Long-term Success of Argon Laser Peripheral Iridoplasty in the Management of Plateau Iris Syndrome

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Objective: To document the long-term effect of argon laser peripheral iridoplasty (ALPI) in eyes with plateau iris syndrome.

Design: Retrospective, noncomparative, interventional case series.

Setting: New York Eye and Ear Infirmary.

Methods: The charts of all patients with plateau iris syndrome treated with ALPI from 1982 to 1991 and subsequently followed for 6 or more years were retrospectively reviewed. Patients with lens-related mechanisms contributing to angle closure (e.g., phacomorphic or malignant glaucoma) were excluded.

Main Outcome Measures: Necessity for repeat ALPI and/or any additional means of intervention.

Results: A total of 26 ALPI procedures were performed in 23 eyes of 14 patients (4 men, 10 women). The mean age was 61±8.7 years. The mean follow-up was 78.9±8.0 months (range, 72–188 months). The angle in 20 of 23 (87.0%) eyes remained open throughout the entire follow-up period after only 1 treatment with ALPI. In 3 eyes, there was gradual reclosure of the angle 5 to 9 years after initial ALPI, but they were readily reopened and maintained open by a single repeat treatment. No filtration surgery was necessary in any eye during follow-up.

Conclusions: ALPI is highly effective in eliminating residual appositional closure after laser iridotomy caused by plateau iris syndrome. The effect is maintained for years, although a small proportion of patients might require retreatment. *Ophthalmology 2004;111:104–108 © 2004 by the American Academy of Ophthalmology.*

Plateau iris configuration refers to an anatomic appearance in which the iris root angulates forward from its insertion in the iridocorneal angle wall and then centrally.[1] In many cases, the iris root is short and is inserted anteriorly on the ciliary face, so that the angle is shallow and narrow, with a sharp drop-off of the peripheral iris at the inner aspect of the angle. The iris surface appears flat, and the anterior chamber is of relatively normal depth clinically. The cause of the configuration is a large or anteriorly positioned pars plicata, which narrows the angle by physically supporting the iris root against the trabecular meshwork.[2,3]

Plateau iris syndrome refers to the development of angle closure, either spontaneously or after pupillary dilatation, in an eye with plateau iris configuration despite the presence of a patent iridotomy. Some patients might have acute angle-closure glaucoma develop.[4–7] Argon laser peripheral iridoplasty (ALPI) involves the application of contraction burns (low energy, large spot size, and long duration) to the peripheral iris. This compacts and contracts the peripheral iris stroma, creating a space between the anterior iris surface and the trabecular meshwork, thus opening the angle.[8–10] The long-term effect of ALPI on the angle configuration and intraocular pressure (IOP) in eyes with plateau iris syndrome has, however, not previously been documented. It was also not known whether ALPI could prevent the progression of peripheral anterior synechiae (PAS) over the long term and also avoid the need for filtration surgery in this group of patients. In this study, we document the long-term effect of ALPI in patients with plateau iris syndrome.

Materials and Methods

We reviewed the charts of all patients with plateau iris syndrome who were treated with ALPI at the New York Eye and Ear Infirmary from 1983 to 1991 and who were followed continuously for at least 6 years afterward. Patients with less than 6 years of

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Figure 1. Double hump sign. With indentation gonioscopy, the anteriorly placed ciliary processes prevent posterior movement of the peripheral iris, resulting in a configuration in which the slit beam follows the curvature of the iris to its deepest point at the periphery of the lens, where the ciliary processes begin, then rises again over the ciliary processes before dropping peripherally. Greater force is needed to open the angle than in pupillary block, because the ciliary processes must be displaced, and the angle does not open as widely.

follow-up or who were followed elsewhere were excluded from analysis.

Plateau iris syndrome was diagnosed by the presence of spontaneous appositional angle closure on darkroom indentation gonioscopy to at least the upper border of the pigmented band of the trabecular meshwork for at least 180° of the drainage angle after laser peripheral iridotomy to eliminate pupillary block in eyes with gonioscopically closed angles. All eyes were treated before the advent of the ultrasound biomicroscope in 1992. The gonioscopic double hump sign (Fig 1), diagnostic for plateau iris, was first noted around 1986.[2] Before this, the diagnosis was based on the presence of a medium or normal depth anterior chamber with a sharp peripheral iris drop-off on indentation gonioscopy. All patients were subsequently determined to have a double hump sign after this had been recognized. If patients were taking pilocarpine for IOP control, it was discontinued, and the patient was reexamined after 72 hours to determine whether the angle was occludable. Eyes with posterior synechiae keeping the pupil miotic and the angle open were not treated.

