

SCIENTIFIC CORRESPONDENCE

Long term results of diode laser cycloablation in complex glaucoma using the Zeiss Visulas II system

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Aim: To investigate the safety and efficacy of the Zeiss Visulas II diode laser system in the reduction of intraocular pressure (IOP) in patients with complex glaucoma.

Methods: The authors analysed the medical records of patients who underwent trans-scleral diode laser cycloablation (TDC) at the Manchester Royal Eye Hospital during a 34 month period. 55 eyes of 53 patients with complex glaucoma were followed up for a period of 12–52 months (mean 23.1 months) after initial treatment with the Zeiss Visulas II diode laser system.

Results: Mean pretreatment IOP was 35.8 mm Hg (range 22–64 mm Hg). At the last examination, mean IOP was 17.3 mm Hg (range 0–40 mm Hg). After treatment, 45 eyes (82%) had an IOP between 5 and 22 mm Hg; in 46 eyes (84%) the preoperative IOP had been reduced by 30% or more. The mean number of treatment sessions was 1.7 (range 1–6). At the last follow up appointment, the mean number of glaucoma medications was reduced from 2.1 to 1.6 ($p < 0.05$). In 10 eyes (18%), post-treatment visual acuity (VA) was worse than pretreatment VA by 2 or more lines.

Conclusions: Treatment with the Zeiss Visulas II diode laser system can be safely repeated in order to achieve the target IOP. Treatment outcomes in this study were similar to those from previously published work using the Iris Medical Oculight SLx laser.

Trans-scleral diode laser cycloablation (TDC) is an established treatment for complex glaucoma^{1–2}—that is, glaucoma which is unresponsive to medical therapy and surgical intervention, and for glaucoma where such therapies carry a high risk of failure. TDC selectively destroys the ciliary body pigment epithelium^{3–4} and has a comparatively low rate of complications.^{5,6}

To date, most studies of this treatment have reported on the Oculight SLx diode laser (Iris Medical Instruments, Mountain View, CA, USA) with the contact G-Probe.^{1,7,8} A previous study on the Zeiss II Visulas system reported on results in a predominantly oriental group of patients.⁹ There are few data available on the efficacy of the Zeiss Visulas II diode laser in white patients.

In this paper, we report on long term results of 55 eyes of 53 predominantly white patients treated at the Manchester Royal Eye Hospital using the Zeiss Visulas II system.

PATIENTS AND METHODS

A retrospective analysis was undertaken of medical records of all patients with complex glaucoma who underwent trans-scleral diode laser cycloablation (TDC) at the Manchester Royal Eye Hospital during a 34 month period.

Indications for TDC were:

(a) medically uncontrolled glaucoma where further surgical treatment carried a high risk of failure, either because of pre-

vious failed surgery or a form of glaucoma with an inherently poor response to conventional surgical treatments

(b) intolerance to antiglaucoma medications (in particular systemic carbonic anhydrase inhibitors)

(c) painful blind glaucomatous eyes for which palliative treatment was required.

Patients were excluded from the study if:

(a) any cyclodestructive treatment other than TDC treatment with the Zeiss Visulas II had been applied (14 eyes), or

(b) less than 12 months' follow up data had been collected ($n = 1$ eye).

Fifty five eyes of 53 patients (23 males, 30 females; 49 white, three Asian Indians, one Afro-Caribbean) met the inclusion criteria. The mean follow up period was 23.1 months (range 12–53 months). The mean age for patients at time of first treatment was 59 years (range 6–90 years). Patients' eyes were categorised into diagnostic subgroups according to the type of glaucoma. These were primary open angle glaucoma (POAG, $n = 5$), secondary open angle glaucoma (SOAG, $n = 9$), aphakic glaucoma ($n = 10$), chronic angle closure glaucoma (CACG, $n = 5$), secondary angle closure glaucoma (SACG, $n = 3$), rubeotic glaucoma ($n = 8$), developmental glaucoma ($n = 6$), uveitic glaucoma ($n = 6$), and glaucoma after vitrectomy with silicone oil ($n = 3$). Table 1 shows the number of eyes in each diagnostic subgroup. No eyes underwent therapy other than diode laser, such as tube surgery, at this time.

