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ORIGINAL ARTICLE

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A prospective, randomized comparison of Nd:YAG and sequential argon-YAG laser iridotomy in Filipino eyes

ABSTRACT

Objective

This study compared Nd:YAG laser alone versus sequential argon-Nd:YAG laser iridotomy in terms of success in attaining patency, differences in visual acuity and intraocular pressure, and rate of complications in dark irides of Filipinos.

Methods

A prospective, randomized, controlled trial was performed involving patients requiring laser iridotomy who were randomized either to Nd:YAG laser or sequential argon-Nd:YAG laser iridotomy. Iris-perforation success rate, the average number of laser shots and amount of laser energy used, the intraocular pressure (IOP) after laser treatment, and the rate of complications were compared. The prelaser pupil size was correlated with the iris perforation success rate.

Results

Forty-one eyes underwent laser iridotomy (23 Nd:YAG and 18 sequential). All eyes had patent iridotomies. There was no difference between the two groups in terms of the number of Nd:YAG laser shots delivered ($p = 0.97$) and amount of Nd:YAG energy used ($p = 0.64$). The total amount of laser energy used was higher in the sequential group ($p = 0.003$). There was no significant difference in the IOP and complication rates after treatment. A positive correlation was seen between prelaser pupil size and number of Nd:YAG shots needed to enlarge ($r = 0.38$, $p = 0.01$).

Conclusion

Nd:YAG laser alone and sequential argon-Nd:YAG have comparable success in attaining patency of laser iridotomy, IOP control, and rate of complications in dark irides of Filipinos.

Key words: *Glaucoma, Laser iridotomy, Nd: YAG laser, Argon laser*

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PRIMARY angle-closure glaucoma is common among Asians, particularly Singaporeans who have the highest incidence.[1] In the Philippines where prevalence studies are lacking, only limited data can be obtained regarding glaucoma occurrence. At the University of the Philippines-Philippine General Hospital (UP-PGH), approximately 1,500 glaucoma consultations were recorded in 2000, about half of them angle-closure cases (De Jesus A, Chief Resident's Annual Report 2000, PGH Department of Ophthalmology and Visual Sciences).

Laser iridotomy (LI) for primary angle-closure glaucoma is currently the treatment procedure of choice.[2] Pupillary block of any degree, determined clinically significant, is an indication for LI.[3] It may be performed using argon laser or Neodymium: Yttrium-Aluminum-Garnet (Nd:YAG) laser, both of which have their own advantages and disadvantages.[4-6]

Aside from pitfalls inherent in the technique, several factors including racial differences in iris pigmentation and thickness affect treatment outcomes. Dilated pupils and miotic resistant pupils increase iris thickness, posing a problem in LI. A study involving Korean eyes has suggested that LI may not be helpful in cases with dilated and miotic-resistant pupils with formation of extensive peripheral anterior synechiae (PAS).[7] A review of sequential argon-Nd:YAG to treat primary angle-closure glaucoma among Singaporeans revealed that eyes with mid-dilated pupils and more than 6 clock hours of PAS required further medical or surgical treatment for uncontrolled IOP despite a patent LI.[8]

Although initial studies showed no significant long-term differences between LI created with Nd:YAG or argon laser,[9] the former has shown clinical advantages in creating a patent iridotomy. One-hundred-percent success rates have been reported with Nd:YAG laser[10-12] while 20 to 58% failure rates were reported for argon laser.[11, 13, 14] Success rates may vary in the thicker and more heavily pigmented Asian irides, which require higher energy levels to penetrate the iris. As a result, more complications and failures have been reported, including iridotomy closure, iris bleeding, transient IOP elevation, and corneal endothelial edema.

A technique utilizing both argon and Nd:YAG lasers has been devised to combine the advantages of both lasers while avoiding the disadvantages. The argon laser creates preparatory stretch burns and the Nd:YAG laser completes the perforation.[15] Such method may be the ideal iridotomy technique for Asian irides.[10, 15-17] A study comparing blue, hazel, and thick brown irides found that the amount of Nd:YAG energy required varied directly with the pigmentation of the iris.[18] Initial studies reported 100-percent success rate for this technique.[10,17]

This study determined whether Nd:YAG laser alone or the sequential argon-Nd:YAG laser were comparable in terms of success in attaining patency of laser iridotomy, control of IOP, and incidence of complications encountered in dark, Filipino irides treated at the UP-PGH. We compared the average number of laser shots and amount of laser energy used for both techniques and correlated the prelaser pupil size with the iris perforation success rate.