Patients with other mechanisms contributing to angle closure (e.g., phacomorphic [lens-related] or malignant glaucoma) were excluded. Eyes in which the lens extended nearly to the angle wall, so that indentation produced a narrow, inverted triangular space and the iris contour remained smoothly domed into its insertion point, were considered to have phacomorphic glaucoma and were not included in this series. Patients with angle closure secondary to central retinal vein occlusion, panretinal photocoagulation, scleral buckling procedures, posterior scleritis, and other causes of anterior rotation of the lens–iris diaphragm were excluded.

All patients signed informed consent. ALPI was performed with topical anesthesia using an Abraham lens after administration of 1 drop of 4% pilocarpine. From 1988 onward, apraclonidine was also given before and after the procedure to blunt any post-laser IOP rise. The laser was initially set at an energy level of 200 mW and increased in 40-mW increments until adequate peripheral stromal contraction was noted. The duration of each laser pulse was 0.5 second, with a spot size of 500 μm. The laser beam was focused onto the peripheral iris as close to the limbus as possible.

Table 1. Ocular Status before Argon Laser Peripheral Iridoplasty and at Last Follow-up Visit

	Before Argon Laser Peripheral Iridoplasty	At Last Follow-up
Mean VA ± SD	0.9 ± 0.3 (range, 0.2–1.3)	0.7 ± 0.3 (range, 0.1–1.0)
Mean IOP ± SD (mmHg)	18.0 ± 4.5 (range, 10.0–24.0)	18.2 ± 4.4 (range, 10.0–27.0)
Mean C/D ± SD	0.3 ± 0.2 (range, 0.1–0.9)	0.4 ± 0.2 (range, 0.2–0.9)
Mean # drugs* ± SD	1.2 ± 1.0 (range, 0–3)	0.6 ± 0.7 (range, 0–3)

C/D ratio = cup-to-disc ratio; IOP = intraocular pressure; SD = standard deviation; VA = visual acuity.
*Number of antiglaucoma medications (including topical and systemic).

The patient was asked to look in the same direction as the quadrant of iris being treated. Tilting of the lens in the nasal, inferior, and temporal quadrants, but not the superior quadrant, usually permits visualization of the angle wall through the periphery of the button on the lens, allowing spot placement at the edge of the iris stroma in apposition to the angle wall. All 4 quadrants (360°) were treated in the initial procedure. The desired end consisted of localized iris contraction at the treated site for each laser application. The laser energy level was reduced if any of the followings was observed: (1) charring of the iris or release of pigment; (2) formation of gas bubbles; (3) production of a "pop." indicating a minute explosion. The laser energy level was increased if there was no contraction response from the iris. Immediately after the procedure, the patient was given a drop of topical corticosteroid. One hour after laser, IOP was measured and patients were treated as necessary if an IOP spike had occurred. Patients were treated with topical corticosteroids 4 to 6 times daily for 4 or 5 days. Gonioscopy was performed 1 week later to assess the effect of the procedure.

The visual acuity, IOP, angle grading based on the Shaffer system as documented by darkroom gonioscopy, vertical cup-to-disc ratio, and the number of antiglaucoma medications were recorded from the charts. These parameters before ALPI and at the last follow-up were compared. The laser settings were also recorded. Any repeat ALPI or supplementary IOP-lowering procedures were noted.

Results

A total of 26 ALPI procedures were performed in 23 eyes (10 right eyes, 13 left eyes) of 14 patients (4 men, 10 women). Mean age of the 14 patients was 61±8.7 years (range, 45–76 years). Only 1 Filipino patient was not Caucasian. Mean follow-up time was 78.9±8.0 months (range, 72–188 months). Of the 5 untreated eyes, 4 were judged sufficiently open so as not to require ALPI, and 1 was prephthisical with no light perception vision. All patients with plateau iris and appositional closure to the functional trabecular meshwork received ALPI after 1983. Patients with closure only to the base of the pigmented portion of the meshwork (low plateau) were not treated. Our database contains a total of 170 patients with plateau iris syndrome diagnosed before 1992.

