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CLINICAL STUDY

Lower energy levels adequate for effective transcleral diode laser cyclo-photocoagulation in Asian eyes with refractory glaucoma

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Abstract

Purpose **To study the treatment parameters for diode laser cyclophotocoagulation (DLCP) in Asian Indian eyes using laser energy titrated to clinical response.**

Methods **This prospective interventional longitudinal study included 66 eyes of 66 patients with varied aetiology refractory glaucoma, no previous cycloablation, and minimum 1 year follow-up. DLCP was performed using the Oculight® Diode laser system (IRIS© Medical Instruments Inc., CA, USA). Power used per spot was titrated according to the audible 'pops' indicating tissue microexplosion. The mean laser energy delivered, post-laser intraocular pressure (IOP) reduction, complications, and requirement of re-treatment in various subgroups were analyzed. Differences in energy delivered in each subgroup were assessed by analysis of variance with *post hoc* Bonferroni corrections. Linear regression analysis was used to identify possible predictive factors for failure of cyclodiode therapy.**

Results **The mean total energy delivered per eye was 87.80 ± 31.8 J (range 105.4 ± 36.8 J in neovascular glaucoma (NVG) to 61.5 ± 8.8 J in uveitic glaucoma ($P = 0.134$)). Mean pre treatment IOP was 36.4 ± 10.7 mmHg, which reduced to 19.4 ± 9.8 mmHg ($P < 0.001$) at 1 week, and 15.6 ± 6.6 mmHg at 1 year. At 1 year, 58 of 66 patients had IOP < 22.0 mmHg (response rate 87.8%), and six patients had hypotony (success rate 78.8%). The uveitic glaucoma group had 100% success rate. NVG group required maximum re-treatments.**

Conclusions **DLCP with a titrated energy protocol needs resulted in lower energy in Asian Indian eyes compared to that reported in literature, and different energy levels are needed for different diseases. 'Standard treatment parameters' for DLCP may be inappropriate for all diseases and all races.**

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Keywords: diode laser; cyclophotocoagulation; transcleral; refractory glaucoma

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Introduction

Cyclodestructive procedures for intractable glaucoma unlikely to benefit from surgery, have evolved in the last 70 years: from penetrating cyclodiathermy,[1] to cyclocryotherapy,[2–4] to ultrasound for ciliary body ablation,[5,6] to laser cyclophotocoagulation.[7–24] The chief drawback of these procedures as a group is a narrow therapeutic window, which implies that there is a very small safety zone in which it is effective without causing significant complications. Currently, transcleral laser cyclophotocoagulation (TSCPC) procedures appear to provide the best combination of effectiveness, portability, expense, and ease of use.

Since Beckman *et al*'s[7] first report of transcleral cyclophotocoagulation using Ruby laser (693 nm), a wide variety of laser wavelengths has been used. The energy uptake appears to be influenced by melanin absorption.[10] The most frequently used lasers for this modality of treatment are the 1064 nm Nd:Yag lasers[8–11] and 810 nm semiconductor diode.[12–24] Both wavelengths can produce

thermal tissue damage, and there is evidence that the semiconductor diode laser with 810 nm wavelength exhibits less scleral transmission and considerably greater absorption by melanin compared to the 1064 nm Nd:Yag laser.[25] The clinically significant effect is that the energy needed to produce comparable lesions is less with the diode laser compared to that required by the Nd:YAG laser.[12] Owing to the same reason, less laser energy has also been reported to be needed in pigmented eyes, to produce the same effect.[10,11]

Although there are numerous reports describing the effectiveness of TSCPC, an accurate comparison of different techniques based on published studies is difficult because of wide variation in treatment parameters and lack of uniform definition of success. There are no standard treatment parameters defined, and the laser energy delivered varies considerably.

We conducted this study to assess treatment parameters of diode laser cyclophotocoagulation (DLCP) in our population of Asian Indian eyes and to see whether the energy delivered in these pigmented eyes differed from that reported in literature.

Material and Methods

This prospective longitudinal study was undertaken in patients with refractory glaucoma who had not responded to or were unlikely to benefit from glaucoma surgery. Patients were recruited from the Glaucoma Clinic of the Postgraduate Institute of Medical Education and Research, Chandigarh, India. Ethical clearance was obtained from the Institute's Ethics Review Committee and the study adhered to the principles enshrined in the Declaration of Helsinki Principles.

