Original Article

Pattern Scan Laser Photocoagulator on Retinopathy: an annual clinical application summary

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Abstract

Purpose: To evaluate the clinical efficacy of Pattern Scan Laser Photocoagulator (PASCAL) by observing the efficacy of PASCAL on retinopathy.

Methods: A total of 92 patients with retinopathy (121 eyes) who underwent PASCAL between December 2008 and February 2009 in our center were retrospectively analyzed to evaluate the visual acuity changes and recovery conditions of the patients from baseline to posterior to the treatment. The retinopathy included: diabetic retinopathy, ischemic retinal vein occlusion (IRVO), central serous chorioretinopathy (CSC), retinal periphlebitis (Eales disease) and retinal degeneration/holes.

Results: The patients were subject to a 12-month follow up after PASCAL. The visual acuity findings were stated as below: for diabetic retinopathy (73 eyes), 10 eyes had improved visual acuity; 55 eyes were stabilized and 8 eyes progressed; for IRVO (13 eyes), 4 eyes showed improvement, 6 eyes were stabilized and 3 eyes progressed; for CSC (9 eyes), 6 eyes were alleviated and 3 eyes progressed; for retinal periphlebitis (5 eyes), 2 eyes had enhanced visual acuity and 3 eyes showed stable visual acuity; for retinal degeneration/holes (21 eyes), 5 eyes presented improved visual acuity, 16 eyes were stabilized and no eye progressed. Indirect ophthalmoscopic reexamination confirmed secured blockage by laser spots and favorable absorption of the retinal edema and newborn capillaries. No obvious leakage was observed during fundus fluorescein angiography and no laser-related ocular adverse effect was reported.

Conclusion: PASCAL is accurate, effective and well-tolerated. The duration of short laser pulse falls within the safety range, ensuring the stabilization and improvement in the patient's visual acuity. The parameters, long-term efficacy and complications of PASCAL should be further demonstrated by performing long-term clinical trials with larger sample size.
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For the purpose of vision protection, retinal photocoagulation can destroy retinal pigment epithelia with high oxygen consumption, improving the retinal ischemic status, and can block the leakage from retinal capillaries and/or microaneurysm, alleviating the retinal edema, thus improving the oxygen supply. As demonstrated in a previous clinical trial, short-pulse retinal photocoagulation is not only equivalently effective to the conventional parametric laser, but also can markedly reduce the discomfort of the patients[1]. Pattern Scan Laser Photocoagulator (PASCAL) was first launched in 2005[2]. This device provided with short exposure time and combined multiple pretreatment modes, showing advantages such as limited laser spot and little thermal diffusion, theoretically capable of reducing the invasiveness and triggering intraretinal healing response. In the present study, the clinical efficacy of PASCAL on the patients with retinopathy was retrospectively investigated in our center to evaluate the safety and effectiveness of short-pulse photocoagulation using the device.

Patients and methods

General data

A total of 92 patients (121 eyes) diagnosed with retinopathy in our center from December 2008 to February 2009 were enrolled in this study. The retinopathy included: ① 45 cases (73 eyes) of dia betic retinopathy (21 men, 24 women; mean age: 56.4 yrs.), comprised of 21 cases (31 eyes) of severe nonproliferative diabetic retinopathy (NPDR) and 24 cases (42 eyes) of proliferative diabetic retinopathy (PDR); ②13 cases of ischemic retinal vein occlusion (IRVO) (9 men, 4 women; mean age: 52.1 yrs.), comprised of 5 cases (5 eyes) of branch RVO (BRVO) and 8 cases (8 eyes) of central RVO (CVRO);

③9 cases(9 eyes)of central serous chorioretinopathy (CSC)(mean age: 42.7 yrs.); ④ 4 cases(5 eyes) of retinal periphlebitis (Eales disease)(4 men, 0 women; mean age: 42 yrs.); ⑤ 21 cases (21 eyes) of retinal degeneration/holes (11 men, 9 women). All the patients received routine mydriasis and topical anesthesia before the procedure (Table 1).

Table 1 The category of the enrolled retinopathic patients

Disease	Patients(eyes)#	Men/women	Eye Right/left	Mean age(years)
DR	73	21/24	39/34	56.4
CRVO	8	7/1	3/5	52.0
BRVO	5	2/3	3/2	52.2
CSC	9	7/2	6/3	42.7
EALES	5	4/0	1/4	42.0
Degeneration	14	6/7	7/7	34.3
Holes	7	5/2	3/4	49.0

Treatment procedure

The retinal photocoagulation was performed using a PASCAL (532 nm). The following photocoagulation procedures were conducted: (1)Panretinal photocoagulation (PRP): the candidates included those with DR or IRVO; the matrix mode (2×2, 3×3, 4×4 and 5×5) in PASCAL was used; the laser spot reaction was in moderate Grade Ⅱ; (2) midperipheral local retinal photocoagulation: The matrix mode (1×1, 2×2 and 3×3) in PASCAL was used; the potential candidates included BRVO, CSC (blocking the leakage point at 250 μm away from the central fovea based on the fundus fluorescein angiographic findings), Eales disease (performing an extensive photocoagulation around the diseased or newborn blood vessels)and retinal degeneration/holes; (3) macular photocoagulation: the potential candidates were those with diffusive macular edema; the macula mode(MAC A and/or B)was used.

