Transscleral diode laser in the treatment of retinopathy of prematurity

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Abstract

Purpose To assess the outcome of contact transscleral diode laser (TSDL) in the treatment of threshold retinopathy of prematurity (ROP).
Method TSDL was performed in 14 eyes of 8 babies who presented to the paediatric ophthalmic service at King's College Hospital between 1996 and 1997 with threshold ROP (median post-conceptual age 26+1 weeks, median birthweight 835 g) by a single surgeon. Follow-up ranged from 9 to 41 weeks (median 21 weeks).
Results In 11 eyes (79%) regression of ROP occurred after a single laser treatment with a good anatomical outcome. In 3 eyes (21%) there was an unfavourable response with the development of traction retinal detachment. These include both eyes of one baby who rapidly progressed to stage IV ROP. One other eye developed a fibrotic band a few months after treatment. No significant complications of laser treatment were observed.
Conclusion These initial results indicate that TSDL photocoagulation is an effective and technically straightforward alternative to cryotherapy in the treatment of ROP.

Key words Laser indirect ophthalmoscopy, Retinopathy of prematurity, Transscleral diode laser

Retinopathy of prematurity (ROP) is a leading cause of childhood blindness in industrialised countries, and the standard treatment for threshold disease (defined as stage III+ disease involving five contiguous or eight cumulative clock-hours in zone 1 or 2) is transscleral cryotherapy to the avascular retina anterior to the ridge. The multicentre North American Cryotherapy for Retinopathy of Prematurity study has reported the long-term safety and efficacy of cryotherapy in preventing blindness in these babies, incidence of blindness being reduced from 48% to 31.5%.[1] Guidelines for the screening and treatment have been developed by the Royal College of Ophthalmologists.[2]

Cryotherapy treatment is associated with significant ocular inflammation,[3] choroidal damage and breakdown of the blood–retinal barrier.[4,5] The development of semiconductor diode lasers (wavelength emission, 790–840 nm) has led to an alternative strategy for the treatment of ROP,[6,7] with a reduced incidence of complications being reported. Currently, diode laser photocoagulation is largely delivered using the indirect ophthalmoscope (LIO[6–10]). Effective treatment produced by the LIO may, therefore, be limited by media opacities and small pupil size. We present our initial findings using the transsceral diode laser (TSDL) in the treatment of threshold ROP.

Method

Babies who presented to the paediatric ophthalmic service at King's College Hospital between 1996 and 1997 with threshold ROP (stage III+) and babies who had not reached 5 clock-hours of contiguous new vessels but had at least 3 clock-hours of new vessels with advanced plus disease (cloudy media or iris rigidity) were treated with TSDL to the peripheral retina anterior to the ridge by a single surgeon (W.A.). All treatment was transconjunctival. Treatments were performed using a semiconductor diode laser, with an emission wavelength of 810 nm (Iris Medical Instruments, Mountain View, CA). The maximum available power was 2 W and the exposure duration could be incrementally increased up to a maximum of 9 s. Laser delivery was accomplished via a transsceral probe, which was applied to the external scleral surface (Fig. 1). A transilluminating red
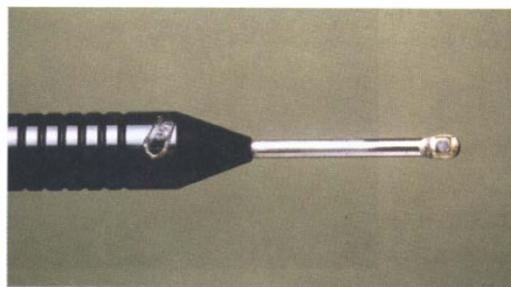

Fig. 1. *Transscleral diode laser probe.*

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Fig. 2. *Viewing the transscleral diode laser indentation of the peripheral retina.*

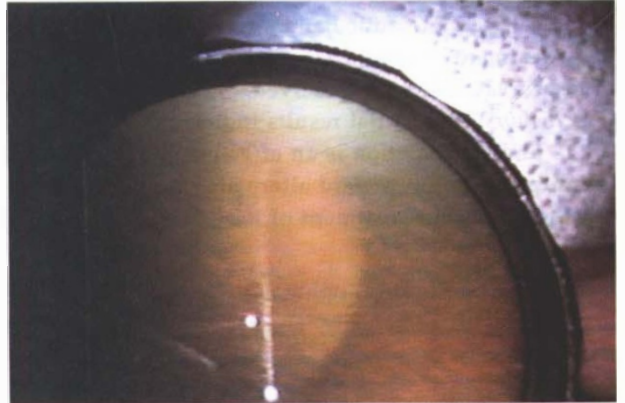**Fig. 3.** *Transscleral diode laser probe with red emitting aiming beam.*

