

PASCAL[®] Laser Systems

Compendium



Introduction

This research compendium provides clinicians with an overview of more than 10 years of peer reviewed research on Pattern Scanning Lasers and more specifically, PASCAL® Laser Systems*. In addition to the scientific abstracts, the compendium provides brief notes on the clinical relevance of each paper, along with a link, allowing the user to access the full paper (subject to permission). The document is regularly updated and every endeavour is made to ensure that all relevant available papers are included, however this cannot be guaranteed.

PASCAL® Laser Systems offer unparalleled control with life-changing results. The first **PA**tttern **SC**Anning **LA**ser (PASCAL®) was developed in 2005 through collaboration with Stanford University and a Silicon Valley venture firm. The combination of precisely positioned treatment patterns and short laser pulse durations, dramatically shortens treatment times and allows for less painful procedures, while maintaining clinical effectiveness and safety.

PASCAL® Laser Systems can also provide patients with effective, NON-DAMAGING photo-thermal therapy using integrated Endpoint Management™ software, customised for the individual patient through precise titration.

The option of Pattern Scanning Laser Trabeculoplasty (PSLT) software makes the Pascal® the laser of choice for general ophthalmology and glaucoma clinics in addition to medical retina clinics.

* PASCAL® Laser Systems and optional software configurations are not available in all countries, please check with your local distributor for availability

Topcon University

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PASCAL® Laser Systems - Pre-Clinical Performance

Blumenkranz MS, Yellachich D, Andersen DE, Wiltberger MW, Mordaunt D, Marcellino GR, et al. Semiautomated patterned scanning laser for retinal photocoagulation. *Retina*. 2006 Mar;26(3):370-6.

This article describes a semiautomated patterned scanning laser retinal photocoagulator that allows for much greater speed and precision than single spot application but without the liabilities of fully automated systems previously described. Semiautomatic in this context means that the physician has control over the treatment at all times. Each pattern of spots is configured and positioned by means of a joystick. Laser delivery can be initiated and interrupted at any time by activating and releasing the foot pedal. By eliminating retinal tracking and automated lesion reflectance feedback, the device is relatively simple and inexpensive to construct yet significantly more efficient than nonpatterned systems. Most features of the system are identical to those of existing laser photocoagulator systems, except for the ability to deliver either a single spot or multiple spots in a predetermined pattern in a single burst. By using pulse durations in the 10- to 20-millisecond range, multiple spots can be delivered in the time required for a single conventional 100-millisecond pulse. Such short pulses also provide the theoretical likelihood of less pain during treatment due to reduced choroidal heating from the thermal diffusion associated with longer duration burns.

We describe the first results of treatment with this system on rabbit retina in vivo, demonstrating delivery of multiple spots in a predetermined pattern. We also evaluate the threshold power, scanning rate, and optimal pulse duration relevant to this approach and compare the histologic appearance of conventional and shorter burns to ensure an equivalent biologic effect.

Significance: This study describes a novel retinal photocoagulation system that has as its main feature, the ability to deliver a predetermined pattern of spots, allowing for the treatment of larger retinal areas in a shorter space of time. The other key feature is a short pulse duration, providing less damaging treatment and precision in spot placement, while improving efficiency and reducing patient discomfort.

Link: http://journals.lww.com/retinajournal/Citation/2006/03000/SEMIAUTOMATED_PATTERNED_SCANNING_LASER_FOR_RETINAL.24.aspx

Jain A, Blumenkranz MS, Paulus Y, Wiltberger MW, Andersen DE, Huie P, et al. Effect of pulse duration on size and character of the lesion in retinal photocoagulation. *Archives of Ophthalmology*. 2008 Jan;126(1):78-85.

Objective: To systematically evaluate the effects of laser beam size, power, and pulse duration of 1 to 100 milliseconds on the characteristics of ophthalmoscopically visible retinal coagulation lesions.

Methods: A 532-nm Nd:YAG laser was used to irradiate 36 retinas in Dutch Belt rabbits with retinal beam sizes of 66, 132, and 330 μm . Lesions were clinically graded 1 minute after placement, their size measured by digital imaging, and their depth assessed histologically at different time points.

Results: Retinal lesion size increased linearly with laser power and logarithmically with pulse duration. The width of the therapeutic window, defined by the ratio of the threshold power for producing a rupture to that of a mild coagulation, decreased with decreasing pulse durations. For 132- and 330- μm retinal beam sizes, the therapeutic window declined from 3.9 to 3.0 and 5.4 to 3.7, respectively, as pulse duration decreased from 100 to 20 ms. At pulse durations of 1 millisecond, the therapeutic window decreased to unity, at which point rupture and a mild lesion were equally likely to occur.

Conclusions: At shorter pulse durations, the width and axial extent of the retinal lesions are smaller and less dependent on variations in laser power than at longer durations. The width of the therapeutic window, a measure of relative safety, increases with the beam size.

Significance: Pulse durations of approximately 20 milliseconds represent an optimal compromise between the favorable impact of speed, higher spatial localization, and reduced collateral damage on one hand, and sufficient width of the therapeutic window (> 3) on the other.

Link: <http://archopht.jamanetwork.com/article.aspx?articleid=420254>

Paulus YM, Jain A, Gariano RF, Stanzel BV, Marmor M, Blumenkranz MS, et al. Healing of retinal photocoagulation lesions. *Investigative Ophthalmology and Vision Science*. 2008 Dec;49(12):5540-5.

Purpose: To systematically assess the changes in retinal morphology during the healing of retinal photocoagulation lesions of various clinical grades.

Methods: Rabbits were irradiated with a 532-nm Nd:YAG laser with a beam diameter of 330 microns at the retinal surface, a power of 175 mW, and pulse durations between 5 and 100 ms. Retinal lesions were clinically graded 1 minute after placement as invisible, barely visible, light, moderate, intense, very intense, and rupture and were assessed histologically at six time points from 1 hour to 4 months.

Results: At all pulse durations, the width of the retinal lesions decreased over time. At clinical grades of light and more severe (pulse durations, 10-100 ms), retinal scarring stabilized at 1 month at approximately 35% of the initial lesion diameter. Lesions clinically categorized as barely visible and invisible (pulse durations of 7 and 5 ms) exhibited coagulation of the photoreceptor layer but did not result in permanent scarring. In these lesions, photoreceptors completely filled in the damaged areas by 4 months.

Conclusions: The decreasing width of the retinal damage zone suggests that photoreceptors migrating from unaffected areas fill in the gap in the photoreceptor layer. Laser photocoagulation parameters can be specified to avoid not only the inner retinal damage, but also permanent disorganization and scarring in the photoreceptor layer. These data may facilitate studies to determine those aspects of laser treatment necessary for beneficial clinical response and those that result in extraneous retinal damage.

Significance: The level of control provided by the PASCAL® laser allows the creation of barely visible and even invisible lesions, representing limited retinal damage.

Link: <http://iovs.arvojournals.org/article.aspx?articleid=2164512>

Sramek C, Paulus Y, Nomoto H, Huie P, Brown J, Palanker D. Dynamics of retinal photocoagulation and rupture. *Journal of Biomedical Optics*. 2009 May-Jun;14(3):034007.

Summary: In laser retinal photocoagulation, short (<20 ms) pulses have been found to reduce thermal damage to the inner retina, decrease treatment time, and minimize pain. However, the safe therapeutic window (defined as the ratio of power for producing a rupture to that of mild coagulation) decreases with shorter exposures. To quantify the extent of retinal heating and maximize the therapeutic window, a computational model of millisecond retinal photocoagulation and rupture was developed. Optical attenuation of 532-nm laser light in ocular tissues was measured, including retinal pigment epithelial (RPE) pigmentation and cell-size variability. Threshold powers for vaporization and RPE damage were measured with pulse durations ranging from 1 to 200 ms. A finite element model of retinal heating inferred that vaporization (rupture) takes place at 180-190 degrees C. RPE damage was accurately described by the Arrhenius model with activation energy of 340 kJ/mol. Computed photocoagulation lesion width increased logarithmically with pulse duration, in agreement with histological findings. The model will allow for the optimization of beam parameters to increase the width of the therapeutic window for short exposures.

Significance: This study describes a model of retinal photocoagulation based on tissue properties and laser characteristics. The pigmentation of the RPE is a main characteristic governing the influence of the laser on the retinal tissue, highlighting the importance of titration for each patient. This study reports that the Arrhenius model accurately describes effect of laser energy on retinal heating and hence RPE damage. This allows for the optimization of laser beam parameters.