Evaluating criteria and indications for additional photocoagulation

During the scheduled 12-month follow-up, the examinations that all the patients underwent included visual acuity test, indirect ophthalmoscopy, fundus fluorescein angiography (FFA) and optical coherence tomography (OCT). The evaluating criteria included: (1)Visual acuity: those whose vision improved up to or more than 2 lines were considered as improvement, impaired up to or more than 2 lines as progression and fluctuated less than 2 lines as stabilization; (2) evaluation on retinopathy: For groups ① to ④, the exacerbated lesions requiring additional photocoagulation included persistent RPE leakage, macular edema/thickening, increased (pre-)retinal hemorrhage, increased retinal newborn blood vessels, increased intraretinal microvascular abnormalities and presence of new nonperfusion area beyond the photocoagulated area, as evaluated by indirect ophthalmoscopy and/or FFA/OCT, and absence of abovementioned lesions was considered as stabilization; for group⑤, the valid laser spot surrounding the retinal degeneration and/or hole area as detected by fundus examination was considered as successful treatment, while those combined with limited retinal detachment and/or few pigmentations or proliferated scar tissue surrounding the retinal holes as detected during the reexamination were the candidates for additional photocoagulation.

Results

The therapy parameters and 12-month follow-up data for the patients with retinopathy (121 eyes/92 patients) undergoing photocoagulation by PASCAL were described as follows:

(1)Diabetic retinopathy(DR)(73 eyes/45 patients) (Figures 1 and 2): The parameters used in the treatment were: laser spot diameter, 200 μm; exposure time, 10–30 ms; number of laser spots, 944–2023 spots; energy, 100–682 mW. At the end of follow-up posterior to PRP, the visual acuity improvement was found in 10 eyes, stabilization in 55 eyes and progression in 8 eyes. Three of the 73 eyes were subject to vitrectomy during the follow-up period. Of 24 patients with PDR, the newborn blood vessel subsided in 13 eyes, while 11 eyes with increased newborn blood vessels exhibited stable visual acuity after additional local photocoagulation.

(2)Ischemic retinal vein occlusion (IRVO): This disease included BRVO (5 eyes/5 patients) and CRVO (8 eyes/8 patients). The parameters used in the treatment were: laser spot diameter, 200 μm; exposure time, 20–30 ms; number of laser spots, 162–815 (593.0 ± 272.0)spots or 411–2026(1017.0 ± 90.8) spots(mean ± SD); energy, 200–920 mV. The vi-

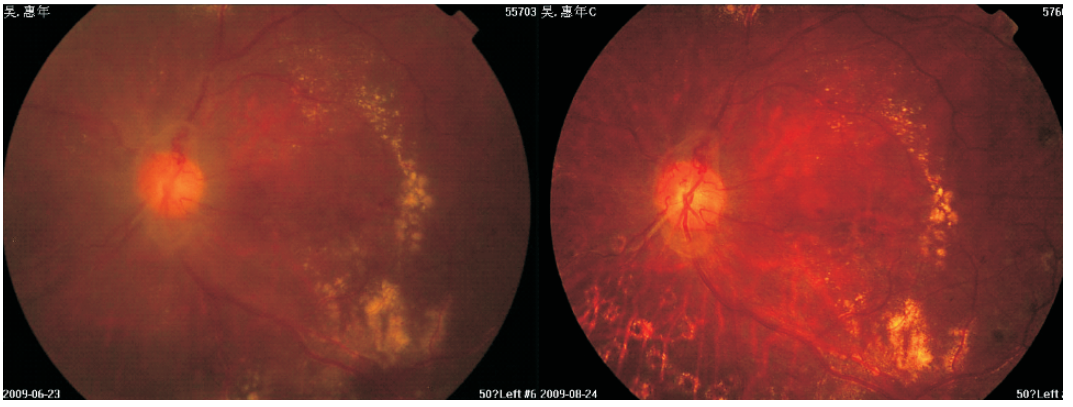

Figure.1 The two color photographs display fundus of a patient with DR before and after short-pulse PASCAL-PRP, showing a good response to the laser spots in a limited scope and absent of obvious retinal injury amid the laser spots.