Fig. 4. *Area of indentation of transscleral diode laser photocoagulation.*

Fig. 5. *Area of laser reaction of transscleral diode laser photocoagulation.*

Table 1. *Patient details*

Patient no.	Post-conceptual age at birth (weeks + days)	Birth-weight (g)	Prenatal complications	Postnatal complications	Ocular appearance before treatment		Disease severity	
					Right eye	Left eye	Right eye	Left eye
1	27 + 4	908	Severe IUGR	RDS, inguinal hernia repair	III+, vitreous haemorrhage	NAD	4 clock-hours (contiguous) zone 2	NAD
2	27	1120	Nil	Ventilation 2 days, in oxygen 9 weeks	III+	Vitreous haemorrhage	6 clock-hours (contiguous), zone 2 with haemorrhage	3 clock-hours (non-contiguous), zones 1 and 2
3	24 + 5	710	Nil	RDS, septicaemia, anaemia, IVH	III+	III+	5 clock-hours (contiguous), zones 1 and 2	5 clock-hours (contiguous), zone 2
4	25	780	Nil	Hypotensive, DIC, septicaemia, IVH, ischaemic foot	III+	III+	6 clock-hours (contiguous), zone 1	5 clock-hours (contiguous), zones 1 and 2
5	28 + 3	1200	Nil	Pneumothorax, septicaemia, PPH, PDA, upper GI bleed	III+	II with plus disease	4 clock-hours (non-contiguous), zone 2	3 clock-hours zones 1 and 2
6	25	650	Nil	RDS, PDA	III+	III+	3 clock-hours (contiguous), zones 1 and 2	3 clock-hours (contiguous), zones 1 and 2
7	26 + 5	890	Twin donor of twin-to-twin transfusion	RDS, PDA, septicaemia, bradycardia, unstable respiration	III+	III+	5 clock-hours (contiguous), zone 1 and 2	5 clock-hours (contiguous), zone 1 and 2
8	25 + 4	680	Maternal pre-eclampsia	Bronchopulmonary dysplasia	III+	III+	4 clock-hours (contiguous), zone 2	5 clock-hours (contiguous), zones 1 and 2
Median	26 + 1	835						
iqr1	25	702.5						
iqr3	27 + 4	961						

IUGR, intrauterine growth retardation; RDS, respiratory distress syndrome: IVH, intraventricular haemorrhage; DIC, disseminated intravascular coagulation; PPH, persistent pulmonary hypertension; PDA, patent ductus arteriosus; GI, gastrointestinal; NAD, no abormality detected; iqr, interquartile range.

emitting diode aiming beam allows the target area to be visualised with an indirect ophthalmoscope and precise treatment in the target area to be given. The laser is activated via a foot switch. The desired visible end-point is a greyish-white retinal lesion (Figs. 2–5). For a pulse duration of 2–3 s, powers of between 500 and 750 mW were employed (see Table 2). Retinal blanching could usually be seen even in the presence of vitreous haemorrhage. In none of the cases was it felt necessary to open the conjunctiva to achieve sufficient treatment of the avascular retina. Minimal chemosis and lid oedema were observed in all patients. Retinal burns appeared as pigmented scars 2 weeks after treatment. G-Predsol-N (Evans) or Oc-Betnesol-N (Evans) t.d.s. were given for 4 days following treatment.

Patients

The demographic details of the babies are shown in Table I. A total of 14 eyes in 8 babies were treated. All babies were born at less than 29 weeks post-gestational age with a median birth weight of 835 g (interquartile range 702.5–961 g).

Results

Outcome following treatment is shown in Table 2. All 14 eyes showed regression of plus disease at 1 week after treatment. Twelve eyes began to show signs of regression of abnormal neovascularisation at 2 weeks. At 2 weeks 2 eyes in one baby showed rapid progression to stage IV ROP, despite initial regression of plus disease. This baby was treated at 35 weeks gestational age and at the time of treatment had very aggressive plus disease. One eye in another baby developed, a few months later, a preretinal fibrotic band extending from the disc to the temporal periphery. This subsequently caused a traction retinal detachment.

At most recent follow-up 11 eyes (79%) showed a favourable outcome. Three eyes had developed traction retinal detachments.

Discussion

Cryotherapy for the treatment of retinopathy of prematurity has been shown to reduce the rate of an unfavourable structural outcome and to improve functional outcome.[1,11–13] Data from the CRYOROP

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Table 2. *Treatment and outcome*

Patient no.	Post-conceptual age at treatment (weeks + days)	Treatment		Outcome at 1 week	Follow-up	Length of follow-up (weeks)
		Right eye	Left eye			
1	40 + 4	74 × 700–750 mW	Nil	Regression	Flat retina, no temporal dragging right and left	41
2	39	100 × 750 mW	150 × 750–1000 mW	Regression right and left, vitreous haemorrhage left	Right retina flat, no temporal dragging, left TRD	31
3	32 + 5	307 × 500 mW	209 × 500 mW	Regression right and left	Flat retina no plus disease right and left	12
4	34	103 × 750 mW	151 × 750 mW	Regression right and left	At 2 weeks developed bilateral TRD	20
5	41 + 4	90 × 500 mW	Nil	Regression	Flat retina, no temporal dragging	34
6	37	121 × 570–600 mW	132 × 570–600 mW	Regression	Flat retina, no temporal dragging	22
7	34 + 5	55 × 750 mW	55 × 750 mW	Regression right, vitreous haemorrhage left	Flat retina right and left, vitreous haemorrhage left	9
8	34 + 4	200 × 550 mW	270 × 550 mW	Regression of plus disease	Flat retina, left mild temporal dragging	20
Median	21					
iqr1	21					
iqr3	34					