The Zeiss Visulas II system uses a probe with a glass ball tip to focus the laser beam (wavelength 810 nm) to a 740 μm spot, 2.1 mm beyond the ball tip. Laser energy is delivered trans-conjunctivally via a fibre optic cable attached to the probe. The probe is reusable and the glass ball tip is sterilised between use. The laser energy output of the fibre optic cable is checked regularly to confirm it is undamaged.

The anterior margin of the 3.0 mm diameter probe was placed along the surgical limbus, perpendicular to the sclera, so that the centre of the focusing tip was positioned 1.5 mm posterior to the limbus. Transillumination was used to ascertain the position of the ciliary body and the probe position was adjusted accordingly.

Laser settings were fixed at 1500 mW of power applied for 1500 ms, as initially recommended by Zeiss. The number of applications ranged from 12 to 30 (median number of applications 24) delivered over 180–360 degrees. Fewer applications were used on occasion where there was concern not to induce phthisis, more applications where required to treat a full 360 degrees.

Local anaesthesia was administered to all patients with the exception of six paediatric patients who underwent TDC under general anaesthesia. Local anaesthetic was delivered as a peribulbar, retrobulbar, or sub-Tenon infiltration (3–5 ml of a 50/50 mixture of 2% lignocaine and 0.25% bupivacaine, or 3–5 ml of 3% prilocaine). Immediately after treatment, a subconjunctival injection of 4 mg of betamethasone was administered and patients continued their usual antiglaucoma medication. Topical steroid drops were administered for 1 week and

tailed off thereafter, according to the degree of post-surgical inflammation. Glaucoma medications were withdrawn as dictated by the IOP response.

The data recorded at baseline (preoperative evaluation) included VA, IOP, number of medications, slit lamp biomicroscopy appearance, and funduscopy. The same data were recorded from post-surgical evaluations performed at 1 day, 1 week, 1 month, 6 months, and 12 months following the first TDC. A final set of data was obtained from the most recent follow up visit. Additional data recorded at each follow up included the presence of any complications.

A numerical value of 1 to 12 was assigned to each grade of visual acuity from 6/6 on the Snellen chart (assigned a numerical value of 1) to no perception of light (assigned a numerical value of 12). This enabled us to include the lower grades of acuity (count fingers, hand movement, perception of light, and no perception of light) in the statistical analysis.

Previous reports have used different criteria to define the success of treatment.^{1 7 8 10} To provide data for comparison, we applied three different criteria for treatment success. Treatment success was defined as:

- (a) post-treatment IOP between 5 and 22 mm Hg
- (b) post-treatment IOP between 5 and 17 mm Hg
- (c) a reduction in IOP of 30% compared with pretreatment IOP.

RESULTS

The mean preoperative IOP was 35.8 mm Hg (SD 9.7, range 22–64). At 12 months after the first treatment mean IOP was 18.3 mm Hg (SD 8.3, range 1–42). At the last review (12–53 months after first treatment) mean IOP was 17.3 mm Hg (SD 7.7, range 0–40).

Longitudinal data of the group as a whole show a definite decline in IOP over the follow up period, from 21.75 (SD 10.2) mm Hg at 1 week to 17.8 (SD 7.7) mm Hg by 12 months and to 17.4 (SD 7.7) mm Hg at final follow up.

Figure 1 compares pretreatment IOP with IOP recorded at the last examination. Using our criteria for success:

- (a) 45 eyes (82%) had an IOP between 5 and 22 mm Hg
- (b) 30 eyes (54%) had an IOP between 5 and 17 mm Hg
- (c) 46 eyes (84%) had an IOP reduction of 30% or more, compared with pretreatment IOP.

Fifty one eyes (93%) received TDC in order to achieve better IOP control and four eyes (7%) received TDC in order to relieve pain. Although all four eyes treated for pain relief had a satisfactory reduction in IOP (46–86% reduction in pretreatment IOP), one eye remained painful and eventually required enucleation.

