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CLINICAL STUDY

Initial clinical experience using a diode red laser (670 nm) in the treatment of retinal disease

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Abstract

Aim **To investigate the clinical use of a 670-nm diode red laser in the treatment of a number of retinal conditions.**

Methods **In all, 17 eyes of 17 patients were treated for conditions such as proliferative diabetic retinopathy, retinal neovascularization in central retinal vein occlusion, rhegmatogenous retinal lesions and retinal breaks, and prophylactic peripheral retinopexy prior to silicone oil removal after three port pars plana vitrectomy.**

Results **Regression of neovascularization was observed in all the eyes treated for vascular proliferation at the 3-month follow-up visit. Adhesive pigmented scars were observed in the remaining eyes 1 month after treatment. No major complications were recorded.**

Conclusions **In this pilot study, the 670-nm diode laser appears to be a promising modality for laser photocoagulation of the retina.**

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Introduction

Therapeutic photocoagulation for the treatment of retinal diseases has been employed for over 40 years. The ruby laser emitting at 694 nm was introduced in ophthalmology in 1960.[1] Subsequently, other lasers with different wavelengths such as the argon blue and green laser (488 and 514 nm), the krypton red laser (647 nm), the tunable dye lasers, the continuous wave Nd:YAG infrared laser (1064 nm), the double frequency Nd:YAG green laser (532 nm), and the solid state diode near-infrared laser (810 nm) were developed and demonstrated their efficacy in the treatment of many chorioretinal diseases.[2–9] In general, although different wavelengths have different characteristics of absorption and transmission at the fundus level, their effects are similar in terms of chorioretinal damage and therapeutic efficacy.

The diode lasers currently available in ophthalmology emit in the near-infrared spectrum. Such lasers have the advantages of being extremely compact, highly efficient, and relatively inexpensive.[10] To our knowledge, there are no published reports on the transpupillary application of the 670-nm diode red laser. The aim of the present pilot study was to investigate the therapeutic efficacy of a new continuous wave diode laser emitting in the red spectrum (670 nm) in the treatment of a number of common retinal conditions.

Materials and methods

Laser

The diode laser used in the study was a portable prototype (Biolitec AG, Bonn, Germany) for use in conjunction with a standard slit-lamp microscope. The cone angle of the treatment beam was 16°. The aiming beam was furnished by an independent diode laser source (635 nm) with a maximum power of 0.4 mW. The smallest available spot size was 160 μm. The maximum available power was 600 mW.

Patients

After informed consent was obtained, 17 eyes of 17 patients were treated with the 670-nm diode red laser for the following conditions: proliferative diabetic retinopathy (five eyes), retinal neovascularization in central retinal vein

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occlusion (two eyes), rhegmatogenous retinal lesions and retinal breaks (eight eyes), and prophylactic peripheral retinopexy prior to silicone oil removal after three port pars plana vitrectomy (two eyes).

Treatment. was performed through a three-mirror Goldmann lens or a Volk (USA) Quadraspheric lens following mydriasis with tropicamide 1% and topical anaesthesia with benoxinate 0.4% eye drops. The end point of the treatment was to produce a white lesion at the retina level as obtained with the other commonly used laser sources. Red-free photographs and intravenous fluorescein angiography if needed were obtained in all patients before and immediately, 1, 3, and 6 months after treatment. Following treatment, patients were asked to report symptoms of discomfort, and pain during therapy. On completion of the operation, an independent professional asked patients to grade discomfort and pain during the treatment on a scale of 0–3 as previously published:[11] 0 = no pain, 1 = mild pain; 2 = moderate pain, 3 = severe pain. All the eyes studied completed a follow-up period of 6 months.

Results

Retinal whitening was obtained in all the patients treated either with a three-mirror Goldmann lens or a Quadraspheric lens. Treatment parameters were as follows and are presented in detail in Table 1: proliferative diabetic retinopathy and central retinal vein occlusion were treated through the wide field lens with a spot size of 300–500 μm and powers between 500 and 600 mW. Rhegmatogenous retinal lesions and retinal breaks were treated through the Goldmann lens with a spot size of 500 μm and powers between 400 and 500 mW. Prophylactic peripheral retinopexy prior to silicone oil removal in vitrectomized eyes was performed through the wide field lens with a spot size of 300–500 μm and powers between 400 and 500 mW. The exposure duration was set in continuous and was determined by the treating physician on the basis of the whitening effect of laser coagulation (Figures 1 and 2).

At the 3-month follow-up visit, all seven eyes with retinal new vessels secondary to diabetic retinopathy and

Table 1 Treatment parameters for each patient studied.