Link: <http://biomedicaloptics.spiedigitallibrary.org/article.aspx?articleid=1103020>

Sramek C, Leung LS, Leng T, Brown J, Paulus YM, Schuele G, et al. Improving the therapeutic window of retinal photocoagulation by spatial and temporal modulation of the laser beam. *Journal of Biomedical Optics*. 2011 Feb;16(2):028004.

Summary: Decreasing the pulse duration helps confine damage, shorten treatment time, and minimize pain during retinal photocoagulation. However, the safe therapeutic window (TW), the ratio of threshold powers for thermomechanical rupture of Bruch's membrane and mild coagulation, also decreases with shorter exposures. Two potential approaches toward increasing TW are investigated: (a) decreasing the central irradiance of the laser beam and (b) temporally modulating the pulse. An annular beam with adjustable central irradiance was created by coupling a 532-nm laser into a 200- μm core multimode optical fiber at a 4-7 deg angle to normal incidence. Pulse shapes were optimized using a computational model, and a waveform generator was used to drive a PASCAL photocoagulator (532 nm), producing modulated laser pulses. Acute thresholds for mild coagulation and rupture were measured in Dutch-Belted rabbit in vivo with an annular beam (154-163 μm retinal diameter) and modulated pulse (132 μm , uniform irradiance "flat-top" beam) with 2-50 ms pulse durations. Thresholds with conventional constant-power pulse and a flat-top beam were also determined. Both annular beam and modulated pulse provided a 28% increase in TW at 10-ms duration, affording the same TW as 20-ms pulses with conventional parameters.

Significance: This study reports the potential improvements in the therapeutic window of PASCAL photocoagulation. Using a temporal modulated pulse or a spatial modulated annular beam the therapeutic window can be improved by about $1/3^{\text{rd}}$ for a 10-ms pulse duration.

Link: <http://biomedicaloptics.spiedigitallibrary.org/article.aspx?doi=10.1117/1.3542045>

Paulus YM, Jain A, Nomoto H, Sramek C, Gariano RF, Andersen D, et al. Selective retinal therapy with microsecond exposures using a continuous line scanning laser. *Retina*. 2011 Feb;31(2):380-8.

Purpose: To evaluate the safety, selectivity, and healing of retinal lesions created using a continuous line scanning laser.

Methods: A 532-nm Nd:YAG laser (PASCAL) with retinal beam diameters of 40 μm and 66 μm was applied to 60 eyes of 30 Dutch-belted rabbits. Retinal exposure duration varied from 15 μs to 60 μs . Lesions were acutely assessed by ophthalmoscopy and fluorescein angiography. Retinal pigment epithelial (RPE) flatmounts were evaluated with live-dead fluorescent assay. Histological analysis was performed at 7 time points from 1 hour to 2 months.

Results: The ratios of the threshold of rupture and ophthalmoscopic visibility to fluorescein angiography visibility (measures of safety and selectivity) increased with decreasing duration and beam diameter. Fluorescein angiography and live-dead fluorescent assay yielded similar thresholds of RPE damage. Above the ophthalmoscopic visibility threshold, histology showed focal RPE damage and photoreceptor loss at 1 day, without inner retinal effects. By 1 week, photoreceptor and RPE continuity was restored. By 1 month, photoreceptors appeared normal.

Conclusion: Retinal therapy with a fast scanning continuous laser achieves selective targeting of the RPE and, at higher power, of the photoreceptors without permanent scarring or inner retinal damage. Continuous scanning laser can treat large retinal areas within standard eye fixation time.

Significance: This article presents enhanced tissue selectivity, reducing permanent retinal sequelae and enabling faster treatments of large retinal areas, as a result of line scanning photocoagulation technology.

Link: http://journals.lww.com/retinajournal/Abstract/2011/02000/SELECTIVE_RETINAL_THERAPY_WITH_MICROSECOND.24.aspx

Palanker D, Lavinsky D, Blumenkranz MS, Marcellino G. The impact of pulse duration and burn grade on size of retinal photocoagulation lesion: implications for pattern density. *Retina*. 2011 Sep;31(8):1664-9.

Purpose: Shorter pulses used in pattern scanning photocoagulation (10-20 milliseconds [ms]) tend to produce lighter and smaller lesions than the Early Treatment Diabetic Retinopathy Study standard 100-ms exposures. Smaller lesions result in fewer complications but may potentially reduce clinical efficacy. It is worthwhile to reevaluate existing standards for the number and size of lesions needed.

Methods: The width of the coagulated zone in patients undergoing retinal photocoagulation was measured using optical coherence tomography. Lesions of "moderate," "light," and "barely visible" clinical grades were compared for 100, 200, and 400 µm spot sizes and pulse durations of 20 ms and 100 ms.

Results: To maintain the same total area as in 1,000 standard burns (100 ms, moderate) with a 400-µm beam, a larger number of 20-ms lesions are required: 1,464, 1,979, and 3,520 for moderate, light, and barely visible grades, respectively. Because of stronger relative effect of heat diffusion with a smaller beam, with 200 µm this ratio increases: 1,932, 2,783, and 5,017 lesions of 20-ms with moderate, light, and barely visible grades correspond to the area of 1,000 standard burns.

Conclusion: A simple formula is derived for calculation of the required spot spacing in the laser pattern for panretinal photocoagulation with various laser parameters to maintain the same total coagulated area.

Significance: This study describes the relationship between beam size, spot pattern density and the total number of lesions.

Link: http://journals.lww.com/retinajournal/Abstract/2011/09000/THE_IMPACT_OF_PULSE_DURATION_AND_BURN_GRADE_ON.27.aspx

Sramek C, Mackanos M, Spitler R, Leung LS, Nomoto H, Contag CH, et al. Non-damaging retinal phototherapy: dynamic range of heat shock protein expression. *Investigative Ophthalmology & Vision Sciences*. 2011 Mar;52(3):1780-7.

Purpose: Subthreshold retinal phototherapy demonstrated clinical efficacy for the treatment of diabetic macular edema without visible signs of retinal damage. To assess the range of cellular responses to sublethal hyperthermia, expression of the gene encoding a 70 kDa heat shock protein (HSP70) was evaluated after laser irradiation using a transgenic reporter mouse.

Methods: One hundred millisecond, 532 nm laser exposures with 400 µm beam diameter were applied to the retina surrounding the optic nerve in 32 mice. Transcription from the HSP70 promoter was assessed relative to the control eye using a bioluminescence assay at 7 hours after laser application. The retinal pigmented epithelium (RPE) viability threshold was determined with a fluorescence assay. A computational model was developed to estimate temperature and the extent of cell damage.

Results: A significant increase in HSP70 transcription was found at exposures over 20 mW, half the threshold power for RPE cell death. Computational modeling estimated peak temperature $T = 49$ degrees C at HSP70 expression threshold. At RPE viability threshold, $T = 57$ degrees C. Similar temperatures and damage indices were calculated for clinical subvisible retinal treatment parameters.

Conclusions: Beneficial effects of laser therapy have been previously shown to extend beyond those resulting from destruction of tissue. One hundred millisecond laser exposures at approximately half the threshold power of RPE damage induced transcription of HSP70, an indication of cellular response to sublethal thermal stress. A computational model of retinal hyperthermia can guide further optimization of laser parameters for nondamaging phototherapy.

Significance: Laser treatment can have beneficial effects through the production of HSP70 heat shock protein. This paper suggests that the maximum effect occurs at temperatures significantly below those causing tissue destruction. Subthreshold treatment which minimises tissue heating is easily achieved with the short pulse duration of the Pascal laser.

Link: <http://iovs.arvojournals.org/article.aspx?articleid=2127223>

Sramek CK, Leung LS, Paulus YM, Palanker DV. Therapeutic window of retinal photocoagulation with green (532-nm) and yellow (577-nm) lasers. *Ophthalmic Surgery, Lasers & Imaging*. 2012 Jul 1;43(4):341-7.

Background and Objective: The 577-nm (yellow) laser provides an alternative to the 532-nm (green) laser in retinal photocoagulation, with potential benefits in macular treatment and through ocular opacities. To assess relative risk of thermomechanical rupture of Bruch's membrane with yellow laser in photocoagulation, the therapeutic window, the ratio of threshold powers for mild coagulation and rupture, was measured.