TRD, traction retinal detachment; iqr, interquartile range.

study[1] have confirmed a reduction in blindness from 48% to 31.5% and in unfavourable retinal outcome from 45.4% to 26.9% with treatment. Fewer of the treated eyes (13%) attained vision better than 6/12 compared with control eyes (17%) at 5.5 years, suggesting that whilst cryotherapy is beneficial overall, this may be at the cost of normal vision in some children. This could be related to the presence of macular abnormalities related to cryotherapy treatment.[14]

Laser indirect photocoagulation with argon and infrared diode lasers has provoked the development of alternative treatment strategies. Argon laser is essentially not portable because of size and weight. It also requires a greater energy output than diode laser to stimulate regression of ROP.[15,16] *In vitro* studies have suggested that diode laser has advantages over cryotherapy. Diode laser produces a chorioretinal lesion that spares the inner retinal layers. Although there is destruction of the choriocapillaris, the larger choroidal vessels are spared.[17] Using a transscleral delivery system 35–71% of diode laser energy is transmitted through the sclera and absorbed by melanin in the choroid and retinal pigment epithelium.[18] TSDL produces a similar chorioretinal scar with preservation of large choroidal vessels. The scleral collagen underlying the lesions remains intact.[19] In contrast cryotherapy produces large atrophic glial scar and destroys the chorioretinal architecture.[5] Cryotherapy also produces a significant breakdown of the blood–retina barrier in comparison with diode laser.[19]

Diode laser delivered by an indirect system has been shown to be as effective as cryotherapy in the treatment of threshold ROP.[6–10] In our group 11 of 14 eyes (79%) showed a favourable outcome following treatment with TSDL. This is comparable to the results described for LIO. Seiberth *et al.*[20–22] report a success rate of 90–96% using TSDL, but had fewer babies with disease in zone 1. In our study, most babies with disease extending into zone 1 had some 'peninsula-like' areas of ischaemic retina beyond the reach of the transscleral probe. Treatment was applied as far back as possible but did not cover every peninsula of avascular retina. This was considered satisfactory on the basis that at least 70% of the avascular retina had been treated.

The baby in our study who continued to develop ROP despite treatment was first seen at 34 weeks and was treated at 35 weeks post-conceptual age. He had very aggressive plus disease at presentation. Despite initial regression of plus disease 2 weeks after treatment, traction retinal detachment developed. In a second baby a traction retinal detachment developed despite initial regression of neovascularisation. This eye developed a fibrous band extending from the disc to the temporal retinal periphery including the fovea, which subsequently caused a traction retinal detachment.

Side-effects of cryotherapy are well documented in the literature. There is almost universal conjunctival chemosis and lid oedema.[3,8,10] This can make re-treatment, if necessary, technically difficult. Usually the side-effects are transitory and do not affect visual development. A case has been reported of persistent conjunctival proliferation which affected a child's visual development at the age of 3 years.[23] Other transient anterior segment complications include conjunctival haematoma, inadvertent conjunctival laceration and corneal clouding. Diode laser treatment delivered by a laser indirect ophthalmoscope is also associated with

anterior segment complications. Lens burns have been described, as has the development of posterior synechiae.[24] Of more concern is the possibility of iris clipping due to the large cone angle of some diode systems.[25] A case of bilateral hyphaema secondary to iris trauma in a baby treated for ROP has been described.[26] This baby had a widely dilated pupil. In our study none of the babies had significant anterior segment trauma. The degree of conjunctival oedema was minimal and resolved in 24 h in all cases. As TSDL is a contact system it is extremely unlikely that iris clipping could occur.

Posterior segment complications as a result of cryotherapy treatment include exudative detachment[27] and macular coloboma and retinal pigment epithelium (RPE) abnormalities.[16] The risk of posterior segment complications with diode laser is small as the majority of energy induced is absorbed at the level of the RPE. Pigmentation of the RPE begins during the seventh post-gestational week, but pigmentation of the choroid only occurs between 20 and 35 weeks gestational age.[28] Thus the risk of choroidal damage in the premature eye with diode laser treatment is small. LIO has not been associated with choroidal haemorrhage and we had no cases of choroidal haemorrhage in our patients.

The diode laser is easily transportable and can be used in the special care baby unit. We have in one case taken the TSDL to the referral hospital and performed treatment on a baby without the necessity for transfer to King's College Hospital. Although LIO has been advocated as a procedure to be performed with sedation,[9] other authors have preferred general anaesthetic.[10] Our preferred method of anaesthesia for TSDL is general anaesthetic as this provides the optimal conditions required for treatment.

This pilot study suggests the efficacy and safety of the TSDL in the treatment of retinopathy of prematurity. The combination of transscleral and indirect laser may prove to be the ideal regimen for treatment of ROP, particularly in babies with extensive disease in zone 1 or those who need re-treatment. Further work is needed to confirm these findings and to determine the long-term functional outcome in these infants.

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