

Multicolor pattern scan laser for diabetic retinopathy with cataract

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Received: 2013-09-29 Accepted: 2014-03-14

Abstract

• **AIM:** To evaluate the ability of various laser wavelengths in delivering sufficient burns to the retina in eyes with cataract using a new multicolor pattern scan laser with green (532 nm), yellow (577 nm), and red (647 nm) lasers.

• **METHODS:** The relationship between the Emery–Little (EL) degree of cataract severity and the laser wavelength required to deliver adequate burns was investigated in 102 diabetic eyes. Treatment time, total number of laser shots, and intra-operative pain were assessed as well.

• **RESULTS:** All EL–1 grade eyes and 50% of EL–2 eyes were successfully treated with the green laser, while 50% of EL–2 eyes, 96% of EL–3 eyes, and 50% of EL–4 eyes required the yellow laser. The red laser was effective in the remaining 4% of EL–3 and 50% of EL–4 eyes.

• **CONCLUSION:** Longer wavelength lasers are more effective in delivering laser burns through cataract when we use a multicolor pattern scan laser system.

• **KEYWORDS:** diabetic macular edema; photocoagulation; retinal hemorrhage; pain; photoreceptors

DOI:10.3980/j.issn.2222-3959.2014.04.16

Hirano T, Iesato Y, Murata T. Multicolor pattern scan laser for diabetic retinopathy with cataract. *Int J Ophthalmol* 2014;7(4):673–676

INTRODUCTION

While pattern scan lasers (PSLs) cause much less stress on patients in the form of decreased pain and shorter operation time, they have been reported to be equally effective for diabetic retinopathy (DR) as conventional single spot lasers (SSLs)^[1-4]. The overall safety of PSLs has been confirmed in large clinical studies^[5,6]. However, retinal bleeding is a potential complication of this technique that occurs in 1.3% of cases since PSLs utilize shorter pulses and

higher power compared with conventional SSLs^[6].

Patients with DR often suffer from media opacity, such as cataract or vitreous hemorrhage, which may diminish laser power and result in insufficient retinal coagulation. In such individuals, PSLs with a green laser (532 nm) require markedly higher maximum laser power than conventional lasers, as much as 1000 mW and 2000 mW, to obtain effective laser burns^[4,5]. Since these settings are comparable to those used in laser iridotomy except for spot size, retinal bleeding may be inevitable when the laser is applied through regions with relatively mild cataract opacity or vitreous haze^[7]. Thus, we hypothesized that it may be preferable to use lasers with longer wavelengths using lower laser power to reduce the possibility of retinal bleeding.

In previous studies using conventional single-spot laser machines, red (647 nm) and yellow (568 nm) krypton were more efficient in delivering laser burns through cataract than green argon (514 nm) since the longer wavelengths reduced scattering or extinction of laser power when passing through the opaque lens^[8-10]. Because of this advantage during pan-retinal photocoagulation (PRP) of eyes with DR associated with opaque media, multicolor photocoagulators equipped with yellow (577 nm) and red (647 nm) lasers in addition to a green (532 nm) one have been among the most commonly used photocoagulator devices in Japan (unpublished data, survey by the supplier). However, all of the above-mentioned studies that confirmed the efficacy of longer wavelength lasers in eyes with opaque media were performed using conventional SSLs only^[6,9,10].

The aim of the present study was to evaluate the effect of laser wavelength on appropriate laser burn delivery in eyes with diabetic cataract using a 20 ms, multi-spot PSL equipped with green, yellow, and red lasers. Since longer wavelength lasers usually cause more discomfort, intra-operative pain and operation time were also investigated for the PSL and compared with those for a conventional SSL^[11].

SUBJECTS AND METHODS

The ethics committee of Shinshu University approved this study, which was conducted in accordance with the tenets of the Declaration of Helsinki. Written informed consent was obtained from all subjects.