Materials and Methods: Retinal coagulation and rupture thresholds, visualized ophthalmoscopically, were measured with 577- and 532-nm lasers using 10- to 100-ms pulses in 34 rabbit eyes. Lesions at 1 and 7 days were assessed histologically.

Results: Coagulation threshold with yellow laser was 26% lower than with green laser. The therapeutic window increased linearly with log-duration for both wavelengths with a difference in parallel-slope intercept of 0.36 +/- 0.20, corresponding to 8% to 15% wider therapeutic window for yellow wavelength.

Conclusion: The therapeutic window of retinal photocoagulation in rabbits at 577 nm is slightly wider than at 532 nm, whereas histologically the lesions are similar.

Significance: Photocoagulation using the 577 nm light (yellow laser) has benefits over the 532 nm light (green laser) since it increases the therapeutic window while inducing the same structural effect. Concurrently, the yellow laser allows for less intraocular light scatter and better light transmittance in opacified media.

Link: <http://www.healio.com/ophthalmology/journals/osli/2012-7-43-4/%7B6eb5d745-3666-4864-a1ab-7649ec56c12d%7D/therapeutic-window-of-retinal-photocoagulation-with-green-532-nm-and-yellow-577-nm-laser>

Lavinsky D, Sramek C, Wang J, Huie P, Dalal R, Mandel Y, et al. Subvisible retinal laser therapy: titration algorithm and tissue response. *Retina*. 2014 Jan;34(1):87-97.

Purpose: Laser therapy for diabetic macular edema and other retinal diseases has been used within a wide range of laser settings: from intense burns to nondamaging exposures. However, there has been no algorithm for laser dosimetry that could determine laser parameters yielding a predictable extent of tissue damage. This multimodal imaging and structural correlation study aimed to verify and calibrate a computational model-based titration algorithm for predictable laser dosimetry ranging from nondamaging to intense coagulative tissue effects.

Methods: Endpoint Management, an algorithm based on a computational model of retinal photothermal damage, was used to set laser parameters for various levels of tissue effect. The algorithm adjusts both power and pulse duration to vary the expected level of thermal damage at different percentages of a reference titration energy dose. Experimental verification was conducted in Dutch Belted rabbits using a PASCAL Streamline 577 laser system. Titration was performed by adjusting laser power to produce a barely visible lesion at 20 ms pulse duration, which is defined as the nominal (100%) energy level. Tissue effects were then determined for energy levels of 170, 120, 100, 75, 50, and 30% of the nominal energy at 1 hour and 3, 7, 30, and 60 days after treatment. In vivo imaging included fundus autofluorescence, fluorescein angiography, and spectral-domain optical coherence tomography. Morphologic changes in tissue were analyzed using light microscopy, as well as scanning and transmission electron microscopy.

Results: One hundred and seventy percent and 120% levels corresponded to moderate and light burns, respectively, with damage to retinal pigment epithelium, photoreceptors, and at highest settings, to the inner retina. 50% to 75% lesions were typically subvisible ophthalmoscopically but detectable with fluorescein angiography and optical coherence tomography. Histology in these lesions demonstrated some selective damage to retinal pigment epithelium and photoreceptors. The 30% to 50% lesions were invisible with in vivo multimodal imaging, and damage was limited primarily to retinal pigment epithelium, visible best with scanning electron microscopy. Over time, photoreceptors shifted into the coagulated zone, reestablishing normal retinal anatomy in lesions $\leq 100\%$, as seen in optical coherence tomography and light microscopy. Transmission electron microscopy at 2 months demonstrated restoration of synapses between shifted-in photoreceptors and bipolar cells in these lesions. Retinal pigment epithelium monolayer restored its continuity after 1 week in all lesions. No damage could be seen $< 30\%$ level.

Conclusion: A retinal laser dosimetry protocol based on the Endpoint Management algorithm provides reproducible changes in retinal morphology in animals with various levels of pigmentation. This algorithm opens doors to clinical trials of well-defined subvisible and nondestructive regimes of retinal therapy, especially important for treatment of macular disorders.

Significance: The Endpoint Management algorithm and titration protocol developed in this study allows optimization of laser parameters to provide desired and reproducible results within the natural variability of pigmentation and transparency of ocular tissue. Subthreshold treatments are particularly useful for macular disorders.

Link: http://journals.lww.com/retinajournal/Abstract/2014/01000/SUBVISIBLE_RETINAL_LASER_THERAPY_Titration.13.aspx

Ito A, Hirano Y, Nozaki M, Ashikari M, Sugitani K, Ogura Y. Short pulse laser induces less inflammatory cytokines in the murine retina after laser photocoagulation. *Ophthalmic Research*. 2015;53(2):65-73.

Aims: The purpose of this study was to evaluate the effect of pulse duration on the expression of inflammatory cytokines in the murine retina after laser photocoagulation treatment with a PASCAL® pattern scan laser photocoagulator and conventional laser treatment.

Methods: Retinal scatter laser photocoagulation was performed on C57BL/6J mice using a short pulse (10 ms) with a PASCAL laser or conventional settings (100 ms) with a multicolor laser. Eyes were enucleated before treatment (control) and 1 day, 3 days and 7 days after treatment. The levels of inflammatory cytokines (i.e., VEGF, MCP-1, RANTES and IL-6) in the retina/choroid were quantified by an ELISA. The expression patterns of VEGF and macrophages (i.e., F4/80) in the retina/choroid were evaluated by immunohistochemistry.

Results: The levels of RANTES, IL-6 and MCP-1 after PASCAL and conventional laser treatments were significantly elevated compared with controls ($p < 0.05$). Conventional laser treatment, but not PASCAL treatment, resulted in the up-regulation of VEGF. RANTES and IL-6 levels on day 1 and MCP-1 levels on day 3 in the sensory retina were also significantly up-regulated with conventional laser treatment compared with PASCAL treatment ($p < 0.05$). Immunohistochemical analysis showed that PASCAL treatment was associated with lower VEGF and F4/80 expression levels compared with conventional laser treatment.

Conclusions: Our data suggested that the short pulse duration induced fewer inflammatory cytokines in the sensory retina compared with the conventional pulse duration. Short pulse laser photocoagulation with the PASCAL may prevent macular edema after panretinal photocoagulation.

Significance: This experimental study demonstrates the smaller inflammatory cascade produced by short pulse photocoagulation using the PASCAL® system. In practical terms the lower expression of inflammatory mediators minimizes the risk of macular edema after single session panretinal photocoagulation.

Link: <https://www.karger.com/Article/Abstract/366520>

PASCAL® Laser Systems – Clinical Experience

Sanghvi C, McLauchlan R, Delgado C, Young L, Charles SJ, Marcellino G, et al. Initial experience with the Pascal photocoagulator: a pilot study of 75 procedures. *British Journal of Ophthalmology*. 2008 Aug; 92(8):1061-4.

Background: The Pascal is a semiautomated photocoagulator that delivers a pattern array of multiple burns in a rapid predetermined sequence with a single foot pedal depression. Each burn is reduced to 10 or 20 ms to achieve this. The authors report their early experience with this system.

Methods: 75 procedures done in 60 patients divided into four groups-group A, patients undergoing panretinal photocoagulation (PRP); group B, patients undergoing focal or modified grid macular laser; group C, patients undergoing macular grid and group D, patients undergoing retinopathy-were retrospectively studied.

Results: 31/34 procedures in group A, 24/26 procedures in group B, 5/7 procedures in group C and all eight patients in group D had successful outcomes. Significantly higher powers were required with the Pascal than with conventional laser ($p < 0.001$) in eyes that underwent PRP and focal/modified grid macular treatment with both systems. Single session PRP was successfully performed in five patients, and five were successfully treated with a macular grid using pattern arrays only. No adverse events were noted.

Conclusion: Although the shorter pulse duration of the Pascal necessitates the use of a higher power, it is not associated with adverse effects. The results here suggest that the Pascal photocoagulator is safe and effective, and offer several potential advantages related to the brief exposure time.

Significance: This report demonstrates the advantages of the technical developments offered by the PASCAL® laser systems. The ability of the system to deliver short pulses of higher power in a grid pattern, does not reduce safety or the efficacy of the procedure and significantly improves patient comfort.