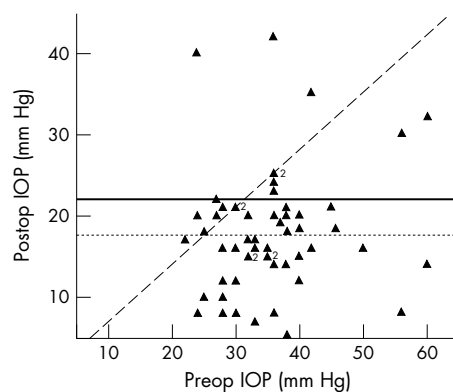


Figure 1 Preoperative IOP versus postoperative IOP at last examination. Solid line at 22 mm Hg. Dotted line at 17 mm Hg. Broken line represents 30% IOP reduction. (The numeral 2 next to data point indicates that two individuals are at this data point.)

Table 1 Mean IOP by diagnostic subgroup

Diagnostic subgroups	No of eyes (% of total)	Mean preop IOP	Mean last IOP	Mean IOP reduction
POAG	5 (9%)	34.0	15.0	19.0
SOAG	9 (17%)	32.1	16.6	15.5
Aphakic	10 (18%)	36.5	17.4	19.1
CACG	5 (9%)	30.6	15.2	15.4
SACG	3 (5%)	29.0	20.0	9.0
Rubeotic	8 (15%)	45.6	18.4	27.2
Developmental	6 (11%)	42.7	16.2	26.5
Uveitic	6 (11%)	34.7	19.0	15.7
Post vitrectomy	3 (5%)	25.7	18.0	7.7

POAG = primary open angle glaucoma, SOAG = secondary open angle glaucoma, CACG = chronic angle closure glaucoma, SACG = secondary angle closure glaucoma.

Table 1 shows the mean pretreatment and post-treatment IOP for each diagnostic subgroup. Patients with rubeotic glaucoma had a significantly higher pretreatment IOP than patients in other diagnostic groups (Kruskall-Wallis non-parametric analysis of variance by ranks, $p < 0.05$). The differences in IOP between the groups were no longer statistically significant at the last examination (Kruskall-Wallis, $p = 0.34$).

The median number of applications was 24 (range 12–30). The mean energy applied at each treatment was 52 J (range 27–68 J). Twenty eight eyes (51%) required repeat treatment of TDC and the mean total energy applied per eye was 91 J (range 34–281 J). There was no significant difference in the mean energy applied between the diagnostic subgroups (Kruskall-Wallis, $p = 0.16$).

The total number of TDC sessions per eye ranged from 1 to 6 (mean 1.7). Twenty seven eyes (49%) had a single TDC session, 19 eyes (34%) underwent two sessions, seven eyes (13%) underwent three sessions, one eye (2%) had four treatments, and one eye (2%) required six sessions. The total number of treatments required was not related to preoperative IOP (Kruskall-Wallis ANOVA, $p = 0.66$). There was a tendency for patients with aphakic glaucoma to require more treatment sessions than the other groups (mean number of sessions 2.7, range 1–6, $p = 0.074$).

The eyes that required re-treatment had a significantly higher IOP at 1 month (before any additional diode laser thus reflecting the initial effect of the diode laser) than eyes that did not require re-treatment (mean 25.9 mm Hg compare with 19.8 mm Hg; $p < 0.05$).

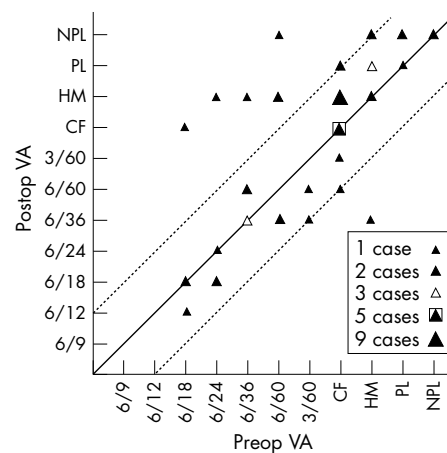


Figure 2 Preoperative VA versus postoperative VA at last examination. Solid line represents no change in VA. Broken lines represent a change of two grades of VA. (Two eyes are excluded, VA was unmeasurable because of learning disability.)

