patients with pupillary-block angle closure.[8–13] However, despite the excellent results of these early laser studies, most ophthalmologists continued to perform incisional iridectomies for several years because of general unfamiliarity with the laser technique and lack of access to an instrument.

The laser iridotomy procedure gained increasing popularity in the early 1980s due to the advent of the Abraham iridectomy lens in 1979,[14] improvements in the technique, the apparent safety and efficacy of the procedure,[13,15] the greater availability of lasers, a multitude of continuing education courses, and an increased use of the laser in other applications such as trabeculoplasty. By the early 1980s, the laser iridotomy had become the primary procedure for pupillary-block glaucoma.

Both the Q-switched neodymium:YAG (Nd:YAG) laser and the Q-switched ruby laser have also been shown to be effective in creating laser iridotomies.[16,17] However, because of the greater availability of Nd:YAG lasers, the ruby laser did not gain popularity. Both Q-switched lasers have an exposure time on the order of nanoseconds, as compared to tenths or hundredths of a second with the argon laser. These lasers also have a much higher irradiance (power/area) than the argon laser. The argon laser creates an iridotomy through a thermal effect (linear absorption) that depends on heat absorption of pigmented tissues. Both the Q-switched Nd:YAG and ruby lasers primarily create an iridotomy through an electromechanical photodisruption (nonlinear absorption) that in the most part is independent of iris pigmentation.

Therefore, the Nd:YAG laser has several advantages over the argon laser and is currently the preferred laser for performing iridotomies in many eyes. Fewer applications of laser energy are required with the Nd:YAG laser, making it easier to treat elderly patients and patients with head tremors. Iridotomies can be created with reasonable facility regardless of iris pigmentation.[16,17] Although the size of the iridotomy may be smaller than that achieved with the argon laser,[16] the Nd:YAG laser iridotomies do not close as often as the argon laser iridotomies in non-uveitic pupillary block. Thus, Nd:YAG laser iridotomies may be more reliable in patients unlikely or unable to return for follow up. Portable Nd:YAG lasers are also available, enabling treatment away from the office if necessary.[18]

The infrared diode laser is another instrument which can be used to perform iridotomies.[19] The tissue effect of this laser is thermal, similar to the argon laser. The versatility of this wavelength and portability of this instrument makes this technology attractive. However, the clinical experience with the infrared laser is still limited.

Technique of Incisional Iridectomy

The technique of incisional iridectomy requires either local anesthesia, usually by retrobulbar injection, or general anesthesia. An incision is made into the anterior chamber either through the limbus or through the peripheral clear cornea adjacent to the limbus. A limbal incision requires the prior creation of either a limbus-based or fornix-based conjunctival flap to expose the limbus. One disadvantage of the limbal incision is that it violates conjunctiva in a site where future filtration surgery might be performed.

Iris tissue is prolapsed into the incision or is grasped with forceps. A small section of peripheral iris is excised with scissors, creating an iridectomy. The corneal or limbal incision and overlying conjunctiva is closed with one or two sutures. Although advances in ophthalmic microsurgery (finer sutures, operating microscopes, etc.) have been applied successfully to the incisional iridectomy, the current technique is similar to that used 30 years ago.[20,21] Incisional iridectomy may be performed as an outpatient procedure, but is always carried out in a surgical site under strict aseptic conditions.

Complications of incisional iridectomy include incomplete iridectomy, wound leak with flat anterior chamber, hemorrhage, damage to the lens capsule, posterior synechiae, excision of the ciliary body, hypotony, failure to reposition the iris or create a patent iridectomy, elevated intraocular pressure, vitreous loss, ciliary block glaucoma, endophthalmitis, sympathetic ophthalmia, and cataract progression.

Indications for Laser Iridotomy

The most frequent indication for incisional or laser iridotomy is primary angle closure, which may be acute, subacute, or chronic. Other indications where a laser iridotomy may be either curative or diagnostic include combined-mechanism glaucoma, the fellow eye of a patient with primary angle-closure glaucoma, plateau iris configuration, nanophthalmos, pupillary block following cataract extraction with or without lens implantation, and imperforate surgical iridectomy. Additionally, if there is iris convexity preventing adequate visualization of the angle structures when performing laser trabeculoplasty, a laser iridotomy may deepen the angle by eliminating pupillary block.