METHODOLOGY

The study protocol and informed consent form were approved by the PGH Institutional Review Board.

All patients seen consecutively at the Glaucoma Clinic of the UP-PGH from June 2001 to October 2002 were screened for possible inclusion into the study. Included were eyes with primary angle-closure glaucoma, the fellow eye of an angle-closure attack, narrow occludable angle, uveitic or inflammatory glaucoma with pupillary block. For those with bilateral involvement, eyes were randomly selected for each procedure. Patients with comorbid systemic diseases such as diabetes and hypertension were included provided that no ocular complications were evident.

Angle-closure glaucoma caused by neovascularization of angles or by ciliary block mechanism, previous intraocular surgery, previous laser surgery, and those unable to tolerate the procedure were excluded.

All patients underwent a standard eye examination which included history taking, visual acuity determination, IOP measurement, slit-lamp biomicroscopy, gonioscopy, and fundus examination.

A laser iridotomy protocol form was filled up and followed for each patient. Baseline ocular examination was performed at least one hour before laser treatment with particular attention to pupil size, IOP, and peripheral anterior synechiae. All eyes were pretreated with 1 drop 2% pilocarpine and 0.5% apraclonidine (Iopidine, Alcon Laboratories, Forth Worth TX, USA) 1 hour before laser surgery. If IOP was greater than 20 mm Hg, 1 tablet of dichlorphenamide 50 mg (Oratrol, Alcon Laboratories, Forth Worth, TX, USA) was given per orem. If the cornea was edematous due to very high IOP, oral hyperosmotic glycerol 1.5 cc/kg was added.

Using a table of random values, each eye was assigned to undergo either Nd:YAG or sequential argon-YAG treatment. Immediately before the procedure, topical anesthetic was administered. If the cornea was still edematous, topical glycerine was added to the anesthetized eye.

An Abraham iridotomy contact lens (Ocular Instruments, Bellevue, WA, USA) with cellulose gel was used for either technique. The choice of iridotomy site was based on the following parameters: (1) superior quadrants of the iris covered by the upper lid, preferably superonasal;

(2) as far peripherally as possible clearing the arcus senilis beyond the outer radial one-third of the iris; (3) thinner looking area or crypt. The 3- and 9-o'clock positions and visible vessels were avoided. The actual iridotomy site was drawn on the protocol form.

Laser iridotomy was performed by six senior residents using standardized parameters to minimize interobserver variability. All measures of visual acuity, IOP, pupillary size, slit-lamp biomicroscopy, gonioscopy on follow-up were done by one clinician (KMEB).

Nd:YAG laser iridotomy

Nd:YAG laser settings: 2.5 mJ power, 1 pulse per burst. Technique: The beam was focused within the iris stroma and not on the surface of the iris. 2.5mJ was the starting power used. If a patent iridotomy was not attained after several shots, the laser parameters were modified to power of 1-10 mJ and 1-3 pulses per burst until patency was achieved. When intraoperative bleeding occurred, gentle pressure was applied on the eye with the lens. When plasmoid aqueous precluded completion of the procedure, intensive steroid eye drops were given and the patient was brought back for completion of laser in 24 hours.

Sequential argon-Nd:YAG laser iridotomy

Settings: 800-1000 mW power (equivalent to 1000 mJ per second), 50 micron spot size, 0.02 second exposure time. Chipping technique was done as follows: The beam was focused within the iris stroma. The first shot was made on the projected final iridotomy site. The subsequent shots were directed immediately adjacent to and around the first shot, forming a rosette pattern. Successful priming using argon laser was defined as the creation of a charred and thinned out area. If this was not reached, argon laser parameters were modified to achieve this end point with power of 1200-2500 mW and exposure time of 0.02 to 0.1 second. The Nd:YAG technique followed as described above, aiming at the center or thinnest part of the argon-treated area of the iris.

The final end point for both techniques was the creation of an iridotomy 100 to 500 micrometers in size through which the aqueous mixed with pigment flowing into the anterior chamber could be visualized, with the iris falling backwards and the peripheral anterior chamber deepening. Patency was confirmed by direct visualization of the lens through the iridotomy and not just by transillumination through the pupil or iridotomy.

Immediately after the laser treatment, 1 drop of apraclonidine 0.5% was administered. Topical steroid eyedrops were given for 7 days. In cases of posterior synechiae formation, pupillary dilation was done.

Visual acuity, IOP, and iridotomy patency were monitored at 1 hour, 2 hours, 3 hours, 24 hours, 1 week, 1 month, 3 months, and 6 months postlaser. The occurrence of complications was monitored.