The study group comprised patients who had never received any form of cycloablative treatment, had a best-corrected visual acuity (BCVA) $<3/60$, and fulfilled one or more of the following inclusion criteria:

(a) medically uncontrolled glaucoma patients who were unlikely to respond to or declined filtering surgery;
(b) poor visual potential in eyes with poor prognosis for filtration surgery (eg prior pars-plana vitrectomy (PPV), penetrating keratoplasty (PK) with failed graft, repeated failed glaucoma surgery, chemical burns, etc.);
(c) painful blind eyes with high intraocular pressure (IOP).

Patients fulfilling the eligibility criteria presenting to our Clinic between July 2004 and January 2006 were consecutively enrolled for the study. Baseline information included patients' age, gender, race, type of glaucoma, underlying ocular disease, BCVA, IOP, number of topical and oral anti-glaucoma medications, and previous glaucoma and/or other ocular surgery.

DLCP procedure

After taking informed consent, the TSCPC procedure was performed under a peribulbar block with anaesthetic mixture of 2% lidocaine hydrochloride and 0.5%. bupivacaine. A lid speculum was used to separate the eyelids. The laser energy was delivered through a 600 μm diametre quartz fibre oriented within the G-probe handpiece of the Oculight® Diode laser system (IRIS Medical Instruments Inc., Mountainview, CA, USA) to centre the treatment 1.2 mm behind the limbus. The fibre optic tip protrudes 0.7 mm from the G-probe contact surface in order to indent the conjunctiva and sclera, thereby improves the laser transmission to the ciliary body. Care was taken to apply the G-probe to the limbus indenting as above as this ensured that the G-probe surface contour matched the scleral curvature, and the posterior angulation was correctly oriented to protect the lens of phakic eyes from laser damage. Three quarters of the circumference of the ciliary body (six per quadrant for 270 degrees resulting in 18 spots) was treated, and the supero-nasal quadrants were spared in all cases.

The energy delivery was started at 1750 mW for 2 s and increased in 250 mW intervals till an audible 'pop' was heard (which indicates tissue disruption[25,26]), following which the power was reduced by 250 mW until the 'pops' were no longer audible, and the treatment was completed at these parameters. The total cyclodiode energy (joules) delivered per session was calculated by multiplying the number of laser burns by the duration (seconds) and power (Watts).

If the patient was on oral acetazolamide before laser treatment, it was continued for a period of 1 week after laser treatment. At 1 week post-laser treatment, oral acetazolamide was discontinued if the IOP was <22 mmHg, were continued topical IOP lowering medications depending on the response. Topical steroids, usually dexamethasone 0.1%, four times a day, and cycloplegics (atropine 1%) three times a day, were prescribed for 2–4 weeks after treatment.

If an adequate response was not achieved in 6 weeks, cyclodiode was repeated up to a maximum of two treatment sessions. The treated quadrants were re-treated each time, leaving the supero-nasal quadrant totally free of cycloablation. The total energy delivered to an eye was calculated by adding the energy delivered in all treatment sessions.

Follow-up examinations were performed weekly for first month, monthly for 3 months, three monthly for the first year, and six monthly thereafter. At every follow-up examination, visual acuity, IOP, anti-glaucoma

medication used, slit-lamp biomicroscopic appearance, and complications were recorded. Only patients completing 1-year follow-up were included in the final analysis.

The outcome of cyclodiode therapy was determined in terms of

1. Success rate: defined as the percentage of eyes achieving an IOP between 5 and 21 mmHg with or without topical medication in all eyes following cyclodiode therapy at their final follow-up visit.
2. Response rate: defined as the percentage of patients achieving an IOP of <22 mmHg or $>30\%$ drop in IOP and included eyes that developed hypotony (IOP <5 mmHg).
3. Cyclodiode efficacy index;[19] defined as the ratio of the response rate (expressed as a decimal) to the mean number of treatment sessions. Thus, a cyclodiode efficacy index of 1.0 would indicate that all the eyes in an evaluated group achieved a satisfactory IOP response following a single treatment episode.

Data were recorded on prospectively filled patient forms.