Link: <http://bj.o.bmj.com/content/92/8/1061.long>

Al-Hussainy S, Dodson PM, Gibson JM. Pain response and follow-up of patients undergoing panretinal laser photocoagulation with reduced exposure times. *Eye (London)*. 2008 Jan;22(1):96-9.

Purpose: We performed a study of laser panretinal photocoagulation in 20 patients with proliferative retinopathy. We compared short exposure, high-energy laser settings with conventional settings, using a 532 nm, frequency doubled, Neodymium-Yag laser and assessed the patients in terms of pain experienced and effectiveness of treatment.

Methods: Twenty patients having panretinal photocoagulation for the first time underwent random allocation to treatment of the superior and inferior hemi-retina. Treatment A used 'conventional' parameters: exposure time 0.1 s, power sufficient to produce a visible grey-white burns, spot size 300 micron. The other hemi- retina was treated with treatment B using exposure 0.02 s, 300 micron and sufficient power to have similar endpoint. All patients were asked to evaluate severity of pain on a visual analogue scale. (0=no pain, 10=most severe pain). All patients were masked as to the type of treatment and the order of carrying out the treatment on each patient was randomised. Patients underwent fundus photography and were followed up for 6-45 months.

Results: Seventeen patients had proliferative diabetic retinopathy, two had ischaemic central retinal vein occlusion and one had ocular ischaemic syndrome. The mean response to treatment A was 5.11, compared to 1.40 treatment B, on the visual analogue scale, which was statistically significant ($P=0.001$). All patients preferred treatment B. Further treatments, if required, were performed with treatment B parameters and long-term follow-up has shown no evidence of undertreatment.

Conclusions: Shortening exposure time of retinal laser is significantly less painful but equally effective as conventional parameters.

Significance: This study shows that single spot laser photocoagulation using shorter pulse duration is less painful and has similar long term efficiency compared to conventional laser settings.

Link: <http://www.nature.com/eye/journal/v22/n1/full/6703026a.html>

Modi D, Chiranand P, Akduman L. Efficacy of patterned scan laser in treatment of macular edema and retinal neovascularization. *Clinical Ophthalmology*. 2009;3:465-70

Purpose: To analyze the benefits, efficacy, and complications of the PASCAL® photocoagulation laser system (OptiMedica, Santa Clara, CA, USA) in patients treated at our institution.

Methods: We conducted a retrospective chart review of 19 patients (28 eyes) who underwent laser treatment using the PASCAL® photocoagulation system from November 2006 to November 2007. These 28 eyes were divided into two groups; group 1 eyes underwent macular grid laser and group 2 eyes underwent panretinal photocoagulation. Treatment was performed for macular edema or for iris or retinal neovascularization. Outcomes measured included best-corrected visual acuity (BCVA), efficacy of laser treatment, complications, duration of the procedure, and pain perception, which were noted in the charts for panretinal treatments.

Results: Follow-up was 5.9 +/- 2.6 months for group 1 and 5.9 +/- 4.0 months for group 2. In group 1, 9/28 eyes required a second treatment for remaining edema. BCVA was stable or better in 66% (14/21) and average central foveal thickness on ocular coherence tomography improved in 71% (15/21). Time to completion for a number of laser patterns for grid photocoagulation was felt to be too long for completing the total pattern safely, although we have not noted any related complications. In group 2, the neovascularization regressed at least partially in 3/7 patients. Patient-reported pain perception was 3.6 on a scale of 1 to 10 for group 2. Occasional hemorrhages occurred secondary to irregular laser uptake at different spots in the patterns. We observed no visual outcome consequences because of these hemorrhages during follow-up.

Conclusions: Retinal photocoagulation by the PASCAL® laser has comparable efficacy to historical results with conventional retinal photocoagulation in short-term follow-up. PASCAL® photocoagulation can be performed quicker with less discomfort for patients.

Significance: Pascal® photocoagulation has comparable efficacy to conventional retinal photocoagulation but induces less patient discomfort and treatment is quicker.

Link: https://www.dovepress.com/articles.php?article_id=3426

Bol'shunov AV. The first experience in clinically using a PASCAL laser photocoagulator (OptiMedica, USA). Vestnik Oftalmologii. 2009 Jul-Aug;125(4):37-8.

Abstract: A new PASCAL laser photocoagulator (OptiMedica, USA) was clinically tested. A total of 38 laser interventions were performed in 38 eyes with diabetic retinopathy (n = 25), peripheral retinal dystrophy (n = 2), retinal ruptures (n = 2), hemophthalmos (n = 3), primary open-angle glaucoma (n = 5), and ectopic pupil (n = 1). An example of successful use of the new laser unit for pupilloplasty for the ectopic pupil is given.

[Article in Russian]

Link: [No link available](#)

Muqit MM, Marcellino GR, Henson DB, Young LB, Patton N, Charles SJ, et al. Single-session vs multiple-session pattern scanning laser panretinal photocoagulation in proliferative diabetic retinopathy: The Manchester Pascal Study. *Archives of Ophthalmology*. 2010 May;128(5):525-33.

Objective: To investigate the effects of pattern scanning laser (Pascal®; OptiMedica, Santa Clara, California) multispot panretinal photocoagulation given in a single-session (SS-PRP) vs single-spot multiple-session PRP (MS-PRP) on proliferative diabetic retinopathy (PDR).

Methods: Single-center, randomized clinical trial of 40 eyes. Proliferative diabetic retinopathy was treated with a 400-mum spot size in 1500 burns given either as Pascal in 20-millisecond SS-PRP or in 3 sessions (100-millisecond MS-PRP) during a 4-week period. Visual acuity, central subfield retinal thickness (CRT), and 24-2 Swedish interactive thresholding algorithm visual fields were recorded at baseline and 4 and 12 weeks. Main Outcome Measures: Central subfield retinal thickness, mean deviation, and PDR grade at 12 weeks.

Results: There was a significant increase in mean CRT with MS-PRP (22 mum at 4 weeks, 95% CI, -32.25 to -10.75; 20 mum at 12 weeks, 95% CI, -28.75 to -10.82; $P < .001$) and no significant increase in the SS-PRP group. The mean deviation increased significantly in the SS-PRP group after 4 weeks (0.73 dB, $P = .048$), with no significant changes in either group at other points. A positive effect on PDR was observed in 74% of eyes in the SS-PRP group vs 53% in the MS-PRP group ($P = .31$). Mean treatment time for SS-PRP was 5.04 minutes (SD, 1.5 minutes) compared with 59.3 (SD, 12.7 minutes) in the MS-PRP group ($P < .001$).

Conclusions: There were no adverse outcomes (CRT, visual acuity, or visual field) from using multispot SS-PRP vs single-spot MS-PRP at 12 weeks postlaser, and treatment times were significantly shorter for multispot SS-PRP. Pascal SS-PRP was as effective as MS-PRP in the treatment of PDR.

Significance: This study demonstrates that single session multispot Pascal® photocoagulation is as safe as single spot laser treatment, with the advantage that can be completed faster, which translates to greater convenience for patients and health services.

Link: <http://archophth.jamanetwork.com/article.aspx?articleid=425572>

Velez-Montoya R, Guerrero-Naranjo JL, Gonzalez-Mijares CC, Fromow-Guerra J, Marcellino GR, Quiroz-Mercado H, et al. Pattern scan laser photocoagulation: safety and complications, experience after 1301 consecutive cases. *British Journal of Ophthalmology*. 2010 Jun; 94(6):720-4.

Background/ Aims: The pattern scan laser photocoagulator (PASCAL®) is a novel laser device that uses 10-30 ms pulse duration for retina photocoagulation. The aim of this study was to analyse the safety profile of this approach.

Methods: This was a retrospective study. We reviewed the clinical records of all laser sessions performed with PASCAL® from November 2007 to July 2008. Where there were any complications, we recorded the laser parameters, type, affected retina region, postoperative interval and treatment if required.

Results: There were 1301 consecutive cases. Complications included 17 cases of retinal bleeding (1.3%), two cases of choroidal detachment (0.15%) and one case of exudative retinal detachment (0.07%). There was no statistical difference between the laser parameters used in patients with or without complications.

Conclusion: The laser parameters for PASCAL® are safe. The complications and adverse effects encountered in this series are similar to those reported in other studies.

Significance: PASCAL® is a safe photocoagulation system with a low complication rate similar to conventional systems.