Other indications include pupillary block associated with uveitis, the need to create an optical iridectomy, and ciliary-block glaucoma. In those patients with pupillary block associated with uveitis, i.e. iris bombé, a laser iridotomy may be difficult to keep patent. Larger or multiple iridotomies may be attempted and use of intensive postoperative steroids may enhance success. An optical iridectomy can be accomplished with the Nd:YAG laser. The Nd:YAG laser also has the advantage of relieving iridovitreal block in ciliary-block glaucoma since its effect does not depend upon pigmentation. In any situation, if the cornea is not clear enough for visualization of the iris in spite of the use of topical glycerin or if the patient is uncooperative, an incisional iridectomy should be performed.

The most difficult therapeutic dilemma is posed by the patient who is asymptomatic but appears to have occludable angles on examination. Considering the morbidity associated with an acute attack of angle-closure glaucoma[22] and the damage to the trabecular meshwork associated with the development of peripheral anterior synechiae, patients with evidence of appositional closure or synechiae should undergo laser iridotomies. Indentation gonioscopy may reveal synechiae which would not be apparent otherwise.

Technique of Laser Iridotomy

The techniques of laser iridotomy will be reviewed in detail as the understanding of this procedure is critical to assessing the role of iridotomy in the modern treatment of pupillary-block glaucoma.

Preoperative Patient Preparation

An informed consent should precede the performance of a laser iridotomy. With angle-closure glaucoma, patients typically receive topical or oral medications to reduce the intraocular pressure and to minimize the pressure increase that frequently occurs after laser iridotomy. Pilocarpine eyedrops may be administered preoperatively to patients not already taking this medication. By inducing miosis, pilocarpine unfolds the iris, reduces iris thickness, and may improve the surgeon's ability to create a full-thickness hole. These advantages must be weighed against an increase in inflammation and development of posterior synechiae which may be enhanced by using a miotic. To blunt postoperative increases in intraocular pressure, 1% apraclonidine can be instilled one hour prior to the procedure and immediately following the procedure.[23] Apraclonidine is the only agent known to effectively diminish the frequency and magnitude of the acute postoperative intraocular pressure rise.

Anesthesia is achieved by topical application of anesthetic eyedrops. A retrobulbar anesthetic injection may rarely be needed, except perhaps in patients with nystagmus or poor fixation.

Patients presenting for treatment in the midst of an acute attack of pupillary-block glaucoma may require special measures to prepare the eye for laser iridotomy. The cornea may be cloudy from the acutely elevated pressure, and the eye is usually markedly inflamed. Topical, oral, and intravenous medications may be required to lower the pressure and clear the cornea sufficiently for better visualization of the anterior segment structures and more accurate laser application. Nausea and vomiting may limit the patient's cooperation to the point that retrobulbar anesthesia is sometimes necessary to obtain symptomatic relief.

In some intensely inflamed eyes it may not be possible to perform laser iridotomy during the initial presentation. However, it is usually possible to "break" the attack with medications and control the intraocular pressure. With continued medical therapy, corneal clouding and inflammation will usually resolve enough to permit laser iridotomy within a few days. Occasionally Nd:YAG laser iridotomy can be performed through a cornea that is too cloudy to allow argon laser iridotomy. In the patient who is unresponsive to medical therapy and is a poor surgical candidate, a laser pupilloplasty or, alternatively, peripheral iridoplasty can be used with the argon laser to attempt to break the pupillary block and relieve the attack.[24,25] Otherwise, an incisional iridectomy can be performed.

The patient is seated at the laser instrument, and the iris is viewed through the slit lamp under magnification. A special contact lens, such as the Abraham iridectomy lens,[14] is used to stabilize the eye, provide additional magnification, and to keep the eyelids open. The Abraham lens has a +66 diopter plano-convex button affixed to its anterior surface. This lens adds increased convergence to the laser beam, reducing its diameter and thus increasing the power density at the iris and decreasing it at the cornea. This facilitates creation of an iridotomy and reduces the risk of producing a corneal burn.