Table 2 Summary of 13 patients who lost or gained 2 or more grades of visual acuity

Case no	Preop VA	VA at last exam	Diagnosis	Cause of altered visual acuity
1	6/24	HM	POAG	Presumed progression of visual field loss
2	HM	NPL	SOAG	Bacterial keratitis and glaucoma progression
3	CF	PL	SOAG	Failure: glaucoma progression due to refractory rise in IOP after 2nd TDC
4	6/60	HM	SOAG	Retinal detachment 8 months postoperatively
5	6/36	HM	SACG	Glaucoma progression due to widely fluctuating IOP in between TDC sessions
6	6/60	HM	Aphakic	Failure: high IOP and glaucoma progression
7	6/60	NPL	Rubeotic (ocular ischaemic syndrome)	Ischaemic visual loss
8	HM	NPL	Rubeotic (CRVO)	Failure: high IOP and ischaemic loss
9	6/18	CF	Developmental	Presumed progression of visual field loss
10	CF	PL	Developmental	Retinal detachment 7 months postoperatively
11	HM	6/36	Rubeotic	Resolution of vitreous haemorrhage
12	CF	6/60	SOAG	Resolution of corneal oedema
13	3/60	6/36	SOAG	Resolution of corneal oedema

POAG = primary open angle glaucoma, SACG = secondary angle closure glaucoma, SOAG = secondary open angle glaucoma, CRVO = central retinal vein occlusion.

The mean total number of medications required at baseline was 2.1 (range 0–6). This was reduced to 1.6 (range 0–4) at the last review (Wilcoxon signed ranks test, $p < 0.05$). Moreover, the requirement for oral acetazolamide was substantially reduced. Seventeen patients (32%) required oral acetazolamide before TDC; only four (8%) were still taking it at their last examination ($p < 0.005$).

Figure 2 compares preoperative VA with that recorded at the last examination. Visual acuity was not formally recorded in two eyes of two patients because they had severe learning difficulties, but neither were felt to have lost vision during follow up. There was a mean deterioration of 0.5 Snellen chart lines (Wilcoxon signed ranks test, $p < 0.05$). A deterioration of VA of 2 or more grades was noted in 10 eyes (19%). Three eyes (6%) showed apparent VA improvements 2 or more grades. For the 13 eyes which showed VA change of 2 or more lines, Table 2 summarises the probable causes of this change.

Three eyes (cases 3, 6, and 8) lost vision as a result of failure of TDC and subsequent loss of central visual field secondary to persistently raised IOPs. In case 5, visual loss followed wide fluctuations in IOP between treatment sessions. In two eyes (cases 4 and 10), visual loss was associated with retinal detachments. Cases 1, 2, and 9 all had advanced glaucomatous field loss and continued to lose vision despite a good IOP response to TDC treatment. One eye (case 7) with ocular ischaemic syndrome continued to lose vision after IOP reduction by TDC. Direct complications from TDC were uncommon. No conjunctival burns were noted postoperatively, nor was there evidence of lens damage in phakic individuals. One patient developed a mild filamentary keratopathy following a second session of TDC, which settled with the use of topical lubricants.

Although there were no cases of phthisis bulbi, two eyes of two patients developed chronic hypotony (IOP below 5 mm Hg for a period of 3 months or longer). In one patient, hypotony developed 3 months after treatment followed by a refractory rise in IOP 12 months later. In the other patient, the IOP decreased unexpectedly 25 months after TDC, but the eye remained comfortable and no further action was required.

DISCUSSION

Current treatments available for complex glaucomas include the insertion of drainage tubes and cyclodestructive procedures, such as TDC.^{1–7} TDC is less invasive than the insertion of drainage tubes and is associated with lower rates of postoperative hypotony.¹¹ Alternative cyclodestructive procedures (cyclocryocoagulation and Nd:YAG laser cycloablation) are associated with greater rates of postoperative inflammation and hypotony than TDC.^{12–15} Diode laser (810 nm wavelength) is better absorbed by the ciliary body pigment

epithelium than Nd:YAG laser (1064 nm).³ This, together with its portability, durability, and reduced maintenance requirements, makes diode laser the cyclodestructive treatment of choice for complex glaucomas.