Subjects A total of 102 patients with type 2 diabetes who underwent PRP at Shinshu University, Matsumoto, Japan

between October 2010 and December 2012 were included in this study. Only one eye of each patient was enrolled. The baseline characteristics of 74 patients who underwent multicolor PSL treatment were, age 57.0 ± 11.6 years old, 12 males and 62 females, 61 (82%) had severe non-proliferative diabetic retinopathy (NPDR) and 13 (18%) had proliferative diabetic retinopathy (PDR), and visual acuity (VA) were 0.13 ± 0.43 logMAR. On the other hand, the baseline characteristics of 28 patients were age 53.3 ± 12.1 years old, 12 males and 16 females, 2 (7%) had moderate NPDR, 19 (68%) had severe NPDR and 7 (25%) had PDR, and visual acuity (VA) were 0.32 ± 0.42 logMAR. There were no significant differences in patient age or mean preoperative VA.

Laser Conditions PRP was performed using an MC-500 Vixi® multicolor PSL (NIDEK Inc., Gamagori, Japan) at powers starting from 300 mW to a maximum of 600 mW for each laser color. Spot size was 200 µm for duration of 20ms. A SuperQuad®160 lens (Volk Optical Inc., Mentor, OH) was used as a contact lens to deliver laser burns. If coagulation spots were not achieved through opaque media with a green laser (532 nm) at the maximum power (600 mW), a yellow laser (577 nm) was then used to avoid retinal bleeding. If appropriate laser burns were still unobtainable, we subsequently employed a red laser (647 nm) using the same power settings. The Emery-Little (EL) cataract classification, laser wavelength used, laser power, total shot number to complete PRP, and treatment time were all recorded for each eye.

At the end of treatment sessions, the intra-operative pain level that the patients felt was assessed using a visual analogue scale (VAS), with 0 being no pain and 10 being unbearable pain. VAS and treatment time were also recorded for a control group that had undergone PRP using a conventional multicolor SSL.

Statistical Analysis Spearman's correlation coefficient by rank was used to assess the correlation between EL cataract classification and laser wavelength. Differences in the pain and operation time between PSLs and SSLs were evaluated using the Mann-Whitney *U* test. A *P* value less than 0.05 was considered statistically significant. All analyses were performed with the Graph Pad Prism version 6.0 for Windows (Graph Pad Software, San Diego, CA, USA).

RESULTS

As demonstrated in Figure 1, all 16 eyes with EL-1 grade cataract were successfully treated with the green laser. Thirteen of 26 eyes with EL-2 cataract were also treatable with the green laser, while the remaining 13 eyes necessitated the yellow laser. The green laser did not deliver any effective burns in the 24 eyes with EL-3 cataract, although the yellow laser was effective in 23 of these eyes, with 1 eye requiring the red laser. Eyes with EL-4 cataract were only treatable with the yellow (4 eyes) or red laser

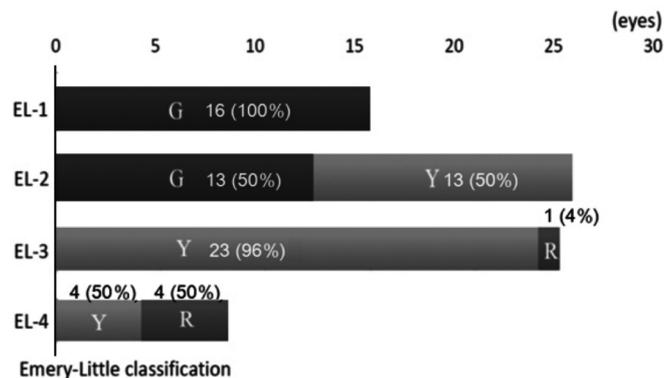


Figure 1 Relationship between cataract severity and laser wavelength required for successful PRP A significant correlation was observed between Emery-Little (EL) cataract classification and the laser wavelength required to complete PRP ($P < 0.0001$, Spearman's correlation test). G: Green; Y: Yellow; R: Red.