Following the same principles, the Wise lens, which uses a 103-diopter optical button, increases the energy density at the iris surface 2.92 times greater than the Abraham lens and further enhances efficient use of laser energy.[26]

Selecting the Iridotomy Site

It is advisable to perform the iridotomy in a superior quadrant of the iris so that it is covered by the upper lid. Some practitioners avoid the 12 o'clock position because gas bubbles (associated with the argon laser) that form during the laser treatment may rise to this area and obscure the surgeon's view of the iridotomy site. Whichever of the superior quadrants is chosen, the laser beam should be angled to strike the iris non-perpendicularly, thus aiming the beam toward peripheral retina, to avoid the chance of a macular burn. This consideration is particularly relevant when using laser light within the visible spectrum.

The iridotomy is usually placed as far peripherally in the iris as possible but within the arcus senilis. A peripheral location increases the distance between the iridotomy and the anterior lens surface, thus minimizing the chance of formation of a localized cataract and posterior synechiae. However, problems may result from placing the iridotomy too far peripherally. Many corneas are hazy in the periphery, and this haze can both block and absorb laser energy, resulting in additional corneal opacification and difficulty in completing the iridotomy. If the peripheral anterior chamber is very shallow, corneal endothelial damage can occur from heat conducted from the iris burn.

The iridotomy is easier to achieve where the iris is thinnest. Relatively thin areas are often found at the base of iris crypts. Targeting treatment to a thin area permits penetration of the iris with a minimum number of laser applications. In lightly pigmented irides, the absorption of laser energy will be improved if the treatment is aimed at a region of greater pigmentation (important when using the argon or diode laser). It is also helpful in these eyes to select an area in which the white collagen beams of the iris stroma are slightly separated.

Unfortunately, it is often not possible to find an iris crypt that is neither too central nor too peripheral, and located just off the 12 o'clock position in one of the superior quadrants. Iris topography varies from patient to patient, and careful judgment is required to select the optimal treatment site in each eye. Finding a crypt is more important for the argon or diode laser versus the Nd:YAG laser.

Once treatment is started, the appropriateness of the site must be re-evaluated. If the first few laser pulses are not effective in the area selected, the surgeon should consider moving to a new site.[10,12]

Treatment Parameters for the Argon Laser

Various combinations of laser parameters have been advocated for performing laser iridotomies. This report will review selected laser parameters and techniques that have been used successfully by many ophthalmologists.

Preparatory Burns. Several techniques have been recommended for applying initial laser burns that put the intended iridotomy site "on stretch." Preparatory laser burns usually have a spot size of 200–500 microns (u), a duration of 0.1–0.5 seconds, and energy levels of 200–600 milliwatts (mW). The thermal laser energy contracts the underlying iris and increases the tension on adjacent iris tissue. Contraction burns can be placed on either side of the intended site. A single broad laser burn will create an elevated area or "hump" nearby.[27] Placing the iridotomy at the top of the hump may facilitate the penetration of the iris. In the "drumhead" technique, three to six such contraction burns are placed in a ring around the intended iridotomy site.[10,11]

Some ophthalmologists do not use preparatory burns because they do not find the contraction burns useful enough to warrant exposing the iris to additional laser energy which releases more pigment into the anterior chamber and ultimately into the trabecular meshwork.[12]

Penetrating Argon Laser Burns. There are no universally accepted standard parameters for performing iridotomies with the argon laser. Based on studies in both monkeys and man, Pollack and Robin have recommended the standard parameters of a 50 u spot size, 0.2 sec exposure duration, and 1000 mW.[12,16] With these settings, the mean number of pulses required to achieve an iridotomy was 48 (range 17–168) in one study[16] and 33[28] (range 15–78) in another.[29]

Although these settings are effective in light brown to medium brown eyes, difficulty may be encountered with pale blue and dark brown irides. In pale blue irides, the absence of pigment in the stroma may allow the laser energy to pass through the stroma and effectively remove the underlying pigment epithelium, leaving the stromal layer intact. In darkly pigmented irides, laser pulses may cause a charred area to form on the iris surface that prevents any further iris penetration.