Most studies reporting on the efficacy of TDC have used the Oculight SLx with the fiberoptic G-probe delivery system (Iris Medical Instruments, Inc, Mountain View, CA, USA). The purpose of our study was to ascertain the safety and efficacy of TDC using an alternative system that delivers energy through a focusing glass ball tip at the end of a fiberoptic cable (Zeiss Visulas II, Carl Zeiss, Jena, Germany).

Wong *et al*⁶ reported on results with the Zeiss Visulas probe in 33 predominantly oriental patients. The mean follow up period of this study was 9.4 months, and 50% of their patients had treatment for rubeotic glaucoma, compared to only 15% in our study. In contrast, most of the 53 patients reported on in our research were white; they had a wider range of pathologies and were followed for a longer period (mean 23.1 months). The different ethnic backgrounds and diagnostic case mix in the study by Wong *et al* hinder direct comparisons with the other studies using the Oculight SLx system. Moreover, their criteria for re-treatment (IOP above 28 mm Hg) resulted in a lower re-treatment rate (24% *v* 51% in our study) and a higher mean postoperative IOP (24.4 mm Hg). Probably as a result of lower re-treatment rates, their overall success rate of 38% (IOP 2–21 mm Hg) is lower than that reported in this paper (82% of patients with post-treatment IOP of between 5 and 22 mm Hg). Our results compare favourably with those published by Bloom *et al*⁷ where 69% (144 eyes) had IOP below 22 mm Hg (mean follow up 10 months). Kosoko *et al*⁸ reported a success rate (defined as an IOP reduction greater than 20% after TDC treatment) of 84% at 1 year and 62% at 2 years. At the final assessment (mean follow up time 23.1 months) TDC treatment resulted in 30% or greater IOP reduction in 84% of eyes in our study.

In terms of patient numbers and follow up duration, our study can be compared most closely with that of Spencer *et al*¹⁰ (58 eyes, mean follow up 18.7 months) whose results using the Oculight SLx were similar to those presented here (81% of eyes at the last examination had an IOP below 22 mm Hg, 59% had an IOP below 17 mm Hg, and 78% had IOP reduction of more than 30% from baseline).

We demonstrated a significant reduction in the mean total number of medications required from 2.1 before to 1.6 after treatment. Of note was the reduced requirement for oral acetazolamide (32% before treatment compared with 7% after treatment) which is associated with a wide range of systemic side effects and is often poorly tolerated.

Significant postoperative visual loss has been associated with cyclodestructive procedures. VA reduction has been reported in between 30% and 70% of eyes following

cyclocryotherapy^{13 16} and for between 11%¹¹ and 47%¹⁴ of eyes after Nd:YAG. In our study, 10 eyes (18%) lost 2 or more lines of VA; this rate of loss is lower than that reported by others. Most of the previous diode laser studies included patients who had already undergone cyclodestructive procedures in the past. Such patients accounted for 18% of the cases in Bloom's study.⁷ We were interested primarily in the efficacy of the Zeiss Visulas II system and, therefore, excluded such patients from the study.

The Oculight SLx G-probe (Iris Medical Instruments) has a fibreoptic tip which directs the laser energy posteriorly parallel to the visual axis. It has been suggested that this may help prevent lens damage in phakic eyes.⁷ In contrast, the glass ball tip of the Zeiss Visulas II is held perpendicular to the conjunctiva and laser energy is directed in line with the angulation of the hand piece. One might assume that phakic eyes might be at greater risk of crystalline lens damage from the Zeiss Visulas II system; however, we did not see evidence of this in our study population.

TDC can safely be repeated until the target IOP has been achieved. No eyes were retreated before 4 weeks post TDC (24% of treated eyes achieved a maximal IOP reduction 4 weeks post-treatment). At 1 month follow up a slight upward trend in the mean IOP was noted. We therefore recommend allowing this period to elapse before any re-treatment is undertaken.

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