Link: <http://bjo.bmj.com/cgi/pmidlookup?view=long&pmid=20508045>

Jain A, Collen J, Kaines A, Hubschman JP, Schwartz S. Short-duration focal pattern grid macular photocoagulation for diabetic macular edema: four-month outcomes. *Retina*. 2010 Nov-Dec;30(10):1622-6.

Purpose: To evaluate the visual acuity (VA) and optical coherence tomography thickness results of short-duration pattern scanning laser macular photocoagulation in the treatment of clinically significant macular edema because of diabetes.

Methods: Consecutive retrospective analysis of VA and optical coherence tomographic data from eyes treated in a modified Early Treatment Diabetic Retinopathy Study style using a short-duration pattern scanning laser.

Results: A total of 100 eyes from 70 patients met study criteria. All subjects were treated with the same PASCAL (pattern scanning laser) photocoagulation unit. Parameters varied according to media and pigmentation status, but typical settings were 100- μm spot size, 10-millisecond pulse duration, 225-mW power, and 29 J/cm fluence to give a pale but visible lesion. At 4 months post-treatment, there was an average improvement in VA of 0.060 logMAR (an improvement from 20/45 to 20/40, or approximately 3 Early Treatment Diabetic Retinopathy Study letters; $P = 0.0007$) and a reduction of central optical coherence tomographic thickness of 40 μm and 37 μm (spectral domain and time domain optical coherence tomography groups, respectively), both of which were statistically significant ($P = 0.0049$ and 0.012, respectively).

Conclusion: Short-duration PASCAL macular photocoagulation has a biological treatment effect at 4 months for the treatment of clinically significant macular edema. While caution must be used when converting between different VA measurement methods and when using literature-based controls, the observed VA improvement seems equivalent to 3 Early Treatment Diabetic Retinopathy Study letters. These findings are similar to the recently published results from the diabetic retinopathy clinical research network cohort. PASCAL laser photocoagulation for clinically significant macular edema appears safe and effective in the short term and may have significant long-term advantages.

Significance: This study demonstrates for the first time the efficacy of short-pulse duration photocoagulation with the PASCAL® laser system in the treatment diabetic macular edema. The short term follow-up demonstrated an effective reduction in macular thickness and improvement in visual acuity.

Link: <http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=2010&issue=11000&article=00010&type=abstract>

Muqit MM, Marcellino GR, Gray JC, McLauchlan R, Henson DB, Young LB, et al. Pain responses of Pascal 20 ms multi-spot and 100 ms single-spot panretinal photocoagulation: Manchester Pascal Study, MAPASS report 2. *British Journal of Ophthalmology*. 2010 Nov;94(11):1493-8

Aims: To evaluate pain responses following Pascal 20 ms multi-spot and 100 ms single-spot panretinal photocoagulation (PRP).

Methods: Single-centre randomised clinical trial. 40 eyes of 24 patients with treatment-naive proliferative diabetic retinopathy randomised to 20 and 100 ms PRP under topical 0.4% oxybuprocaine. A masked grader used a pain questionnaire within 1 h (numerical pain score (NPS)) and 1 month after treatment (numerical headache score (NHS)). Primary outcome measure was NPS immediately post-PRP. Secondary outcome measures were mean NHS scores and levels of photophobia reported within 4 weeks of primary PRP.

Results: Mean laser fluence was significantly lower using 20 ms PRP (4.8 J/cm^2) compared to 100 ms PRP (11.8 J/cm^2); $p < 0.001$). Mean NPS scores for treatment were 2.4 (2.3) (mild) for 20 ms PRP group compared to 4.9 (3.3) (moderate) in 100 ms PRP group—a significant difference (95% CI 4.3 to 0.68; $p = 0.006$). Mean NHS score within 1 month was 1.5 (2.7) in 20 ms PRP group compared to 3.2 (3.5) in the 100 ms PRP group ($p < 0.05$). The median duration of photophobia after 20 ms PRP was 3 h, and significantly less compared to 100 ms PRP after which 72 h of photophobia was reported ($p < 0.001$).

Conclusions: Multi-spot 20 ms PRP was associated with significantly lower levels of anxiety, headache, pain and photophobia compared to 100 ms single-spot PRP treatment. Possible reasons include lower fluence, shorter-pulse duration, and spatial summation of laser nociception with multi-spot Pascal technique.

Significance: 20 ms multi-spot (Pascal®) panretinal photocoagulation is significantly more comfortable than multiple session 100 ms conventional laser panretinal photocoagulation. Longer pulse durations are associated with higher pain and post-treatment photophobia.

Link: <http://bj.o.bmj.com/content/94/11/1493.long>

Muqit MM, Marcellino GR, Henson DB, Young LB, Turner GS, Stanga PE. Pascal panretinal laser ablation and regression analysis in proliferative diabetic retinopathy: Manchester Pascal Study Report 4. *Eye (London)*. 2011 Nov;25(11):1447-56.

Aims: To quantify the 20-ms Pattern Scan Laser (Pascal®) panretinal laser photocoagulation (PRP) ablation dosage required for regression of proliferative diabetic retinopathy (PDR), and to explore factors related to long-term regression.

Methods: We retrospectively studied a cohort of patients who participated in a randomised clinical trial, the *Manchester Pascal Study*. In all, 36 eyes of 22 patients were investigated over a follow-up period of 18 months. Primary outcome measures included visual acuity (VA) and complete PDR regression. Secondary outcomes included laser burn dosimetry, calculation of retinal PRP ablation areas, and effect of patient-related factors on disease regression. A PDR subgroup analysis was undertaken to assess all factors related to PDR regression according to disease severity.

Results: There were no significant changes in logMAR VA for any group over time. In total, 10 eyes (28%) regressed after a single PRP. Following top-up PRP treatment, regression rates varied according to severity: 75% for mild PDR (n=6), 67% for moderate PDR (n=14), and 43% in severe PDR (n=3). To achieve complete disease regression, mild PDR required a mean of 2187 PRP burns and 264 mm² ablation area, moderate PDR required 3998 PRP burns and area 456 mm², and severe PDR needed 6924 PRP laser burns (836 mm²; p<0.05).

Conclusions: Multiple 20-ms PRP treatments applied over time does not adversely affect visual outcomes, with favourable PDR regression rates and minimal laser burn expansion over 18 months. The average laser dosimetry and retinal ablation areas to achieve complete regression increased significantly with worsening PDR.

Significance: Panretinal photocoagulation with 20 ms Pascal® produces good rates of regression of proliferative diabetic retinopathy eye disease. More burns are required to achieve regression for more severe PDR. Despite the high burn density there was no negative effects on visual acuity.

Link: <http://www.nature.com/eye/journal/v25/n11/full/eye2011188a.html>

Sheth S, Lanzetta P, Veritti D, Zucchiatti I, Savorgnani C, Bandello F. Experience with the Pascal® photocoagulator: an analysis of over 1,200 laser procedures with regard to parameter refinement. *Indian Journal of Ophthalmology*. 2011 Mar-Apr;59(2):87-91.

Aim: To systematically refine and recommend parameter settings of spot size, power, and treatment duration using the Pascal® photocoagulator, a multi-spot, semi-automated, short-duration laser system.

Materials and Methods: A retrospective consecutive series with 752 Caucasian eyes and 1242 laser procedures over two years were grouped into, (1) 374 macular focal / grid photocoagulation (FP), (2), 666 panretinal photocoagulation (PRP), and (3) 202 barrage photocoagulation (BP). Parameters for power, duration, spot number, and spot size were recorded for every group.

Results: Power parameters for all groups showed a non-gaussian distribution; FP group, median 190 mW, range 100 - 950 mW, and PRP group, median 800 mW, range 100 - 2000 mW. On subgroup comparison, for similar spot size, as treatment duration decreased, the power required increased, albeit in a much lesser proportion than that given by energy = power x time. Most frequently used patterns were single spot (89% of cases) in FP, 5x5 box (72%) in PRP, and 2x2 box (78%) in BP. Spot diameters as high as approximately 700 µm on retina were given in the PRP group. Single session PRP was attempted in six eyes with a median spot count of 3500.

Conclusion: Overall, due to the small duration of its pulse, the Pascal® photocoagulator tends to use higher powers, although much lower cumulative energies, than those used in a conventional laser. The consequent lesser heat dissipation, especially lateral, can allow one to use relatively larger spot sizes and give more closely spaced burns, without incurring significant side effects.