Statistical methods

Sample size calculation

The aim of this study was to compare the success in our patients with that reported in literature. Reported success rates vary from 66 to 80% in Caucasians[15,18,19] to 92% in Indian eyes.[20] Taking a mean reported success rate of 70% and a difference of at least 20% to be significant, a study with 80% power and 5% significance would require a minimum of 63 patients, by the following formula:

$$\text{Minimum sample size} = \frac{2\times(1.96+0.84)^2\times 80\times 20}{20^2} = 62.72$$

Statistical analysis

Results were analyzed using the SPSS for Windows software, Version 10.0, ©SPSS Inc., Chicago, US. Differences in pre treatment and final IOP and pre- and post-treatment topical anti-glaucoma drug use were analysed using the Wilcoxon Signed Rank Test. The difference in pre- and post-treatment systemic carbonic anhydrase inhibitor use was compared using the McNemar test. The differences in energy delivered to eyes in each subgroup were assessed by analysis of variance with *post hoc* Bonferroni corrections. Linear regression analysis was used to identify possible predictive factors for failure of cyclodiode therapy such as age, gender, pretreatment IOP, and diagnosis. The results were considered significant at $P<0.05$.

Results

In total, 71 eyes of 71 eligible patients, were recruited for the study. Five patients were lost to follow-up after the first 3 months and were excluded from the study group. Data from 66 eyes of 66 patients were analysed. Mean follow-up was 14.3 ± 2.2 months. Baseline characteristics are detailed in Table 1. The mean age was 47.2 ± 17.3 years and 52 patients were male. Neovascular glaucoma (NVG) accounted for the largest subgroup (27.3%) of patients.

The mean total energy delivered per eye was 87.80 ± 31.8 J. The energy delivered in each subgroup is detailed in Table 2. The mean total energy delivered ranged from 105.4 ± 36.8 J in the NVG group to 61.5 ± 8.8 J in the uveitic glaucoma group, but these differences did not reach statistical significance ($P=0.134$). Eleven patients required one re-treatment, which meant that 66 eyes required 77 treatments, translating into mean 1.16 sessions per eye. There was no significant difference in the energy delivered between the first and second treatments. Of the eyes needing re-treatment, five eyes had NVG, two eyes had post-PK glaucoma, one each had primary angle closure glaucoma (PACG), primary open angle glaucoma (POAG), post-PPV glaucoma, post-scleral buckling (SB) glaucoma, and traumatic glaucoma.

The mean pre treatment IOP was 36.4 ± 10.7 mmHg, which reduced significantly ($P<0.001$) to

Table 1 Baseline characteristics of patient

Gender	*No (%)*
Males	52 (78.8)
Females	14 (21.2)
Age (years)	
(Mean $\pm$ SD)	47.2 ± 17.3
(Range)	(13–72)
Diagnosis	
Neovascular glaucoma	18 (27.3)
Post-penetrating keratoplasty	12 (18.2)
Post-PPV glaucoma	8 (12.1)
Uveitic glaucoma	6 (9.1)
Traumatic glaucoma	6 (9.1)
POAG	6 (9.1)
Post-scleral buckle	5 (7.6)
Angle closure glaucoma	3 (4.5)
Buphthalmos	2 (3.0)
Total	66 (100)

19.4±9.8 mmHg at the first week following treatment, and was maintained at 15.6±6.6 mmHg at 1 year follow-up (Figure 1). Details of IOP reduction in all subgroups are depicted in Table 3. There was no significant difference in the pre-treatment IOP ($P=0.166$) or the final IOP at 1 year ($P=0.653$) between any of the subgroups.

Before treatment, 49 patients (74.2%) required oral acetazolamide for IOP control, and the number of patients with IOP decreased to 37 (56.1%), 31 (47%), and 16 (24.2%) patients at 1 week, 1 month, and 3 months, respectively. Of these 49 patients, NVG comprised the largest subgroup (17 patients) followed by post-penetrating keratoplasty (PK), post-pars-plana vitrectomy (PPV), and post-traumatic glaucoma (6 patients each). No patient required acetazolamide after from the 6 months follow-up ($P<0.000$; Figure 1). Dependence on topical anti-glaucoma medication also reduced significantly. Mean topical anti-glaucoma drug requirement decreased from 2.6±0.9 before treatment to 2.1±1.1 at 3 months and to 1.8±1.2 (Figure 1) at the end of 1 year — the differences were statistically significant ($P=0.020$ and $P<0.001$, respectively).