Table 1 presents the mean visual acuity, mean IOP, mean vertical cup-to-disc ratio, and the mean number of antiglaucoma medications before ALPI and at the final follow-up a mean of 6.6 years after laser. Of the 23 eyes, 16 were using pilocarpine 4 times

Table 2. Long-term Results of Argon Laser Peripheral Iridoplasty in Plateau Iris Syndrome

Patient	Age	Gender	Right Eye/ Left Eye	Follow-up (mos)	Visual Acuity at Presentation	Intraocular Pressure at Presentation (mmHg)	Energy Setting of Argon Laser in Argon Laser Peripheral Iridoplasty (mW)	Number of Laser Spots in Argon Peripheral Iridoplasty	Number of Repeat Argon Laser Peripheral Iridoplasties to Maintain Angle Opening	Visual Acuity at Final Follow-up	Intraocular Pressure at Final Follow-up (mmHg)
1	55	M	OS	72	0.8	16	200	40	0	0.1	17
2	57	F	OD	77	0.5	22	250	21	0	0.3	21
			OS	77	1.0	22	250	21	0	0.4	22
3	73	M	OD	72	1.0	20	500	34	0	1.0	20
			OS	72	1.0	23	400	33	0	1.0	22
4	66	F	OD	82	0.5	11	300	38	0	0.5	18
5	76	F	OS	95	0.5	22	350	28	0	0.2	27
6	45	F	OS	84	0.2	16	250	21	0	0.4	22
7	53	F	OD	140	1.0	24	300	26	0	0.5	27
			OS	138	1.0	12	250	38	0	0.7	17
8	53	M	OS	138	1.0	21	200	31	0	0.5	21
			OD	138	1.0	23	200	24	0	1.0	20
9	61	F	OD	115	1.0	17	300	28	0	0.5	16
			OS	115	1.0	17	300	28	0	0.3	10
10	55	F	OD	143	1.0	15	200	28	0	0.7	16
			OS	125	1.0	16	300	19	0	0.8	18
11	72	F	OS	158	0.3	20	250	31	0	0.5	11
12	61	F	OS	155	1.0	13	350	24	1	0.8	15
			OD	92	1.0	10	300	20	1	1.0	14
13	61	M	OD	188	1.3	15	300	40	0	1.0	19
			OS	187	1.0	12	300	31	0	1.0	18
14	59	F	OD	97	1.0	24	300	33	1	1.0	15
			OS	91	1.0	22	300	22	0	0.8	13

F = female; M = male; OD = right eye; OS = left eye.

daily before ALPI. Seven eyes were using a topical β-blocker, 2 were using topical dipivefrin, and 2 were taking oral acetazolamide.

The mean number of laser applications was 29.2±6.9 (range, 19–42). The mean energy level used was 282.7±69.2 mW (range, 200–500 mW). The laser spot size was set at 500 μm for 24 of the 26 procedures. In the remaining 2 eyes, which were light gray, the spot size was reduced to 200 μm, because 500 μm did not produce peripheral contraction. Burn duration was 0.5 seconds in all procedures. One week after the initial procedure in the 23 eyes, the appositionally closed segment of the drainage angle was opened to grade II (Shaffer). In 18 of the 23 eyes, the angle was widened to grade III. There were no complications attributable to the laser procedure. Only 1 eye had an IOP spike of 10 mmHg, before the advent of apraclonidine.

The angle in 20 of 23 (87.0%) eyes remained open indefinitely after only 1 treatment. The remaining 3 eyes had gradual reclosure of the angle years later (5, 7, and 9 years later); these were readily reopened and maintained open by a single repeat treatment of 14 to 24 laser applications of the same settings over 360° placed peripheral to the center of the previous spots (when the angle is opened by a contraction burn, the iris that was apposed to the trabecular meshwork now becomes exposed) when possible. There were no complications from the repeat treatment. At the final follow-up, all 23 eyes had the drainage angle maintained open to at least grade II, with 7 eyes open to grade III. There was no documented progression of PAS in the 23 eyes during follow-up.

The change in visual acuity from pre-ALPI to the last follow-up was statistically significant ($P<0.001$). Most of the decrease in visual acuity was accounted for by the gradual development of cataract. The changes in IOP and vertical cup-to-disc ratio, from pre-ALPI to the last follow-up, were not statistically significant. Although there was no statistically significant change in the mean IOP before ALPI and at the last follow-up, the mean number of antiglaucoma medications decreased from 1.2±1.0 to 0.6±0.7. Pilocarpine was discontinued in 8 of 16 eyes and was initiated in both eyes of 1 patient 4 years after ALPI.