Significance: The Pascal® requires a higher laser power than conventional laser photocoagulations but because of the short pulse duration, delivers significantly lower cumulative laser energy and therefore results in less heating of the tissue. This allows for the use of larger spot sizes placed closer together without causing significant side-effects.

Link: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3116566/>

Ye H, Jin C, Zhong X, Tian Z, Lin W. Pattern scan laser photocoagulator on retinopathy: an annual clinical application summary. *Eye Science*. 2011 Jun;26(2):70-4.

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.

Significance: PASCAL® is effective, safe and improves patients' tolerance to photocoagulation in the treatment of diabetic retinopathy. A wide variety of the conditions can be addressed using the options offered by PASCAL®.

Link: <http://www.pubfacts.com/detail/21692202/Pattern-scan-laser-photocoagulator-on-retinopathy-an-annual-clinical-application-summary>

Muqit MM, Marcellino GR, Henson DB, Fenerty CH, Stanga PE. Randomized clinical trial to evaluate the effects of Pascal panretinal photocoagulation on macular nerve fiber layer: Manchester Pascal Study report 3. Retina. 2011 Sep;31(8):1699-707.

Purpose: To investigate the effects of panretinal photocoagulation (PRP) on macular thickness and macular nerve fiber layer thickness in eyes with proliferative diabetic retinopathy.

Methods: Single-center, randomized clinical trial (n = 40 eyes). Proliferative diabetic retinopathy was treated with 1,500 burns given as Pascal 20-millisecond single-session PRP (SS-PRP) or as multiple-session PRP (100 milliseconds, MS-PRP) over a 4-week period. The main outcome measures included optical coherence tomography measurements of total retinal thickness and nerve fiber layer at the macula, visual acuity, and proliferative diabetic retinopathy regression and were recorded at baseline, 4 weeks, and 12 weeks. Optic disc photographs were graded by masked a glaucoma specialist.

Results: At 12 weeks, in the SS-PRP group, there was no significant change in total nerve fiber layer thickness from baseline (4 weeks; +7.2 μm , P = 0.78; 12 weeks, -1.8 μm , P = 0.95). There was a significant increase in total retinal thickness for the MS-PRP group at 4 weeks from baseline (96 +/- 17 μm ; P < 0.001) and at 12 weeks (56 +/- 21 μm ; P = 0.0167). After 4 weeks in the MS-PRP group, total nerve fiber layer thickness increased significantly by 31 +/- 54 μm (P = 0.029) from baseline, with a significant reduction at 12 weeks from baseline (35 +/- 63 μm ; P = 0.034). There was no change among groups for optic nerve appearance post-laser. At 12 weeks, the mean visual acuity was 81 +/- 6 letters (SS-PRP group), compared with 77 +/- 15 letters in the MS-PRP group (95% confidence interval, 5.2 to 9 letters; P = 0.286). For the SS-PRP group, a positive effect on proliferative diabetic retinopathy regression was observed in 74% of eyes compared with 53% of the eyes in the MS-PRP group (P = 0.31).

Conclusion: Compared with 20-millisecond SS-PRP, eyes treated with conventional 100-millisecond single-spot delivered over multiple sessions showed increased total macular thickness at 4 weeks, with a thinning of the macular nerve fiber layer at 12 weeks.

Significance: Short-pulse photocoagulation for PRP, which due to the reduced patient discomfort and short treatment time, can be performed in one sitting, prevents nerve macular fiber layer loss compared to conventional laser treatment. This study may have important implications for patient requiring recurrent laser over time.

Link:http://journals.lww.com/retinajournal/Abstract/2011/09000/RANDOMIZED_CLINICAL_TRIAL_TO_EVALUATE_THE_EFFECTS.31.aspx

Muqit MM, Sanghvi C, McLauchlan R, Delgado C, Young LB, Charles SJ, et al. Study of clinical applications and safety for Pascal® laser photocoagulation in retinal vascular disorders. *Acta Ophthalmologica*. 2012 Mar;90(2):155-61.

Purpose: To establish safe laser parameter standards for 10-30 ms Pascal® laser in clinical practice and to evaluate clinical and visual outcomes using this 532-nm multi-spot photocoagulation system.

Methods: Retrospective observational case series of 313 patients treated between 2006 and 2008. Evaluation of eight groups: A - panretinal photocoagulation (PRP) for proliferative diabetic retinopathy (PDR); B - focal laser treatment for clinically significant diabetic macular oedema; C - grid laser for diffuse diabetic macular oedema; D - sector PRP for ischaemic branch retinal vein occlusions (I-BRVO); E - full PRP for ischaemic central retinal vein occlusions (I-CRVO); F - macular laser treatment for macular oedema secondary to non-ischaemic BRVO; G - full PRP for rubeosis iridis and/or neovascular glaucoma (NVG) secondary to I-BRVO, I - CRVO or PDR; H - laser retinopexy for retinal breaks/degenerations.

Results: Mean LogMAR visual acuity for all procedures improved post-laser ($p = 0.065$), and laser prevented visual loss in 85% eyes. Topical anaesthesia only was required. At mean follow-up of 5 months, 72% procedures had a successful clinical outcome. Significantly higher powers were required for PRP using Pascal® compared to conventional laser ($p = 0.001$) in PDR, I-BRVO, I-CRVO and NVG. Sixty-seven per cent of patients were successfully treated with single-session 20-ms PRP using a mean 1952 burns. There were no laser-associated adverse effects or ocular complications associated with multi-spot PRP or macular Pascal® arrays.

Conclusions: The clinical efficacy using 10- to 30-ms pulse duration Pascal® laser is comparable to conventional standard protocols used for the treatment of vascular retinal disorders. Higher power, 10- to 30-ms pulse duration laser may be safely and effectively used in clinical practice.

Significance: This study reports the safe parameters for PASCAL® photocoagulation using 10 to 30 ms pulses, which allow for safe and efficacious treatment of a range of retinal vascular disorders.

Link: <http://onlinelibrary.wiley.com/doi/10.1111/j.1755-3768.2009.01854.x/full>

Pitcher JD, 3rd, Liu T, Prasad PS, Schwartz SD, Hubschman JP. Short-duration focal pattern grid photocoagulation for macular edema secondary to branch retinal vein occlusion. *Seminars in Ophthalmology*. 2012 May-Jul;27(3-4):69-72.

Purpose: To evaluate the safety, functional, and anatomical outcomes of short-duration pattern scanning laser (PASCAL) macular photocoagulation in the treatment of macular edema related to branch retinal vein occlusion (BRVO).

Methods: Consecutive retrospective analysis of visual acuity (VA), optical coherence tomography (OCT), and adverse events from eyes treated with PASCAL macular photocoagulation for BRVO-related macular edema. Two-tailed paired t-tests were used to compare pre- and post-treatment VA and central retinal thickness (CRT).

Results: A total of 35 eyes from 35 patients and 18 eyes from 18 patients met study criteria for VA and OCT analysis, respectively. All treatments were delivered with the same PASCAL photocoagulation unit. Mean laser settings were 133-microm spot size, 15-millisecond pulse duration, 250-mW power, and fluence of 29 J/cm² with an average of 1.4 treatments and 335 shots per patient. Adjunct treatment with intravitreal anti-VEGF injections and pan-retinal photocoagulation was administered in 27 and 16 eyes, respectively. At an average follow-up of 12 months (range 3-43 months) post-treatment, no laser-related ocular complications were observed. Visual acuity was not significantly changed ($p = 0.07$), although the number of patients with vision better than 20/40 doubled following treatment. CRT was reduced by an average of 110 microm ($p = 0.0009$).

Conclusion: Short-duration PASCAL macular photocoagulation appears to be a safe treatment option that results in significant anatomical improvement in macular edema related to BRVO.

Significance: PASCAL® short pulse photocoagulation allows a safe and effective treatment of macular edema secondary to branch retinal vein occlusion.

Link: <http://www.tandfonline.com/doi/abs/10.3109/08820538.2011.643272?journalCode=isio20>

Muqit MM, Young LB, McKenzie R, John B, Marcellino GR, Henson DB, et al. Pilot randomised clinical trial of Pascal TargETEd Retinal versus variable fluence PANretinal 20 ms laser in diabetic retinopathy: PETER PAN study. British Journal of Ophthalmology. 2013 Feb;97(2):220-7.