Alternative laser parameters have been suggested to counteract these treatment problems. In blue irides, a two-step approach has been advocated.[30] The parameters for step one are a 50 u spot size, a power setting of 1500 mW, and an exposure setting of 0.5 sec. The high-power, long-duration burn causes a gas bubble to form on the iris surface at the intended iridotomy site, and the foot pedal is released. The actual exposure time is around 0.3 to 0.4 sec. The laser surgeon should be cautious when using long exposure times due to the heat generated at higher energy levels and the resultant damage to surrounding structures. A second pulse is aimed at the base of the bubble. Iris penetration usually occurs after the second pulse, although a third is sometimes required. In the second step, pulses of 50 u spot size, 0.05 sec, and 1000 mW are used to remove the remaining pigment epithelium from the opening.

In dark brown irides a "chipping" technique has been recommended.[31] The suggested parameters in one report were a 50 u spot size, 0.02 sec duration, and power settings of 1500–2500 mW. With these settings, an iridotomy was achieved after 50–250 pulses. Other investigators have advocated using the chipping technique for all irides. However, with short laser exposure times, up to 900 laser pulses were required in one study to achieve a patent iridotomy.[32] This can be tiring for both the patient and clinician.

It is clear that no single set of laser parameters is appropriate for all types of irides or for all laser surgeons. The laser parameters need to be adjusted intraoperatively according to the ophthalmologist's judgment of how the laser energy is affecting the target tissue.

The endpoint of treatment is observation of a patent iridotomy as evidenced by visualization of the lens capsule through the iris. Deepening of the anterior chamber angle following treatment often also occurs, documented by careful gonioscopy before and after treatment.[15] Temporary relief of the pupillary block may be obtained, however, by distortion of the iris from the laser treatment, with temporary deepening of the angle without a patent iridotomy. One suggested method to demonstrate patency is to perform a postoperative provocative test. The test should be negative if the iridotomy is open.[15] A positive test, however, may indicate either non-patency of the iridotomy or the presence of a plateau iris.

Treatment Parameters for the Neodymium: YAG Laser

As indicated previously, the Nd:YAG offers several advantages over the argon laser when performing iridotomies such as less required energy, fewer pulses, and greater patency rate. Using an Nd:YAG laser with settings of 6–8 millijoules, an Nd:YAG laser iridotomy can be performed fairly easily in most eyes.[23] However, specific guidelines may depend in part on a particular laser being used. In one study of 200 iridotomies performed with the LASAG

Microruptor 2, the energy settings varied from 3 to 9.5 millijoules with a burst of 1 to 6 pulses per application.[17] A patent iridotomy was achieved after an average of 5 applications in brown irides and 3.4 in blue irides. Other authors have utilized 5 to 15 millijoules in bursts of 1 to 3 pulses.[16,18,23,28,33] Furthermore, bursts of 5 to 6 pulses have been found to damage the underlying lens.[34,35] It appears that the chance of achieving a patent iridotomy with one laser application increases with increasing energy, but the incidence of iris bleeding also increases.[33] This bleeding only rarely layers into a significant hyphema. If bleeding does occur, the bleeding can be stopped by applying light pressure on the eye with the contact lens, thus increasing the pressure within the eye temporarily. Either pretreatment of the iris with the argon laser prior to Nd:YAG laser iridotomy or pretreatment with apraclonidine also decreases bleeding.[36]

Late Retreatment of Laser Iridotomies

Although a patent laser iridotomy can be achieved in most eyes with a single session, the argon laser iridotomy subsequently may partially close in up to 30 percent of cases.[12] By creating a larger iridotomy, this problem may be reduced. With experience, the incidence of retreatment because of closure may be reduced from 44 percent to 19 percent.[15] Argon laser iridotomies may close more often than iridotomies created with the Nd:YAG laser.[16] However, retreatment to open an Nd:YAG iridotomy may be required in up to 9 percent of cases.[17]