In 22 of 23 (95.7%) eyes, there was no documented deterioration in the results of automated perimetry during the follow-up period. No filtration surgery was necessary in any patient during follow-up, but argon laser trabeculoplasty was performed in 2 eyes to control IOP, whereas supplementary laser peripheral iridotomy was performed in 1 eye to maintain patency of the iridotomy. Phacoemulsification was performed in 1 eye. Table 2 summarizes the results of ALPI in the 23 eyes.

Discussion

Gradle and Sugar[11] observed angle-closure glaucoma in a number of eyes with normal anterior chamber depths. In 1955 Higgett and Smith[12] described 2 cases of angle-closure glaucoma in younger patients who had a flat iris and a narrow angle secondary to an abrupt angulation at the root of the iris. Chandler described a 37-year-old woman with recurring intermittent angle-closure glaucoma despite a patent iridectomy who was successfully treated with pilocarpine.[7] Tornquist[1] was the first to use the term plateau iris in a publication in 1958, when he described the appearance of the iris of a 44-year-old male with angle-closure glaucoma who was found to have a normal anterior chamber

depth, flat iris surface, with a sharp backward curvature to the peripheral iris. The introduction of indentation gonioscopy greatly aided our diagnosis and classification of the different forms of angle-closure glaucoma.[13,14]

In 1977, Wand et al[7] differentiated plateau iris configuration from plateau iris syndrome. Classically, plateau iris configuration refers to the pre-iridotomy findings of a normal anterior chamber depth, flat iris plane, and a narrow, or closed, angle. Plateau iris syndrome describes the postiridotomy findings of either spontaneous or dilatation-induced angle closure in patients with plateau iris configuration. Plateau iris syndrome can be divided into complete and incomplete subtypes.[15] In the complete syndrome, which is rare and comprises the classic situation, IOP rises when the angle closes. In the incomplete syndrome, IOP does not change. The differentiating factor is the level of the iris with respect to the angle structures or the "height" to which the plateau rises. If the angle closes to the upper trabecular meshwork or Schwalbe's line, the IOP will rise, whereas if it closes partially, leaving the upper portion of the filtering meshwork open, it will not. The latter situation is far more common and is clinically significant, because these patients can have PAS develop up to years after a successful iridotomy produces what appears as a well-opened angle.

Patients with plateau iris tend to be female, younger (30s to 50s), and less hyperopic than those with relative pupillary block and often have a family history of angle-closure glaucoma.[16] Except in the rare younger patients (20s and 30s), some element of pupillary block is also present. In a series of 67 patients with angle closure developing at age 40 or younger, only 2 patients had pure pupillary block, whereas 35 had plateau iris syndrome.[17] However, because of the nature of the anatomic relationships of the structures surrounding the posterior chamber, the degree of relative pupillary block necessary to induce angle closure is less than that necessary in primary angle-closure glaucoma; this seems to account for the deeper anterior chamber and flatter iris surface in eyes with angle closure and plateau iris.[16]

Pupillary block must be eliminated by iridotomy before plateau iris syndrome can be diagnosed.[9] As a general rule, the older the patient the less prominent the angulation of the peripheral iris and the more rounded the peripheral iris contour. The important diagnostic criterion is the presence of an occludable angle after iridotomy on the basis of the configuration of the iris on indentation gonioscopy and ultrasound biomicroscopy (Fig 2).[14] A plateau iris appearance (pseudoplateau iris) can be caused by multiple iris–ciliary body cysts.[17,18] To our knowledge, no patients had this appearance. Some of our patients never had ultrasound biomicroscopy performed, because they were treated and subsequently lost to follow-up before its advent.

Treatment of the iris by application of laser burns directly into the angle (gonioplasty) to open a closed angle was originally described by Kimbrough et al[19] in 1979 in patients with nanophthalmos. They used a 200-μm spot size and 0.2 second duration. Weiss et al[20] reported using this technique to treat angle-closure glaucoma unrelieved by patent iridectomy, applying a mean power of 723 mW, successfully treating 20 of 30 eyes; the successes had a shorter median duration of angle closure.