Patient #	*Condition*	*Lens used*	*Spot size (μm)*	*Power (mW)*
1	PDR	Wide-field	300	500
2	PDR	Wide-field	500	600
3	PDR	Wide-field	300	500
4	PDR	Wide-field	500	600
5	PDR	Wide-field	500	600
6	CRVO	Wide-field	500	600
7	CRVO	Wide-field	300	500
8	RB	3-Mirror	500	400
9	RB	3-Mirror	500	400
10	RB	3-Mirror	500	450
11	RB	3-Mirror	500	500
12	RB	3-Mirror	500	500
13	RRL	3-Mirror	500	450
14	RRL	3-Mirror	500	500
15	RRL	3-Mirror	500	400
16	PRPPV	Wide-field	500	500
17	PRPPV	Wide-field	300	400

PDR, proliferative diabetic retinopathy; CRVO, central retinal vein occlusion; RB, retinal break, RRL, rhegmatogneous retinal lesion; PRPPV, prophylactic retinopexy after pars plana vitrectomy.

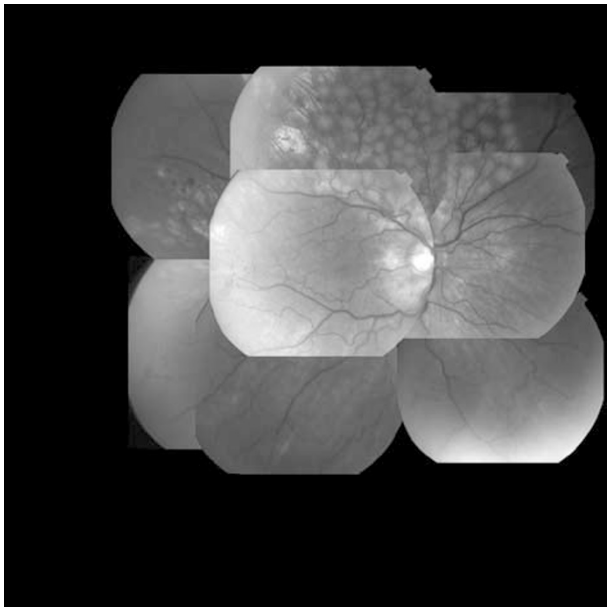

Figure 1 Red-free photograph immediately after scattered laser photocoagulation of the superior retina in the case of central retinal vein occlusion.

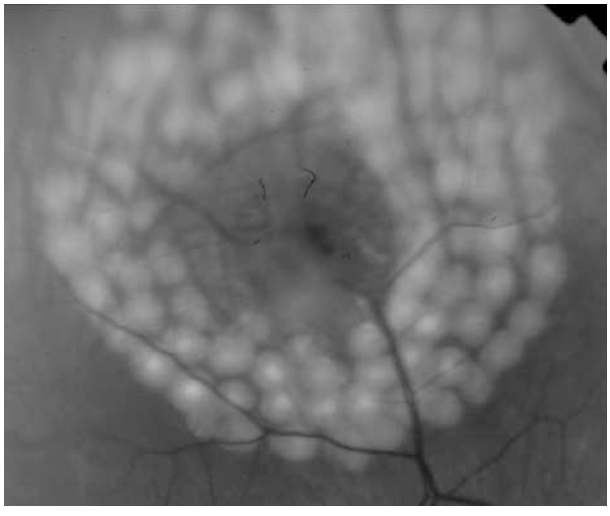

Figure 2 Red-free photograph immediately after laser treatment of a peripheral retinal tear.

central retinal vein occlusion showed regression of lesions at fundus biomicroscopy and fluorescein angiography, and remained so for the remaining follow-up period (Figure 3). Adhesive pigmented scars were observed in the remaining eyes 1 month after treatment. Moderate discomfort (grade 2) was reported by all patients but in no case was it necessary to abandon therapy, or to perform retrobulbar or peribulbar anaesthesia. No major intraoperative or postoperative complications such as retinal and choroidal haemorrhages, or detachments were recorded.

Discussion

Semiconductor diode near-infrared lasers were introduced in ophthalmology by Brancato *et al* in the late 1980s.[10–14] These lasers have the advantage of compact dimensions, efficient electric-optical conversion, absence of major cooling requirements, long life, and minimal maintenance. However, the biophysical properties of the near-infrared wavelength require a significant learning curve for its routine use in clinical practice.[7] The absorption spectrum of this wavelength by the tissues of the eye is not as favourable as that of krypton red lasers, with no absorption by haemoglobin and 80% less absorption by the retinal pigment epithelium compared to krypton laser.[15,16] As a consequence, the lesions induced by the 810-nm diode laser penetrate further into the choroid and require higher total levels of energy to produce visible lesions.[14] The 670-nm diode laser combines the good absorption spectrum of a red laser with the advantages of portable and less costly equipment. The absorption characteristics of the 670-nm diode wavelength are very similar to those of the 647-nm krypton laser. As regards the transmission through the ocular media, the red wavelength has an excellent curve that is scarcely influenced by opacities and is very similar to the transmission of the 810-nm diode near-infrared laser. Irradiation can pass through a crystalline lens and vitreous opacities and haemorrhages. Also, it is well absorbed by the retinal pigment epithelium and choroidal melanocytes.[17] Therefore, the red wavelength has excellent properties for laser photocoagulation of the retina. Retinal whitening is obtained easily and no learning curve is needed as for the diode near-infrared laser.