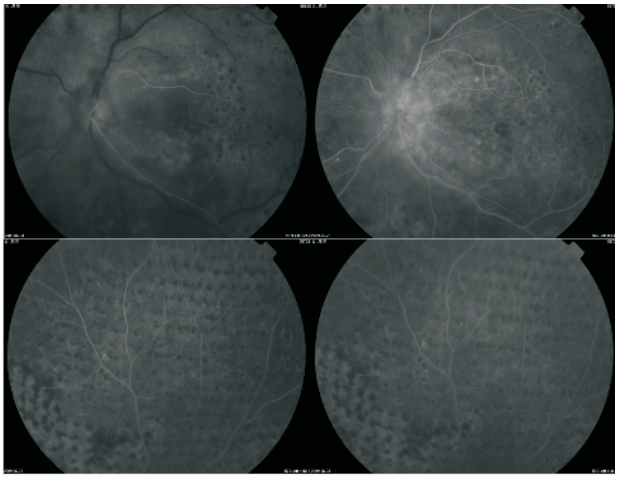

Figure.2 The fundus fluorescein angiographic image obtained 1 month after triple-staged PASCAL-PRP for a patient with DR showed grid pattern laser spots in the macular edema area, midperipherally well-arranged photocoagulation spot matrix; no fluorescent filling at laser spot site and no fluorescent leakage of the newborn blood vessels were observed, confirming a secure blockage; no obvious change in the retinal fluorescent status and vascular arrangement in fundus was observed.

sual acuity improvement was found in 4 eyes and stabilization in 6 eyes. At the end of the 12-month follow-up, all of the above mentioned eyes showed satisfactory absorption of retinal hemorrhage and regression of macular vesicular edema (Of them, one patient underwent an additional macular grid pattern photocoagulation during the visit at 2 month after the primary surgery, showing a stabilized visual acuity at the last visit.)The visual impairment progression was found in 3 eyes due to angiogenesis in the optic disc which could not be remedied with laser therapy and resulted in vitrectomy for vitreous hemorrhage.

(3)Central serous chorioretinopathy (CSC)(8 eyes).The parameters used in the treatment were: laser spot diameter, 50–200 μm; exposure time, 20–30 ms; number of laser spots, 3–24 (8.0±2.4) spots; energy, 100–900 (246.0±176.8) mV. The visual acuity improvement was found in 6 eyes and stabilization in 3 eyes.All the patients presented with improved visual acuity and subsided retinal edema. No leakage was observed during FFA reexamination.

(4) Retinal periphlebitis (Eales disease) (5 eyes/4 patients): The parameters used in the treatment were: laser spot diameter, 200 μm; exposure time, 20–30 ms; number of laser spots, 643–1359 (784.1±135.6) spots; energy, 175–547(284.4±93.6) mV. The visual acuity improvement was found in 2 eyes and stabilization in 3 eyes. No patient showed exacerbated vision impairment. FFA reexamination showed secured blockage to avascular region and subsided newborn blood vessels.

(5)Retinal degeneration/holes(21 eyes): The parameters used in the treatment were: laser spot diameter, 200 μm; exposure time, 10–30 ms; number of laser spots, 62–817 (419.0±103.5) and 74–281(193.0±80.7) spots; energy, 100–500 mV. The laser spot reaction was in Grade Ⅱ. All the patients had favorable outcomes after once surgery. The visual acuity improvement was found in 5 eyes and stabilization in 16 eyes, without further impaired visual acuity.

Discussion

Retinal laser photocoagulation consists of local retinal and panretinal photocoagulations. The local retinal photocoagulation is a method utilizing a small number of laser spots in treating localized lesions including retinal degeneration/holes, CSC, microaneurysm and other diseases resulting in local leakage, as well as diffusive leakage at the macular area for which a gird pattern photocoagulation should be applied. Panretinal photocoagulation (PRP) is another variant. As recommended by DRS and ETDRS, PRP should be divided into 3 to 4 stages during performance. For each stage, the laser spots produced should be no more than 900, with an about 2-week interval between the two stages. However, the conventional photocoagulation has some drawbacks such as excessive exposure time, inhomogenous thermal exposure to tissues, conspicuous fused and diffused laser spots (which may impair the normal retinal tissue around the laser spots and induce inflammatory response) and pain. Moreover, the staging during PRP may lead to an unsatisfactory control of the condition and impair the compliance of patients. A novel laser excitation system developed by Opti-Medica Corporation, the 532 nm PASCAL, in which the short-pulse settings are utilized, can excite multiple laser spots by order rapidly by a single shoot preset by the program, competent for the efficient and safe performance of PRP and other fundus photocoagulation therapies in theory.