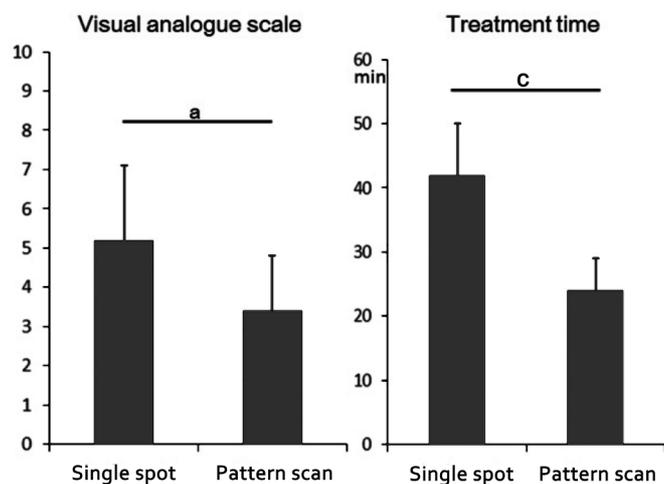


Figure 2 The multicolor pattern scan laser caused less pain according to a visual analogue scale than a conventional single spot laser. The pattern scan laser also required significantly less treatment time than the single spot laser. ^{ac} $P < 0.05$.

(4 eyes). There were no eyes with EL-5 cataract in this study. We witnessed a significant correlation between advanced EL cataract classification and the necessity of a longer wavelength laser ($P < 0.0001$, Spearman's correlation test).

Pain Score and Operation Time As shown in Figure 2, the multicolor PSL treatment (3.5 ± 1.8 VAS pain score) caused less pain than the conventional SSL (5.2 ± 1.6 VAS pain score) ($P < 0.0001$). In addition, mean treatment time in the multicolor PSL group (23.4 ± 5.1)min was significantly shorter than that in the conventional SSL group (43.1 ± 6.6)min ($P < 0.0001$).

Total Number of Laser Burns In the multicolor PSL group, PRP was completed in two sessions in this study in a pattern demonstrated in Figure 3, whereby the upper half of the retina was treated 2-4wk after the lower half. In the conventional SSL group, PRP was divided into 4 sessions. Since the laser spots of PSLs are known to reduce in size

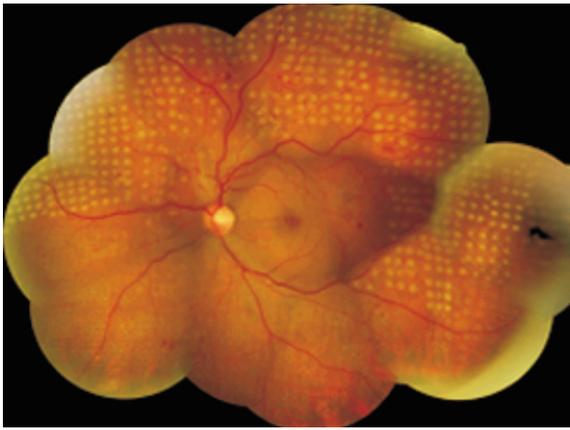


Figure 3 Orderly arrangement of laser burns using a pattern scan laser Emery-Little classification 1; Green laser; Pulse duration: 20ms; Laser power: 400 mW; Spot size: 400 μ m (200 \times 2 μ m using a SuperQuad[®] lens); Spacing: 0.75 \times spot size; Number of burns: 3302.

with time, the spacing between the burns was set at 0.75, in contrast to between 1 and 2 for conventional SSLs^[12,13]. Consequently, the total number of laser spots was significantly larger for the multicolor PSL (3544 \pm 665) than for the multicolor SSL (1686 \pm 269) ($P < 0.0001$) (Figure 4), and were in agreement with previous reports^[6].