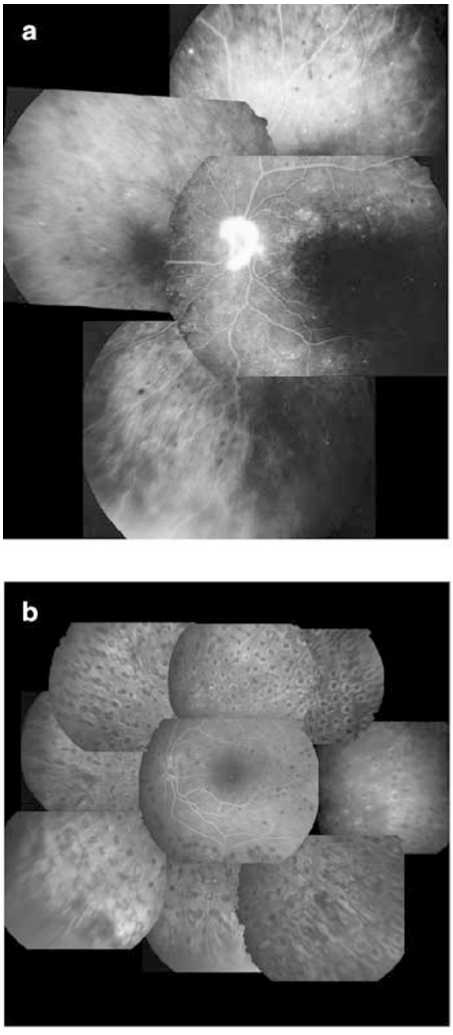

Figure 3 Fluorescein angiography before (a) and after (b) panretinal photocoagulation for proliferative diabetic retinopathy with neovascularization of the disc. At 3 months after treatment with the diode red laser new vessels show regression.

Immonen *et al*[18] were the first to evaluate trans-scleral contact and endolaser delivery of a 670-nm diode laser in rabbits. They concluded that this laser was a promising modality for laser photocoagulation of the retina and ciliary body. To our knowledge, our study represents the first clinical application of a transpupillary diode red laser emitting at 670 nm. In this first report on the treatment of different retinal conditions, in addition to specific information being gained on the therapeutic efficacy of the 670-nm diode laser, valuable data have been obtained on the beneficial characteristics and current limits of this system. This pilot study also allowed a measure of comparison with conventional lasers, particularly regarding ease of utilization and patience tolerance. With regard to the clinical results of this study, indirect comparison with the use of other wavelengths and laser sources suggests a similar level of efficacy. However, this is only a preliminary report on a limited number of cases treated for various retinal diseases. Controlled studies on a larger case series of homogeneous diseases will be necessary to confirm the equivalent level of efficacy. The laser was reliable, no malfunction being encountered during the period of the study. Its portability and simplicity of use conferred a

flexibility of operation similar to that allowed by other diode lasers emitting at different wavelengths. The levels of power needed for retinal photocoagulation are of the same magnitude as those generally used with the krypton red laser. This is due to the similar absorption rate of the 670 and 647-nm wavelength at the level of the retinal pigment epithelium.

Owing to some limitations of the photocoagulator used in the present study (ie spot dimensions, low power of the aiming beam), we did not treat diseases of the macula and the posterior pole. Currently, the major limitations of the experimental diode red laser are related to the low power of the aiming beam and the relatively low power of the emitting source. A low illumination must be used in order to see precisely where the aiming beam is located on the retina. In case of a very light fundus, more power is needed to obtain retinal whitening, especially with the use of a wide field lens, which requires increased power with respect to the Goldmann lens (about 10–15%). A new prototype with a maximum output power of 1 W, a brighter aiming beam, and a minimum spot size of 50 μm is currently under clinical evaluation at our Department.

In conclusion, the 670-nm diode laser combines the favourable wavelength characteristics of the krypton red laser, with the advantages of portable, less bulky, and less costly equipment. The 670-nm diode laser might be a good alternative as a portable laser for efficient retinal photocoagulation. Clinical trials to examine this possibility are needed.

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