At 1 year follow-up, 58 of 66 patients had IOP less than 22.0 mmHg with or without topical drugs, translating a response rate of 87.8% (Table 2). Six patients had final IOP <5.0 mmHg. Thus the outcome in terms of success was 78.8% (52/66). Outcome in all patient subgroups is detailed in Table 2. Uveitic glaucoma, post-PPV glaucoma, and congenital glaucoma showed the best response rate (100%), but one patient each in the PPV and congenital glaucoma group developed hypotony. The Uveitic glaucoma group had 100% success rate, followed by post-PPV group with 87.5%. Post-traumatic glaucoma (66.7%) and PACG (66.7%) had the least success rates. However, these differences did not reach statistical significance ($P=0.81$).

Table 2 Energy delivered and outcome of DLCP in all subgroups

Diagnosis	*Total energy delivered per eye (J)*	*Re-treatment sessions (no)*	*Mean treatments per patient (no)*	*Response (IOP<22.0 mmHg) no (%)*	*Success (IOP 5–22 mmHg) no (%)*	*Cyclodiode efficacy index*
All patients ($n=66$)	87.8±31.8	11	1.16	58 (87.8)	52 (78.8)	0.758
NVG ($n=18$)	105.4±36.8	5	1.3	15 (83.3)	13 (72.2)	0.64
Post-PK ($n=12$)	83.2±31.2	2	1.2	11 (91.7)	10 (83.3)	0.77
Post-PPV ($n=8$)	85.5±24.5	1	1.1	8 (100.0)	7 (87.5)	0.91
Uveitis ($n=6$)	61.5±8.8	0	1.0	6 (100.0)	6 (100.0)	1.0
Trauma ($n=6$)	85.5±34.5	1	1.2	5 (83.3)	4 (66.7)	0.69
POAG ($n=6$)	84.0±32.0	1	1.2	5 (83.3)	5 (83.3)	0.69
SB ($n=5$)	93.6±33.4	1	1.2	4 (80.0)	4 (80.0)	0.67
PACG ($n=3$)	72.0±9.0	0	1.0	2 (66.7)	2 (66.7)	0.67
Congenital glaucoma ($n=2$)	76.5±6.4	0	1.0	2 (100)	1 (50)	1.0

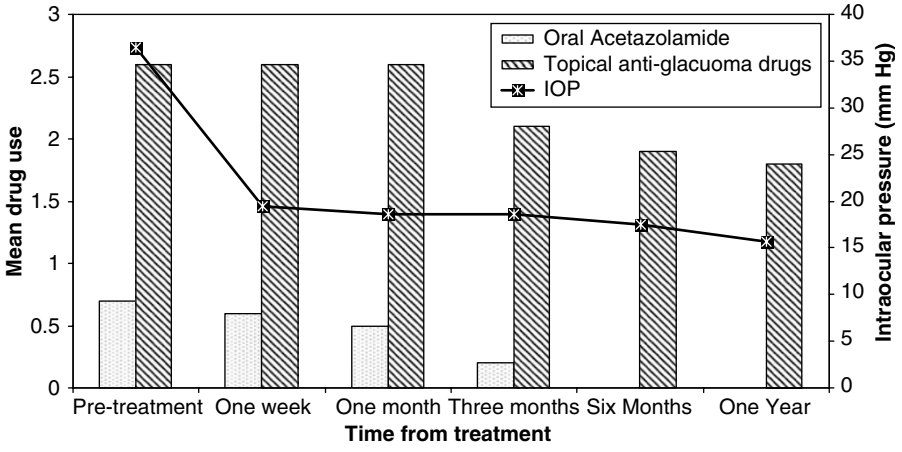

Figure 1 Oral and topical anti-glaucoma drug use with IOP reduction over time.