The closure of a previously patent iridotomy emphasizes the need for meticulous evaluation of the opening and careful follow up. An iridotomy should not be considered patent unless the lens capsule (or zonules in a very peripheral iridotomy) can be seen through it. However, a visible lens capsule does not always ensure functional patency because adhesions between the iridotomy edge and the lens may obstruct the anterior flow of aqueous. Dilation of the pupil may help to identify any areas of posterior synechiae and break those that are recently formed.

It may be difficult to determine whether an iridotomy is open. In addition, it is not known what minimum aperture diameter is required for functional relief of pupillary block. According to one case report, an acute attack of angle-closure glaucoma occurred despite the presence of a patent 75 u iridotomy.[37] The effectiveness of a given iridotomy probably depends on its configuration, the presence of bridging fibers, the proximity to the anterior lens capsule, and other factors. If there is any doubt about the patency of the iridotomy, the opening should be enlarged or a second iridotomy should be created.

Closure of an iridotomy may occur within the first 24 hours. Most closures occur within the first month following treatment.[12] It is quite rare for an iridotomy to close after it has remained patent for 6 weeks.[12,15]

Complications

The skill and experience of the laser surgeon are important factors in minimizing complications, which can occur following laser iridotomy using any technique. Complications of the argon laser iridotomy include transient and chronic iritis, acute and chronic intraocular pressure elevation, late closure of the iridotomy, localized corneal and lens damage, hemorrhage, laser burns to the peripheral retina, laser burns to the fovea causing profound visual loss, glare and diplopia through the iridotomy, pupillary distortion, and formation of posterior synechiae.

Both argon and Nd:YAG laser iridotomies cause at least a transient anterior uveitis in every eye. The iridotomy provokes inflammation by liberating pigment and tissue debris, releasing prostaglandins and other inflammatory mediators, and breaking down the blood-aqueous barrier.[38] With treatment, the uveitis usually resolves after one week, although it may last up to several weeks. Severe cases have been associated with hypopyon[39] and macular edema.[40]

The possibility of a marked, acute increase in intraocular pressure is the most serious risk following laser iridotomy. A pressure increase of 10 mmHg or greater above baseline may occur in 30 to 35 percent of cases.[16,17,41] While this pressure spike usually resolves without sequelae, in susceptible patients the elevated pressure may cause irreversible visual loss. This sight-threatening complication can usually be prevented by treating patients with medications such as 1% apraclonidine before and after iridotomy, or 500 to 1000 mg Diamox prior to iridotomy. In any case, it is important to monitor pressures in all patients in the first several hours following laser treatment.[30]

Closure of the iridotomy may occur in up to one-third of patients and has been discussed in the "Late Retreatment of Laser Iridotomies" section of this statement.

Laser treatment often produces a focal corneal opacity.[12,16] An epithelial burn can be caused by heat absorption as the laser energy passes through the cornea. Use of a converging contact lens reduces this thermal effect in two ways. First, the lens itself acts as a heat sink and helps to keep the cornea cool. Second, as previously noted, the plano-convex button on the lens sharply increases the convergence of the laser beam, keeping it less convergent as it passes through the anterior cornea.[14] An endothelial burn can be caused by thermal conduction from the iris surface, or the Nd:YAG laser's shock wave can damage the endothelium. Risk of endothelial damage is greatest in eyes with a shallow anterior chamber where the cornea is in close proximity to the iris. Proper focusing may minimize this problem.

The likelihood of both types of corneal burns can be reduced by careful focusing and by using pulses of low power and short duration.[12] These parameters, however, may increase the number of applications required to achieve an iridotomy, thereby prolonging the treatment and increasing the potential for corneal damage. A balance between the power and duration parameters is necessary to create an iridotomy expeditiously to minimize the risk of corneal damage.