Purpose: To investigate the short-term effects of high-density 20-ms laser on macular thickness using Pascal-targeted retinal photocoagulation (TRP) and reduced fluence/minimally-traumatic panretinal photocoagulation (MT-PRP) compared to standard-intensity PRP (SI-PRP) in proliferative diabetic retinopathy (PDR).

Methods: Prospective randomised clinical trial. Treatment-naive PDR was treated with single-session 20-ms Pascal 2500 burns photocoagulation randomised to one of three treatment arms (TRP:MT-PRP:SI-PRP). Primary outcome measure was change in central retinal thickness (CRT) on OCT. Secondary outcomes at 4 and 12 weeks post-laser included: OCT peripapillary nerve fibre layer (NFL) thickness; PDR disease regression on Optos angiography; SITA-Std visual fields (VF); and, visual acuity (VA).

Results: 30 eyes of 24 patients were studied, ten eyes/arm. At 12 weeks, there were significant reductions in CRT after TRP (9.6 micron; 95% CI, 1.84 to 17.36; $p=0.021$) and MT-PRP (17.1 micron; 95% CI, 11 to 23.2; $p=0.001$), versus SI-PRP (+5.9 micron; 95% CI, -6.75 to 18.55; $p=0.32$). PDR regression was similar between groups (TRP 70%; MT-PRP 70%; SI-PRP 90%; $\kappa=0.76$). No significant changes in VA and NFL thickness developed between groups. The VF mean deviation scores increased significantly in all groups at 12 weeks ([TRP, +0.70dB; 95% CI, 0.07 to 1.48; $p=0.07$], [MT-PRP, +0.63dB; 95% CI, 0.12 to 1.15; $p=0.02$], [SI-PRP, +1.0dB; 95% CI, 0.19 to 1.74; $p=0.02$]). There were no laser-related ocular complications.

Conclusions: This pilot study reports that high-density 20-ms Pascal TRP and MT-PRP using 2500 burns did not produce increased macular thickness or any ocular adverse events during the short-term.

Significance: The PETER PAN study demonstrates the versatility, efficacy and safety of the different photocoagulation strategies offered by the PASCAL® laser system in treating proliferative diabetic retinopathy. Targeting areas of retinal capillary non-perfusion/intermediate ischaemia (TRP) and minimally traumatic laser therapy (subthreshold treatment, now replaced by titration and Endpoint Management™), both proved more effective at reducing central retinal thickness than standard laser treatment.

Link: <http://bj.o.bmj.com/content/97/2/220.abstract>

Muqit MM, Marcellino GR, Henson DB, Young LB, Patton N, Charles SJ, et al. Optos-guided pattern scan laser (Pascal)-targeted retinal photocoagulation in proliferative diabetic retinopathy. *Acta Ophthalmologica*. 2013 May;91(3):251-8.

Purpose: To investigate the clinical effects and safety of targeted pattern scan laser (Pascal®) retinal photocoagulation (TRP) in proliferative diabetic retinopathy (PDR).

Methods: Prospective and non-randomized study of 28 eyes with treatment-naive proliferative diabetic retinopathy (PDR). Single-session 20-ms-Pascal TRP strategy applied 1500 burns to zones of retinal capillary non-perfusion and intermediate retinal ischaemia guided by wide-field fluorescein angiography (Optos). Main outcome measures at 12 and 24 weeks included; PDR grade (assessed by two masked retina specialists); central retinal thickness (CRT); mean deviation (MD) using 24-2 Swedish interactive threshold algorithm (SITA)-standard visual fields (VF); and ETDRS visual acuity (VA).

Results: Following primary TRP, there was PDR regression in 76% of patients at 12 weeks ($\kappa = 0.70$; $p < 0.001$). No laser re-treatment was required at 4 weeks, and 10 eyes underwent repeat TRP at 12 weeks. Wide-field Optos angiography at 24 weeks showed complete disease regression in 37% and partial regression in 33%. Additional panretinal laser photocoagulation (PRP) was planned for active PDR in 30%. There were significant reductions in CRT over time (10.4 μm at 12-weeks, $p = 0.007$; 12.1 μm at 24-weeks, $p = 0.0003$). The MD on VFs improved after 12 weeks (+1.25 dB; $p = 0.015$) and 24 weeks (+1.26 dB, $p = 0.01$). The VA increased by +3 letters at 24 weeks (95% CI, 1.74-5.01; $p < 0.0001$).

Conclusions: This pilot study reports that Optos-guided Pascal 20-ms TRP using 1500 burns for treatment-naive PDR is a promising procedure with favourable safety profile.

Significance: This study demonstrates the efficacy of the PASCAL® laser system to treat retinal capillary non-perfusion and intermediate retinal ischaemia, without adverse outcomes as loss of structural and visual function.

Link: <http://onlinelibrary.wiley.com/doi/10.1111/j.1755-3768.2011.02307.x/abstract>

Michalska A, Dorecka M, Jackiewicz K, Miniewicz-Kurkowska J, Sobieraj R, Michalski M, et al. Evaluation of mean retinal sensitivity using MP-1 microperimeter in patients with diabetic macular edema before and after laser photocoagulation treatment. *Polskie Archiwum Medycyny Wewnętrznej*. 2013;123(3):98-104.

Introduction: Diabetic macular edema (DME) is a common cause of visual acuity deterioration among patients with diabetes. Laser photocoagulation still remains the most common treatment of DME and diabetic retinopathy.

Objectives: The aim of the study was to assess mean central retinal sensitivity among patients with DME before and after laser photocoagulation treatment. Additionally, we estimated the best-corrected visual acuity (BCVA) and retinal macular thickness before and after treatment.

Patients & Methods: The study included 30 patients (35 eyes with DME). The mean age was 61.9 +/-4.8 years. Insulin was administered in 22 patients and oral antidiabetics in 8. Laser photocoagulation in the macular area was performed in all patients using the Pascal laser. We measured the BCVA, mean central retinal sensitivity, and retinal thickness in the macula (divided into 9 segments). The measurements were performed before and at 1, 3, and 6 months after laser treatment. Central retinal sensitivity was assessed with the MP-1 microperimeter and macular thickness with optical coherence tomography (Stratus OCT). Results: The statistical analysis did not reveal significant differences between BCVA and central retinal sensitivity in the study group before and after laser treatment. The analysis of the mean central retinal thickness showed a significant decrease in macular edema in the individual segments at 1, 3, and 6 months after photocoagulation.

Conclusions: Photocoagulation of DME with the Pascal laser did not cause significant changes either in the BCVA or central retinal sensitivity. Laser treatment in patients with DME significantly reduced central retinal edema in most segments.

Significance: The treatment of diabetic macular edema with the particular features of the Pascal® laser system helps to reduce macular edema without damaging macular sensitivity as assessed using a microperimeter.

Link: <http://pamw.pl/en/issue/article/23303431>

Ota S, Nozaki M, Hirahara S, Hattori T, Yoshida M, Ogura Y. A case of retinopathy of prematurity treated by pattern scan laser photocoagulation. *Clinical Ophthalmology*. 2014;8:1409-12.

Abstract: We experienced a case of retinopathy of prematurity that was successfully treated with pattern scan laser. Pattern scan laser treatment should be considered as one treatment option for Retinopathy of Prematurity.

Significance: The PASCAL® laser system can be applied safely and successfully in delicate clinical cases such as retinopathy of prematurity.

Link: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4122559/>

Park YR, Jee D. Changes in peripapillary retinal nerve fiber layer thickness after pattern scanning laser photocoagulation in patients with diabetic retinopathy. Korean Journal of Ophthalmology. 2014 Jun;28(3):220-5.

Purpose: To examine the effects of panretinal photocoagulation (PRP) using a pattern scanning laser (PASCAL) system on the retinal nerve fiber layer (RNFL) thickness in patients with diabetic retinopathy.

Methods: This retrospective study included 105 eyes with diabetic retinopathy, which consisted of three groups: the PASCAL group that underwent PRP with the PASCAL method (33 eyes), the conventional group that underwent conventional PRP treatment (34 eyes), and the control group that did not receive PRP (38 eyes). The peripapillary RNFL thickness was measured by optical coherence tomography before, six months, and one year after PRP to evaluate the changes in peripapillary RNFL.