Table 3 IOP change in various subgroups over time

Diagnosis	*Pretreatment Mean IOP (mmHg)*	*One week Mean IOP (mmHg)*	*One month Mean IOP (mmHg)*	*Six months Mean IOP (mmHg)*	*One year Mean IOP (mmHg)*
All patients ($n=66$)	36.4	19.4	18.6	17.5	15.6
NVG ($n=18$)	42.9	21.3	21.1	17.1	15.5
Post-PK ($n=12$)	33.7	22.5	22.1	18.4	15.6
Post-PPV ($n=8$)	31.0	16.4	11.4	14.8	13.3
Uveitis ($n=6$)	34.7	15.3	12.0	13.0	13.3
Trauma ($n=6$)	38.8	19.3	20.0	23.0	18.3
POAG ($n=6$)	33.3	13.7	15.3	16.0	15.3
SB ($n=5$)	35.2	24.6	21.4	21.6	18.6
ACG ($n=3$)	31.3	13.3	19.3	22.6	19.3
Congenital glaucoma ($n=2$)	32.0	21.0	11.0	10.0	10.0

The overall cyclodiode efficacy index was 0.758 (0.88/1.16), meaning that 75.8% of patients in our study group achieved satisfactory IOP control following a single treatment session. The cyclodiode efficacy index is depicted group wise in Table 2. The uveitic and congenital glaucoma groups were most sensitive to DLCP with cyclodiode efficacy index of 1.0, whereas the NVG group was the least sensitive with a cyclodiode efficacy index of 0.64.

Post-laser complications included pain requiring oral analgesics in 30 (45.5%) eyes, hyphema in two (3.03%) eyes (both eyes had neovascular glaucoma), and hypotony in six (9.09%) eyes, not related to the subtype of glaucoma. The post-intervention IOP course in these six patients is depicted in Figure 2. All patients except two showed IOP control by 1 month after intervention, but developed hypotony by 3 months. One patient with NVG and one with post-traumatic glaucoma were re-treated at 6 weeks for persistent raised IOP, and developed hypotony subsequently.

A total 63 patients preserved their pre treatment visual acuity, whereas it deteriorated in three patients from counting fingers to light perception. No eye lost light perception vision after DLCP.

Linear regression analysis model for possible predictors of response to cyclophotocoagulation is shown in Table 4. The response was significantly related to only pre-treatment IOP ($P=0.030$), whereas the type of glaucoma, age, or gender had no bearing on the final outcome.

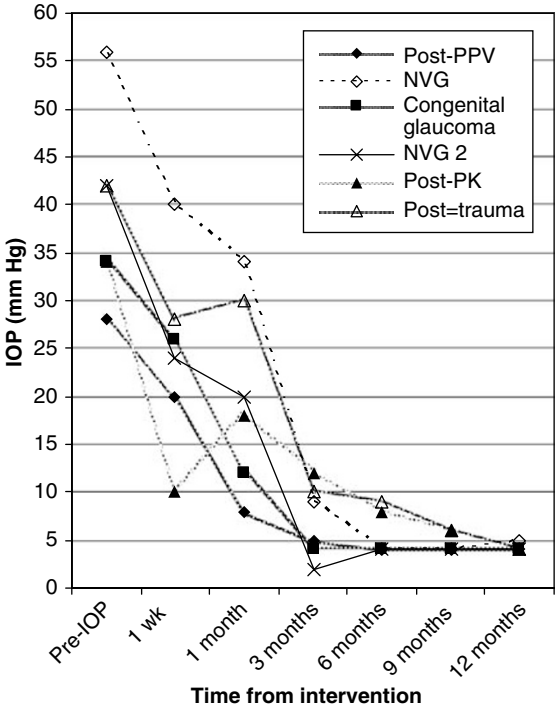

Figure 2 Course of IOP reduction following DLCP in the six patients who developed hypotony.

Table 4 Linear regression analysis model of predictive factors for response to cyclophotocoagulation

Independent factors	*Pearson correlation coefficient*	*Significance (P)*[a]
Age	0.104	0.630
Gender	0.034	0.714
Diagnosis	0.060	0.248
Baseline IOP	0.257	0.030

[a]Linear regression analysis; dependant variable: response to treatment.