If a corneal opacity occurs early in the treatment, it is wise to move to another location. The opacity increases the local heat uptake, and further laser treatment causes the opacity to become more dense. The opacity blocks the transmission of laser energy to the iris, and the treatment becomes progressively less effective.

A focal, non-progressive lens opacity has been noted beneath the iridotomy in 35 percent of eyes treated with the argon laser.[16] These opacities do not appear to progress and are not associated with visual loss. They are less likely to occur if the iridotomy is performed peripherally where there is greater separation between the iris and lens. The clear ocular media, including the crystalline lens, transmit almost all argon and Nd:YAG laser energy. However, the mild, diffuse yellowing that is present in the aging lens may increase the heat absorption and the risk of focal opacity.[12] Argon laser energy can accelerate cataractous change as has been seen in patients undergoing pan-retinal photocoagulation. It is possible that this will occur with laser peripheral iridotomy as well.

Once the iris is penetrated, the laser energy may be transmitted to the retina. Peripheral retinal burns and visual field defects have been observed following argon laser iridotomy.[10,42] Fluorescein angiography may detect focal abnormalities even when retinal burns are not visible ophthalmoscopically.[42] In general, laser burns to the peripheral retina are not noticed by the patient. However, a case of an inadvertent laser burn to the fovea has been reported that reduced the patient's visual acuity from 20/20 to 20/400.[43]

Steps can be taken to minimize the risk of visual loss from retinal burns. The use of a converging contact lens, such as the Abraham iridectomy lens, diverges the laser light posterior to the iris and greatly reduces the risk of a retinal burn. The laser beam should never be aimed perpendicular to the iris, for this places it roughly parallel to the visual axis, capable of being refracted directly onto the fovea. The risk of retinal damage is greatest after iris penetration, while residual pigment is being removed. At this point in the treatment it is especially important to aim the laser beam obliquely and to reduce the power setting.

Glare and diplopia may be noted by the patient through the iridotomy. This problem is avoided by placing the iridotomy beneath the upper eyelid. Progressive enlargement of the iridotomy may rarely occur following treatment,[15] and may increase the risk of glare and diplopia.

Adhesions may form between the margins of the iridotomy and the lens surface and functionally obstruct the iridotomy. Heat contraction of the iris may cause the pupil to become peaked toward the iridotomy. This pupillary distortion may become permanent if adhesions develop. Posterior synechiae are a common complication and occur more frequently and more extensively after argon laser iridotomy. They can usually be prevented by dilating the pupil soon after treatment and by treating the inflammation appropriately.

Iritis, increased intraocular pressure, corneal opacification, and cataract formation also can occur after iridotomy with the Nd:YAG laser.[16,17] Bleeding from the iridotomy site has occurred in 45 percent of cases following treatment with the Nd:YAG laser in one study.[16] Some surgeons claim to have reduced the incidence of this complication by making the iridotomy between iris vessels. The hemorrhage is usually minimal and transient, may be stopped if pressure is applied to the eye through a contact lens, and has no long-term sequelae. Although it is rare, bleeding can also follow argon laser iridotomy.[44] Apraclonidine HCl is a potent iris vasoconstrictor and may reduce the incidence and degree of this bleeding.[30]

Excessive laser treatment increases the risk of most complications (elevated intraocular pressure, inflammation, retinal damage, cataract, glare, corneal opacity, etc.). However, insufficient treatment may fail to achieve a successful iridotomy and thus exposes the patient to a continuing risk of visual damage from pupillary-block glaucoma. The major technical challenge of the procedure is to create a patent iridotomy with minimal laser energy, under difficult circumstances such as infirmity, pain, and corneal edema.

Follow-Up Care After Laser Iridotomy

Factors influencing the frequency of follow-up care include the degree of pre-existing glaucomatous damage, the response to laser iridotomy, and other considerations specific to the patient. General guidelines can be given that apply to both argon and Nd:YAG iridotomies.