Analysis of variance (ANOVA) and Kruskal-Wallis test were used to determine differences in parameters between the two treatments. Correlation studies were also performed.

RESULTS

Forty-one eyes of 41 patients (8 males and 33 females) were included in the study. Twenty-three patients were assigned to the Nd:YAG group, 18 to the sequential laser group. The mean patient age was 62 years (range of 42 to 86 years). Thirty-one patients had a diagnosis of narrow occludable angle, 9 had intermittent angle-closure glaucoma, and 1 had chronic angle-closure glaucoma. There was no significant difference in preoperative parameters between the treatment groups (Table 1).

In the Nd:YAG group 22 (95.65%) patients were seen on day 1, 15 (65.22%) on week 1, 10 (43.48%) at 1 month, and 2 (8.69%) at 3 months. Three (13%) out of 23 patients completed the six-month follow-up.

In the sequential group, 8 (44.44%) patients were seen on day 1, 15 (83.33%) on week 1, 11 (61.11%) at 1 month and 2 (16.67%) at 3 months. Two (11.11%) out of 18 patients completed the six-month follow-up.

All eyes had patent iridotomies at the end of each session.

The mean number of Nd:YAG laser shots needed to perforate the iris (initial gush of fluid) was 14.52 ± 19.35 for the Nd:YAG only group and 14.33 ± 14.76 for the sequential group. There was no staticsally significant difference between the two treatments ($p = 0.97$) (Table 2).

The mean amount of Nd:YAG energy used in producing the initial gush was 40.81 ± 57.96 mJ in the Nd:YAG group and 33.45±35.89 mJ in the sequential group (Table 2). There was no statistically significant difference between the two treatment groups ($p = 0.64$).

The number of Nd:YAG laser shots needed to enlarge the iridotomy was significantly fewer in the sequential group with a mean of 24.56 ± 13.61 compared with 52.74 ± 56.96 in the Nd:YAG only group ($p = 0.05$).

The mean total energy used to enlarge the iridotomy was 222.61 ± 183.65 mJ in the Nd:YAG group and 431.01 ± 183.65 mJ in the sequential group; the difference was statistically significant ($p = 0.003$).

There was a statistically significant difference in the iridotomy sizes between the two groups ($p = 0.05$) with a mean of 2.51 ± 0.90 mm in the Nd:YAG group and 2.65 ± 0.97 mm for the sequential group.

Segmental analysis of different parameters on follow-up was done. Regardless of treatment, there was no significant difference in visual acuity across follow-up periods ($p = 0.72$). Furthermore, there was no difference between

Table 1. **Baseline characteristics and treatment parameters.**

	Nd:YAG (n=23)	Sequential (n=18)
Age (years)[1]		
Mean +/- SD	64 ± 9	60 ± 12
Median	65	62
Range	45-82	42-86
Gender[2]		
Male	5	3
Female	18	15
Angles[3]		
360 open occludable	20	11
1-6 clock-hours closed	3	6
360 closed	0	1
Mean Baseline Parameters		
Visual Acuity[4*]	0.80 ± 0.27	0.77 ± 0.29
Intraocular Pressure[5] (mm Hg)	16.00 ± 2.03	17.33 ± 3.24
Pupil Size[6] (mm)	2.11 ± 0.94	2.11 ± 0.93

[1]p = 0.25; [2]p = 0.50; [3]p = 0.13; [4]p = 0.66; [5]p = 0.33; [6]p = 0.83
*converted into decimal units: 1=20/20, 0.5=20/40, 0.25=20/80 and so on

Table 3. **Visual acuity between treatment groups at follow-up.**

Follow-up Time	Mean Visual Acuity (Decimal Units)		p
	Nd:YAG	*Sequential*	
After 24 hours (n=29)	0.76 ± 0.25	0.86 ± 0.20	0.31*
One week (n=28)	0.76 ± 0.30	0.78 ± 0.24	0.81*
One month (n=20)	0.93 ± 0.12	0.79 ± 0.22	0.09*
Three months (n=5)	0.65 ± 0.21	1.00 ± 0	0.05

*Not statistically significant.

Table 4. **Intraocular pressure within treatment groups at follow-up.**

Follow-up Time	Mean IOP	
	Nd: YAG[1]	Sequential[2]
Baseline (prelaser)	12.96 ± 3.94	12.00 ± 5.52
24 hrs	11.96 ± 4.37	12.13 ± 3.56
1 week	12.87 ± 2.95	14.47 ± 5.10
1 month	12.00 ± 2.87	17.64 ± 14.48
3 months	16.00 ± 5.66	17.33 ± 1.16
6 months	12.67 ± 3.06	15.50 ± 3.54

[1]p = 0 .75; [2]p = 0.35.