Conduct of PRP with PASCAL

During the 12-month follow-up in this study, of the patients with DR (71 eyes/43 patients), the visual acuity was improved in 10 eyes (14.1%), stabilized in 53 eyes (74.6%) and further impaired in 8 eyes (11.3%). As detected during indirect ophthalmoscopy and FFA, the newborn blood vessels subsided in 13 eyes of 24 patients with PDR and increased in another 11 eyes, which were subject to one or two additional photocoagulations during the postoperative follow-up period. Three of the 11 eyes also received vitrectomy due to changes in the conditions during the follow up. We revealed that for the patients with developed retinopathy, the blood glucose levels were not readily under control before and after the treatment and some of the patients were also complicated with hypertension, hyperlipemia and/or diabetic nephropathy, indicating the passive effect of the course of diabetes and the general condition of patients on the control of diabetic retinopathy. For IRVO (13 eyes, including CRVO and BRVO), the visual acuity was improved in 4 eyes and stabilized in 6 eyes. Three eyes of them were subject to vitrectomy due to vitreous hemorrhage caused by angiogenesis in the optic disc which could not be remedied with photocoagulation. The remaining 10 eyes showed a satisfactorily absorbed retinal hemorrhage and macular vesicular edema as well as ideally improved visual acuity. Only 1 eye of them was subject to an additional macular grid pattern photocoagulation during the visit at 2 months after the primary surgery and the visual acuity was stable during the last visit.

Local retinal photocoagulation with PASCAL

The local retinal photocoagulation was performed for the patients with CSC, Eales disease and retinal degeneration/holes in this study using PASCAL. During the postoperative follow-up, the indirect ophthalmoscopy showed pigmentation around the degeneration and hole and absorption of retinal hemorrhage and edema. FFA/OCT showed absence of RPE leakage and retinal angiogenesis, confirming the secure blocking efficacy by laser spots.

In PASCAL, the designated pulse duration for the macular photocoagulation is 10 ms and that for PRP is 20–30 ms. As reported previously, excessive exposure time may result in extensive thermal diffusion which can be effectively reduced by short pulse[2]. Jain and Muqit et al reported that the pulse with the duration between 10 and 30 ms used in the retinal photocoagulation could trigger the intraretinal healing response and reduce the destructiveness[3,4]. SA1 Hussainy et al revealed that although the retinal photocoagulation with reduced exposure time was equivalent to the conventional parametric photocoagulation on their effectiveness, it could significantly reduce the discomfort of patients[1]. This study demonstrated that the short-pulse laser spots from PASCAL were characterized by secure efficacy, limited damage to the surrounding retinal tissue and acceptable tolerance. However, due to a limited comprehension on

this novel device and technique, during the follow-up period, a small portion of patients underwent additional laser photocoagulation, which showed a favorable efficacy.

Other than the routine but tedious "spot to spot" mode, PASCAL provides some novel modes including matrix mode (1×1, 2×2, 3×3, 4×4 and 5×5), curve mode, macular MAC OctA and B mode, markedly reducing the treatment duration for patients. After one mode is chosen, the laser spots will shoot from the device at a specified time span which is determined by the number and individual exposure time of the laser spots. The patient only feels one sparkling from the laser ray and the space between the two laser spots and the mode selection is more precise than the single laser spot in one-by-one photocoagulation. By using this device, the PRP for DR and CRVO even can be accomplished by once operation without obvious discomfort and severe complications[5,6].

The selection of therapeutic mode in PASCAL should be based on the condition of target area: the standard matrix mode is suitable for the retinal lesion at the posterior pole or midperipheral area, while curve mode is suitable for the peripheral fundus. In the present study, the matrix 2×2, 3×3 and 4×4 mode was selected in PRP for lesions located at posterior pole and midperipheral area, macular mode MAC OctA and B for diffusive macular edema and curve mode for peripheral retinal degeneration and holes, covering the diseased area immediately. During the course of photocoagulation, the laser parameters should be changed if necessary and the repeated operation should be performed for the patients presenting with dismal outcomes of the retinal hypoxia improvement (such as microaneurysm and severe intraretinal microvascular abnormalities)[7].

PASCAL is safe and precise and can improve the therapeutic efficiency and patients' tolerability when compared with the conventional laser photocoagulation, capable of performing an individualized therapy based on patients and their conditions. The limited thermal diffusion to the choroid reduces the inflammatory response and partially protects the nerve fibers from the injury. In addition, PASCAL is also effective for macular edema and newborn vessels and clinically predominant in improving the outcome of ischemic retinopathy[8]. PASCAL arouses a challenge over the manual "spot to spot" working mode, providing a new idea for the rapid development of laser therapy in ophthalmology. However, a limited number of clinical trials regarding the clinically safe application of PASCAL are currently available. We considered that, although this new technique is encouraging, it should be considered with enough reason. The photocoagulation related parameters, long term efficacy and complications should be further demonstrated in long-term clinical trials with larger sample size.

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