Because of the occurrence of acute pressure elevation after laser iridotomy, patients should have their pressure checked one to two hours after treatment. Apraclonidine HCl may be administered to the treated eye one hour prior to, and immediately following, iridotomy. This medication markedly decreases the risk of significant pressure rise.[30] If the pressure becomes severely elevated in an eye susceptible to damage from a short-term pressure rise, additional glaucoma medications should be given, and the response should be monitored over several hours. Carbonic anhydrase inhibitors or oral hyperosmotic agents such as glycerin, are effective in aborting this pressure rise.

Patients generally are initially maintained on their preoperative glaucoma medications. Additional glaucoma medications may be prescribed if the pressure becomes elevated after treatment. Although many surgeons dilate the pupil to help prevent posterior synechiae formation, others prescribe pilocarpine four times daily on the supposition that maximal pupillary constriction helps to keep the iridotomy patent. Pilocarpine and other miotics may contribute to the iritis, however, their use reduces the potential for an attack of acute angle closure if the iridotomy closes.

A topical steroid prescribed frequently on the day of treatment and four times daily for four to five days controls most laser-induced anterior uveitis. If the uveitis is particularly severe, the frequency of steroid administration may be increased.

Patients are usually examined within the first week after the iridotomy procedure to be sure that the pressure is satisfactory, the iridotomy is patent, and the uveitis is responding to steroid treatment. If there is any question regarding patency, if there were any intraoperative problems or if the intraocular pressure was acutely elevated, the patient should be seen the day after the procedure. Glaucoma medications can be adjusted depending on the intraocular pressure. If the iridotomy has closed, additional laser treatment can be administered. Patients should be examined again two to four weeks later. The topical steroids usually are discontinued at one or two weeks after treatment. The pilocarpine, if used, can also be discontinued if the iridotomy is definitely patent and if the intraocular pressure is controlled without it.

Follow up is especially important if the patient has been treated during an acute attack of angle closure. In this context it is critical that the patient be followed frequently until it is certain that the iridotomy is patent and that there is no danger of its closure.

Advantages of Laser Iridotomy over Incisional Iridectomy

A major advantage of laser iridotomy over incisional iridectomy is greater safety for the patient. Several rare but serious complications may occur after incisional iridectomy that are avoided by the laser technique. The general anesthesia or retrobulbar injection that is required for incisional iridectomy carries the risk of death from an anesthetic complication or allergic reaction. The retrobulbar injection also has the risk of ocular perforation with subsequent retinal detachment or other intraocular complication. Since incisional iridectomy is an intraocular procedure, patients may develop endophthalmitis, expulsive hemorrhages, malignant glaucoma, cataracts, or postoperative wound leaks.

The laser procedure can be performed entirely in the ophthalmologist's office or in a hospital laser facility (or even in remote areas with a portable Nd:YAG laser unit). Although the incisional iridectomy may be performed as an outpatient procedure, the technique still requires full aseptic precautions, because it is an intraocular procedure and should be performed in an operating room at either a hospital or an ambulatory surgical center. The laser technique is more cost-effective as there is no need for an operating room, an anesthesiologist, a scrub nurse, circulating nurse, or other ancillary personnel. Preoperative blood tests, electrocardiogram, chest x-ray, and physical examination may be necessary before incisional iridectomy, but are not necessary prior to laser iridotomy.

Patients recover more quickly after laser iridotomy than after incisional iridectomy. There are almost no restrictions following the laser procedure, and most patients may return to work the next day. Following incisional iridectomy, the presence of a newly-sutured ocular incision imposes many important restrictions on patients, including the wearing of a protective shield over the eye when glasses are not worn. Most such patients are also cautioned not to bend, exercise, lift heavy objects, or rub the eye. The wound may also cause a refractive change.

Despite its many advantages, the laser procedure can be a difficult technique to perform successfully. The laser parameters and technique must be adjusted according to variables such as iris color. The location of the prospective site initially selected may not turn out to be optional. During the procedure, a new site may be selected or laser parameters adjusted according to the observed reaction. Even in experienced hands, a patent iridotomy may be difficult to achieve in the first session of laser treatment.