Table 2. **Comparison of Nd:YAG laser shots between treatment groups.**

Parameters	Mean Number of Shots			Mean energy (mJ)		
	Nd:YAG	*Sequential*	*p*	*Nd:YAG*	*Sequential*	*p*
Iris perforation (initial gush)	14.52 ± 19.35	14.33 ± 14.76	0.97	40.81 ± 57.96	33.45 ± 35.89	0.64
Enlarge iridotomy	52.74 ± 56.96	24.56 ± 13.61	0.05	222.61 ± 183.65	431.01 ± 183.65	0.003

treatment groups over time (Table 3). There was also no difference in IOP between treatment groups (p = 0.33) (Table 4) and angles over time (p = 0.36).

There was a positive correlation between pupil size and number of Nd:YAG shots to perforate (r = 0.30; p = 0.06) and between iridotomy size and amount of Nd:YAG energy to enlarge (r = 0.38; p = 0.01). Weaker correlation between iridotomy size and total energy was found (r = 0.28; p = 0.08).

No significant interoperator difference was found in the number of Nd:YAG laser shots to perforate (p = 0.22), shots to enlarge (p = 0.17) and total energy used (p = 0.14).

Complications seen were transient intraoperative bleeding at the site of iridotomy in 4 eyes (17.4%) in the YAG group and 4 eyes (22.2%) in the sequential group (p = 0.71). Endothelial burn was observed in 2 eyes (8.7%) in the YAG group, none in the sequential group (p = 0.50). Stratified analysis of anterior-chamber reaction showed no difference between treatments (p = 0.22). Closure of iridotomies was not observed.

DISCUSSION

The outcome of laser iridotomy is determined by several patient and treatment factors. This study gave particular attention to thick and densely pigmented irides in Filipino eyes and the effect of such on the outcomes of sequential argon-YAG laser and YAG laser only in the treatment of angle-closure glaucoma. Other patient factors such as pupil size, chronicity of disease, and IOP were likewise taken into consideration as these affect treatment outcomes as well.

Several studies have suggested that sequential iridotomy was safe and effective especially in dark irides. Ho and Fan[10] conducted sequential iridotomies in 20 eyes of 13 patients, with a mean total energy delivered per eye of 3.6 J by the argon and 0.0094 J by the Nd:YAG laser. These were one-third of corresponding values reported by Robin and Pollack[19] for pure argon (12 ± 11 J) and pure Nd:YAG (0.033 ± 0.25 J) iridotomies. Thus, there were advantages in combining the two types of laser.

The mean energy of 0.03345 J administered in the YAG part of this study was comparable to the 0.033 J in the Robin and Pollack study.[19] There was no statistically significant difference between the two groups in the number of shots of Nd:YAG laser delivered to perforate the iris and in the amount of Nd:YAG energy used. However, the total energy used in the sequential technique was significantly higher since the amount of energy to enlarge the iridotomy was higher and the argon laser per se used more energy at 1000 mW per second. Twice the number of Nd:YAG laser shots was needed to enlarge iridotomies in the Nd:YAG only group compared to the sequential group. The thicker brown iris absorbs argon energy well and less Nd:YAG energy and fewer shots were needed to enlarge the iridotomy in pretreated thinned out iris.

The use of two laser machines instead of one may be less cost-effective in the treatment of eyes requiring iridotomy. Although the sequential technique theoretically offers an advantage over Nd:YAG laser only in the treatment of darker irides, no such advantage was found in this study, considering the 100-percent perforation rate in both techniques and the comparable number of shots and amount of Nd:YAG laser energy delivered in both treatment groups. A study by Fleck[20] yielded similar results; pretreatment with argon was performed 6 weeks prior to Nd: YAG laser. No differences in visual acuity, IOP control, and angles were observed between treatment groups during the follow-up period.

Patency of laser iridotomy over time requires an opening in the iris of at least 100 spot size; the larger the opening, the less likely it will close. In this study, there was a positive correlation between iridotomy size and amount of Nd:YAG energy to enlarge, indicating that more energy was required to obtain a larger opening. The mean iridotomy size in the sequential group was significantly larger and correlated with the higher total energy used in this group. The thick brown iris absorbs argon energy well, making subsequent perforation and enlargement of the iris opening easier. Longer-term studies are needed to determine the correlation between size of opening and patency over time.

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