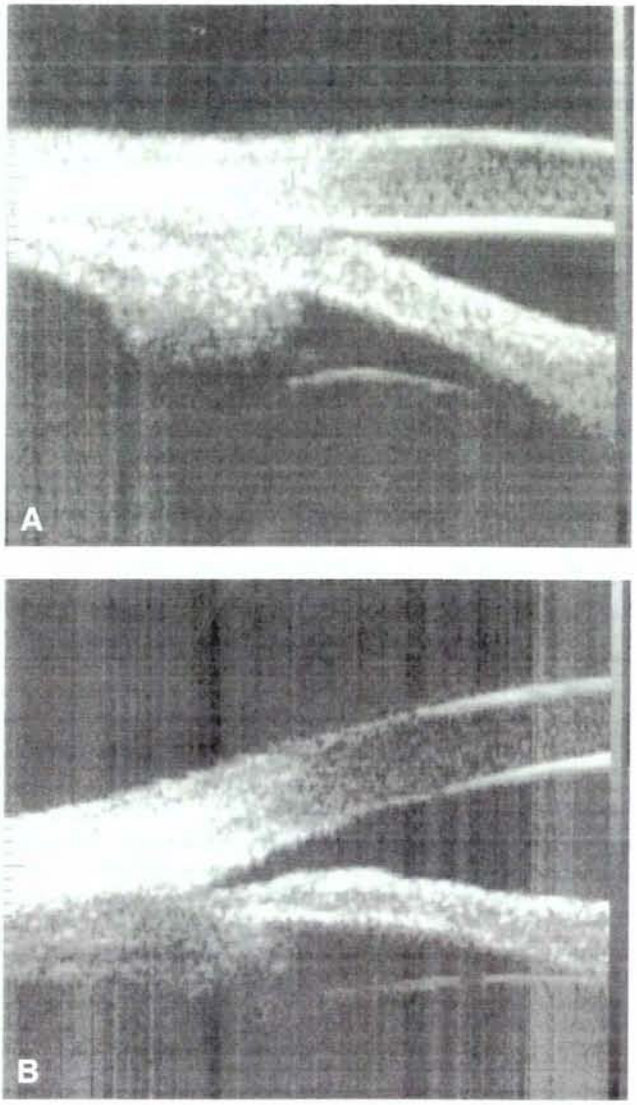

Figure 2. **A,** Ultrasound biomicroscopy image taken showing the drainage angle region in an eye with plateau iris syndrome after peripheral iridotomy. The iris root rises upward from its insertion. There is no visible ciliary sulcus between the thick iris root and the anteriorly positioned and prominent ciliary body. The drainage angle is closed. **B,** The same eye after argon laser peripheral iridoplasty. The angle is open after compaction and thinning of the stroma of the iris root by contraction burns of long duration, low power, and large spot size.

Much greater peripheral iris contraction is achieved by using large spot size, long duration contraction burns (peripheral iridoplasty) with an Abraham lens. This technique was originally described for relieving medically unbreakable attacks of angle-closure glaucoma.[21] Its value has since been substantiated with both the argon and the diode lasers both after medical therapy for acute angle closure and as primary intervention.[22–28] Detailed techniques and indications for ALPI in eyes with residual appositional closure after iridotomy on the basis of various anatomic mechanisms (plateau iris, phacomorphic glaucoma, ciliary block) have been described.[8,29,30]

Pilocarpine was continued in 8 eyes of 5 patients in this

series and was instituted in 2 eyes of an additional patient. In all eyes, it was required for IOP control; the only other classes of medications available at the time were β-blockers and oral carbonic anhydrase inhibitors (epinephrine compounds were considered contraindicated in angle closure). It is possible that some of these angles might have closed and required retreatment during the follow-up period had they not been treated with pilocarpine. Nevertheless, these eyes had appositional closure after iridotomy while being treated with pilocarpine, for which reason ALPI was initially performed. It is also possible that occult posterior synechiae were present in some eyes but not evident or not recorded when the pupils were dilated after ALPI was performed.

To our knowledge, this is the first report of the long-term success rate of ALPI in the treatment of residual appositional closure after iridotomy in eyes with plateau iris syndrome. The results in our patients were highly satisfactory. In eyes with plateau iris syndrome, ALPI can produce opening of the angle that lasts for years. Only 3 eyes required 1 retreatment. ALPI is a safe and effective procedure for persistent appositional closure after laser peripheral iridoplasty in eyes with occludable angles or angle closure on the basis of plateau iris. Filtration surgery necessitated by progressive PAS formation and subsequent IOP elevation if ALPI is not performed can be avoided indefinitely.

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