Discussion

The goal of transcleral cyclophotocoagulation is to significantly reduce the IOP whereas minimizing damage to adjacent tissues and preventing hypotony. As the effectiveness of laser energy appears to be related to melanin absorption,[10,11] it may translate into lower energy levels required in pigmented eyes. However, a simple comparison with the numerous published DLCP studies is difficult owing to differences in treatment protocols, follow-up, times and success definitions. We, therefore, attempted to compare our results to those

studies in other populations, that analysed using outcome measures similar to our study.

We did not use uniform treatment parameters for all eyes in our study, but titrated the laser energy delivered by the sound of audible 'pops'. These 'pops' characterize intraocular uveal micro-explosion and represent boiling of tissue water.[27] Post-operative irido-cyclitis is reportedly more severe with increased 'pops'.[26] Such extensive destruction in the ciliary body region may not be desirable, and may result in increased risk of complications such as hypotony or phthisis. Therefore, our treatment protocol was strictly designed to limit power to a level where these 'pops' were not audible.

In our study, the mean energy delivered per eye was 87.8 ± 31.8 J, with a response rate of 88%, success rate of 78, and 16.7% rate of re-treatment. The mean IOP reduced by 20.8 mmHg (57.1%) at the end of 1 year, and all patients were free of oral acetazolamide by 6 months following treatment. These results were more favourable compared to another study in Indian eyes by Gupta and Agarwal.[20] Of the 52 patients they enrolled, only 22 completed 1 year follow-up. They used 120–160 joules per eye at each session, and treated 360 degrees of the limbus. The success rate was 55.7% at 2 months, and 22 patients (42%) required re-treatment.

Chang *et al*,[21] in their study on Chinese eyes, compared two treatment protocols with different energy levels and varied the number of laser applications. One protocol used 135 J per session with 27 applications, whereas the other protocol used 165 J with 55 applications. By 6 months, there was no significant difference in mean IOP reduction between the two groups (19.1 and 14.2 mmHg, respectively), but there were far more complications in the group receiving greater energy (hyphema: 23 *vs* 7; 8% exudation *vs* no exudation in the less-energy group). In contrast, our study showed better results with lower energy delivery, and fewer laser applications. As Chinese eyes are also pigmented, many laser applications may have resulted in far greater energy delivery than required for adequate IOP control.

Noureddin *et al*[22] reported their results in West Asian eyes, which are also more pigmented than Caucasian eyes. They used a standard 'aggressive' protocol for all eyes delivering 126 J per session, without titrating for audible 'pops'. The mean IOP fall was 53% at 1 year. However, vision worsened in 22% of their patients, and 25% needed re-treatment. With our 'titrated' energy delivery protocol, 63 of our 66 patients (95.5%) maintained their pre treatment visual acuity, whereas it worsened in three patients, again highlighting the fact that aggressive protocols may not confer too many advantages, but may lead to unacceptably higher rate of complications.

Murphy *et al*,[19] in their study on Caucasian eyes reported results similar to our study, but with higher energy levels. The mean laser energy delivered was 104.1 ± 37.5 J per session. The IOP drop was 23.0 mmHg from pre treatment levels (52.6%), the mean response rate was 89%, success rate was 79.5%, and the mean cyclodiode efficacy index was 0.59. More than one-third of their patients (34.2%) needed to be re-treated. We had similar outcomes, but the cyclodiode efficacy index was 0.76, meaning that our patients were more sensitive to DLCP. In both studies, NVG patients required the maximum and uveitis patients required the least energy, but the quantum of energy required in our population was much less. This comparison probably illustrates most clearly that nonpigmented eyes require more energy and more re-treatments for the same effect.

Conversely, there is evidence that suggests that comparable energy levels used in Caucasian and pigmented eyes resulted in better outcomes in the latter. Walland[23] compared two 'standard' treatment protocols in eyes that were assigned to either group according to the pre treatment IOP and previous cyclodestructive treatment. The 'full' treatment group (which included those with baseline IOP >30.0 mmHg and no previous cycloablation) received 90 J per session. Seven of the 22 patients (32%) in this group required re-treatment. Success rate (including hypotony) was 59.1% and response rate ($>30\%$ reduction of IOP) was 77%. This study in Australian eyes showed less successful outcomes and greater number of re-treatments than our patients, when similar energy levels were used.