DISCUSSION

In the current study, the green laser could not deliver appropriate laser burns during PRP in patients with EL-3 or EL-4 diabetic cataract, whereas the yellow or red lasers successfully delivered effective burns at settings ranging from 300 mW to 600 mW at a spot size of 200 μ m and duration of 20ms. This increased efficacy of longer wavelength lasers in the treatment of DR with opaque media appears to be the reason why multicolor PSLs have become more popular in Japan (unpublished data, survey by the supplier)^[9,10]; in fact, a 577 nm yellow laser has recently been added to the original PASCAL[®] PSL (TOPCON, Tokyo, Japan), which had previously been equipped with a green laser (532 nm) only.

Effective delivery of laser burns in PRP of the non-perfused retina, as well as focal/grid laser burns to the macula, have been considered as essential to assure a good visual prognosis in patients with DR^[14,15]. One potential mechanism of the therapeutic effect of laser photocoagulation on DR is the coagulation and destruction of ischemic retinal cells that are the origin of pathologic overexpression of VEGF in the diabetic retina. It has been reported that VEGF levels in the vitreous are reduced after laser photocoagulation^[16,17]. Many earlier studies predicted that inhibition of VEGF overexpression was the key to effective DR treatment, which has since been confirmed by the advent of anti-VEGF drugs and their excellent results in clinical studies on both diabetic macular edema (DME) and proliferative diabetic retinopathy

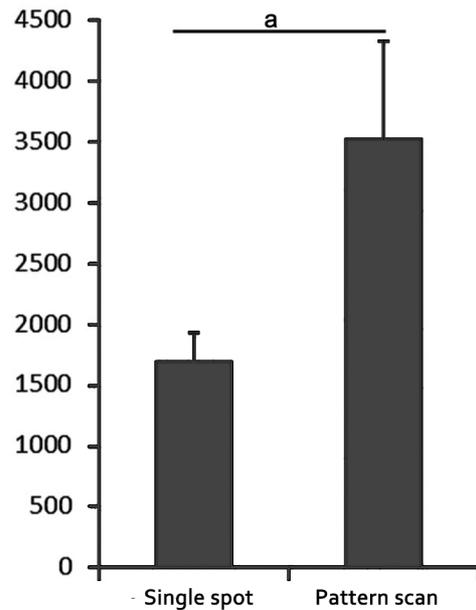


Figure 4 Average total number of laser burns needed to complete pan-retinal photocoagulation. The pattern scan laser required more laser burns than the conventional single spot laser. ^a $P < 0.05$.

(PDR)^[16,18-26]. Recent studies suggested that macular focal/grid laser treatment is still a useful adjunctive treatment tool in the field of anti-VEGF treatment, potentially in reducing the number of required injections of anti-VEGF drugs^[22,27]. In addition, Gaucher *et al*^[21] reported spontaneous resolution of DME after extensive PRP in florid PDR without focal/grid laser or intravitreal injection of anti-VEGF drugs. They suggested that DME became resolved after laser treatment of the ischemic retina halted excessive production of VEGF in the non-perfused retina. Consequently, focal/grid laser and PRP continue to be two of the most effective treatment modalities for DME and PDR, although anti-VEGF drugs are likely to become the first-line treatment for DME patients^[22-24].

Lastly, our clinical findings revealed that multicolor PSLs can be a useful tool to deliver effective PRP or focal/grid laser treatment to eyes afflicted with DR complicated with cataract at virtually any EL stage. We also witnessed that discomfort and operation time were both significantly reduced with a multicolor PSL as compared with a conventional multicolor SSL.

In conclusion, recently introduced multicolor photocoagulators with pattern scan delivery functions not only reduce pain and operation time, but are also effective in delivering laser burns through opaque media. Lasers with longer wavelengths, such as yellow and red, appear to be more effective than a green laser in treating retinopathy in eyes with diabetic cataract.

ACKNOWLEDGEMENTS

Conflicts of Interest: Hirano T, None; Iesato Y, None; Murata T, None.

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