In routine cases, follow-up care after laser iridotomy is often simpler than after iridectomy. The patient, following incisional iridectomy, must be monitored for endophthalmitis, wound leak, posterior synechiae formation, and mandates a postoperative refraction. On the other hand, the laser iridotomy patient must be monitored for intraocular pressure rise, inflammation, and closure of the iridotomy.

The Impact of Laser Iridotomy on Quality of Care

The success of laser iridotomy has had a profound impact on the treatment of pupillary-block glaucoma. As the laser technique gained popularity in the early 1980s, it became apparent that the rate of laser iridotomies being performed greatly exceeded the previous rate of incisional iridectomies. This raised the concern that the availability of the laser procedure may have changed the indications for performing an iridotomy or iridectomy.

The indications for laser iridotomy were examined in one study and compared to the indications for incisional iridectomy.[45] The investigators documented the increased rate of laser iridotomies but found that the classical indications had not changed. Instead, the increased safety of the laser procedure allowed the same indications to be applied more consistently and earlier in the disease process. The improved quality of care brought about by the laser is best illustrated by examining the impact of laser iridotomy on the treatment of the specific types of narrow-angle problems.

In one study, laser iridotomies were performed for acute pupillary-block glaucoma in twice as many patients in 1982 as those numbers of patients who underwent incisional iridectomies in the pre-laser years.[45] The data suggested that before the introduction of the laser, patients needing iridectomy were more likely to be lost to follow up. Prior to the laser it was not unusual for patients to present with an acute attack, have it broken medically, and then refuse surgery. However, without surgery they remained at great risk of visual loss from a subsequent acute attack. Since the development of laser iridotomy, patients are less fearful of the procedure and more likely to undergo appropriate treatment.

After an acute attack of angle-closure glaucoma, the fellow eye is usually at high risk of acute angle closure and should undergo iridectomy. However, patients often are quite reluctant to have surgery on their asymptomatic, "good" eye. From 1977 to 1979, 59 percent of fellow eyes in one study underwent incisional iridectomy an average of two months after the acute attack.[45] The other patients refused surgery or were lost to follow up. In 1982, 100 percent of fellow eyes underwent laser iridotomy, almost always within three days of the acute attack.

The laser also has improved the treatment of chronic angle-closure glaucoma by dramatically improving the risk-benefit ratio in favor of performing an iridotomy. It allows the ophthalmologist to perform the iridotomy as a therapeutic trial earlier in the disease when the potential for a beneficial effect is greatest. If laser iridotomy is not effective, the eye has not been subjected to the increased risks of incisional surgery. If necessary, a trabeculectomy can be performed in the future as the initial incisional procedure. The portable Nd:YAG laser now makes it possible to treat patients in remote sites such as Indian reservations and Eskimo villages where some of the patients previously lost vision because of the unavailability of proper treatment.

Whether iridectomy is performed with laser or incisional techniques, the challenge in treating angle closure is to decide correctly which patients need treatment. By focusing attention on the importance of recognizing and diagnosing the different forms of angle closure, laser iridotomy has encouraged the improvement of gonioscopy skills and has increased the ophthalmologist's awareness and understanding of the angle-closure glaucomas. Through the delivery of appropriate care to more patients earlier in the disease course, the laser iridotomy has dramatically improved the quality of care given to patients with all forms of angle-closure glaucoma. The improved safety of laser iridotomy compared to incisional iridectomy when performed by a skilled ophthalmologist allows more patients to be treated earlier in the disease course.

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CATEGORY	*ABBREV.*	*SPECIFIC FINANCIAL INTERESTS*
Product	P	Financial interest in equipment, process, or product presented.
	Pc	Such interest in potentially *competing* equipment, process, or product.
Investor	I	Financial interest in a company or companies supplying the equipment, process, or product presented.
	Ic	Such interest in a potentially *competing* company.
Consultant	C______	Compensation received within the past 3 years for consulting services regarding the equipment, process, or product presented.
	Cc	Such compensation received for consulting services regarding potentially *competing* equipment, process, or product.

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	C3 or Cc3	3. *Ad hoc* consulting fees
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	C5 or Cc5	5. Contribution to research or research funds
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