Spencer and Vernon[24] reported their results in white patients using less energy by virtue of less number of laser applications (14 per eye). The mean energy delivered was 55.5 ± 1.4 J per session. Although the mean IOP drop was 15.1 mmHg at 1 year, 26 of their 58 eyes (45%) required to be re-treated. The lower power used in their study was most likely inadequate, which resulted in more re-treatments for appropriate IOP reduction.

In our study, uveitic eyes were most sensitive to DLCP, whereas eyes with NVG were most resistant. Mean energy levels delivered differed markedly in eyes with uveitic and rubeiotic glaucoma (61.5 ± 8.8 *vs* 105.4 ± 36.8 J, respectively), although the difference did not reach statistical significance. Uveitic eyes probably have compromised ciliary body function owing to long-standing cyclitis, as a result of which they respond readily to cycloablation of the remaining functional part of the ciliary body. The 'pops' in eyes with uveitic glaucoma were audible at lower energy levels compared to other subgroups. Probably there is also a degree of ciliary body atrophy in these eyes, which may explain tissue explosion at lower energy levels. All these eyes had a successful outcome with a single treatment session.

In contrast, of the 11 eyes requiring re-treatment, five had NVG. Although the ultimate success rate in these eyes seemed better than that in eyes with trauma, angle closure glaucoma, and congenital glaucoma, a true comparison would probably not be appropriate owing to the small number of patients in the latter subgroups.

Experimental reports have described ciliary body atrophy with abnormal ciliary epithelium 4 weeks after cyclophotocoagulation.[28] Most clinical studies[15,19] have considered 4–6 weeks as the time frame for the response of DLCP, after which the eyes are re-treated. We waited for 6 weeks before re-treating our patients. However, as our study shows, acetazolamide use decreased upto 3 months following treatment, suggesting that one may wait for this much time before declaring the procedure a failure and re-treating the patient.

DLCP is reportedly less successful in younger individuals,[15,20] and they appear to recover from treatment more rapidly compared to adults.[29] In our study, there were only two patients with congenital glaucoma, both responded to treatment, and one patient developed hypotony. However, one cannot read much into data from just two patients, and these results should not be commented upon.

The most dreaded complication of ciliary ablation is hypotony and phthisis. In eyes with extremely limited outflow facility, reducing aqueous production to a level that would result in 'normal' IOP on no medication increases this risk manifold. This is one of the reasons for the narrow therapeutic window of cyclodestructive procedures. However, most studies with DLCP have reported low risk of these complications,[15–17] especially when the treatment protocol involved titrating energy delivery by audible pops. Six of our 66 patients developed hypotony, but there was no alteration in structural integrity of these eyes. Most IOP reductions were seen to occur by 1 month, with hypotony manifesting most commonly by 3 months. One patient each with NVG and post-PK glaucoma were re-treated at 6 weeks for persistently raised IOP. The numbers are too small to comment upon whether this in fact was the cause of the hypotony, but it does suggest that it may be prudent to wait at least 3 months before re-treating.

One important consideration of cyclodestruction is providing freedom from oral acetazolamide, which is a practical concern for many ophthalmologists using this treatment modality. In the present study, 74% of patients were dependant on oral acetazolamide before treatment, all of whom could be taken off the drug by 6 months. The number of topical drugs required for IOP control also reduced significantly in all subgroups of patients. Other studies have also demonstrated 100% freedom from oral acetazolamide following DLCP,[15,30] whereas in the study by Spencer and Vernon[24] (who used a lower energy treatment protocol), 91% of patients were free from oral acetazolamide.

Only the pre -treatment IOP was a significant factor predictive of response to DLCP. Eyes with higher IOP responded better to treatment. Schlote *et al*[15] demonstrated a significant association between age and success, whereas in the study by Murphy *et al*[19] male sex was associated with failure of DLCP. We found no such association with age or gender, but the less number of patients in our study needs to be kept in mind before drawing any definitive conclusions.

To summarize, our study demonstrates good results of DLCP with a treatment protocol strictly titrated according to the audible evidence of intraocular tissue explosion. Pigmented eyes appeared to require less energy level than that reported in Caucasian eyes with comparable outcome. DLCP in Asian eyes with lesser energy levels appears to be a safe and effective treatment modality for IOP control in eyes with intractable glaucoma. Larger studies with longer follow-up periods will answer questions pertaining to its long-term efficacy.

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