Results: The RNFL thickness in the PASCAL group did not show a significant difference after six months (average 3.7 times, $p = 0.15$) or one year after the PRP (average 3.7 times, $p = 0.086$), whereas that in the conventional group decreased significantly after six months (average 3.4 times, $p < 0.001$) and one year after PRP (average 3.4 times, $p < 0.001$).

Conclusions: The results of this study suggest that the PASCAL system may protect against RNFL loss by using less energy than conventional PRP.

Significance: The Pascal® method allowing very short duration laser pulses to be applied, limits damage of surrounding areas of the retina during photocoagulation, due to the limited build up of heat. This may help to protect against RNFL damage.

Link: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4038727/>

Mukhtar A, Khan MS, Junejo M, Ishaq M, Akbar B. Effect of pan retinal photocoagulation on central macular thickness and visual acuity in proliferative diabetic retinopathy. *Pakistan Journal of Medical Sciences*. 2016 Jan-Feb;32(1):221-4.

Objective: To evaluate the effect of pan-retinal photocoagulation with Pattern Scan Laser (pascal) on best corrected visual acuity and central macular thickness in patients having proliferative diabetic retinopathy (PDR).

Methods: This study was conducted at AFIO, Rawalpindi, Pakistan from Oct 2014 to Jul 2015. Sixty seven eyes of 46 patients having proliferative diabetic retinopathy were included in the study. All patients underwent ophthalmic clinical examination including uncorrected distant visual acuity (UCVA), best corrected visual acuity (BCVA), fundus examination with slit lamp and optical coherence tomography to document the pretreatment central macular thickness (CMT). Two sessions of PRP using Pattern Scan Laser were performed 04 weeks apart and OCT was repeated 04 weeks after the 2nd session. Central macular thickness and BCVA were documented.

Results: Sixty seven eyes of 46 patients (29 females and 17 males) with mean age of 57.45 +/- 5.78 years underwent treatment with two sessions of laser PRP. Mean pretreatment BCVA was 0.67 +/- 0.43 and mean post-treatment BCVA was 0.57 +/- 0.3. Mean central macular thickness (CMT) as measured by OCT was 391.93 +/- 170.43 before treatment and 316.91 +/- 90.42 um after treatment. The magnitude of induced change in CMT after treatment was 75.01 +/- 90.75 and BCVA was 0.09 +/- 0.14.

Conclusions: Laser PRP with Pattern scan laser alone in patients with combined presentation of PDR and DME is safe and effective.

Significance: Laser Panretinal Photocoagulation with the PASCAL® system is safe and effective in patients with combined presentation of Proliferative diabetic retinopathy and diabetic macular edema. It reduces the risks and complications with progression of neovascularization and leads to an improvement of vision and diabetic macular edema.

Link: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4795873/>

PASCAL® Laser Systems – Endpoint Management™

Lavinsky D, Palanker D. Nondamaging photothermal therapy for the retina: initial clinical experience with chronic central serous retinopathy. *Retina*. 2015 Feb;35(2):213-22.

Purpose: To assess safety and clinical efficacy of the nondamaging photothermal therapy for the macula for the treatment of chronic central serous retinopathy.

Methods: Sixteen eyes of 16 patients with persistent central serous retinopathy (>4 months of duration) were treated with the PASCAL Streamline at 577-nm wavelength, using 200- μm retinal spot sizes. Using Endpoint Management Software, the laser power was first titrated for a barely visible burn with 15-ms pulses, which was defined as 100% pulse energy. Treatment was then applied over the area of serous retinal detachment and adjacent nonthickened retina, using 30% pulse energy with the spot spacing of 0.25 beam diameter. Changes in subretinal fluid, Early Treatment Diabetic Retinopathy Study best-corrected visual acuity, and central macular thickness were measured over 6 months of follow-up. Pretreatment and posttreatment fluorescein angiography and fundus autofluorescence were also assessed.

Results: On average, 532 spots have been applied per treatment. No visible laser marks could be detected by clinical observation, optical coherence tomography, fundus autofluorescence, or fluorescein angiography. On average, 12 Early Treatment Diabetic Retinopathy Study letters gain was achieved at 2 months and was sustained by 6 months ($P < 0.001$). Central macular thickness decreased from 350 μm to 282 μm ($P = 0.004$). Subretinal fluid completely resolved in 37% of the patients after first treatment, whereas 44% of the patients required retreatment after 3 months because of recurrent fluid or incomplete resolution. The remaining 19% of the patients received a second retreatment. By 6 months, in 75% of the patients, the subretinal fluid was completely resolved, whereas in 25%, there was some minimal fluid left.

Conclusion: Photothermal therapy using 577-nm PASCAL laser with Endpoint Management graphic user interface was safe, and it improved visual acuity and resolution of subretinal fluid in chronic central serous retinopathy. Lack of tissue damage allows periodic retreatment without cumulative scarring, characteristic to conventional photocoagulation. This technique should be tested in the treatment of other macular disorders and may offer an alternative to conventional laser coagulation of the macula and to anti-vascular endothelial growth factor pharmacological treatments of macular diseases.

Significance: PASCAL system using Endpoint Management™ software, (which allows customized sub-threshold retinal treatment associated with limited tissue damage), is safe and effective in the treatment of central serous retinopathy. This new feature broadens the application of PASCAL® laser systems to other retinal pathologies other than diabetes.

Link:http://journals.lww.com/retinajournal/Abstract/2015/02000/NONDAMAGING_PHOTOTHERMAL_THERAPY_FOR_THE_RETINA__6.aspx

Pei-Pei W, Shi-Zhou H, Zhen T, Lin L, Ying L, Jiexiong O, et al. Randomised clinical trial evaluating best-corrected visual acuity and central macular thickness after 532-nm subthreshold laser grid photocoagulation treatment in diabetic macular oedema. *Eye (London)*. 2015 Mar;29(3):313-21; quiz 22.

Purpose: To compare best-corrected visual acuity (BCVA) and central macular thickness (CMT) after 532-nm subthreshold laser grid photocoagulation and threshold laser grid photocoagulation for the treatment of diabetic macular oedema (DME).

Patients and Methods: Twenty-three patients (46 eyes) with binocular DME were enrolled in this study. The two eyes of each patient were divided into a subthreshold photocoagulation group and a threshold photocoagulation group. The eyes of the subthreshold group underwent 532-nm pattern scanning laser treatment (PASCAL®) with 50% Endpoint Management subthreshold laser grid photocoagulation therapy, whereas the threshold photocoagulation group underwent short-pulse grid photocoagulation with a 532-nm PASCAL® system. BCVA and CMT were assessed in all patients before treatment, 7 days after treatment, and 1, 3, and 6 months after treatment.

Results: After grid photocoagulation, the mean BCVA improved in both the subthreshold group, and the threshold group, and the two groups did not differ statistically significantly from each other. Similarly, the macular oedema diminished in both groups after treatment, and the two groups did not differ statistically significantly from each other with regard to CMT.

Conclusion: Both 532-nm subthreshold laser grid photocoagulation and threshold laser grid photocoagulation can improve the visual acuity and reduce CMT in DME patients.

Significance: PASCAL subthreshold (Endpoint Management™) and full threshold photocoagulation are effective in the treatment of diabetic macular edema with beneficial effects for visual acuity.

Link: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4366477/>

Lavinsky D, Wang J, Huie P, Dalal R, Lee SJ, Lee DY, et al. Nondamaging Retinal Laser Therapy: Rationale and Applications to the Macula. *Investigative Ophthalmology & Vision Sciences*. 2016 May 1;57(6):2488-500.

Purpose: Retinal photocoagulation and nondamaging laser therapy are used for treatment of macular disorders, without understanding of the response mechanism and with no rationale for dosimetry. To establish a proper titration algorithm, we measured the range of tissue response and damage threshold. We then evaluated safety and efficacy of nondamaging retinal therapy (NRT) based on this algorithm for chronic central serous chorioretinopathy (CSCR) and macular telangiectasia (MacTel).

Methods: Retinal response to laser treatment below damage threshold was assessed in pigmented rabbits by expression of the heat shock protein HSP70 and glial fibrillary acidic protein (GFAP). Energy was adjusted relative to visible titration using the Endpoint Management (EpM) algorithm. In clinical studies, 21 eyes with CSCR and 10 eyes with MacTel were treated at 30% EpM energy with high spot density (0.25-diameter spacing). Visual acuity, retinal and choroidal thickness, and subretinal fluid were monitored for 1 year.

Results: At 25% EpM energy and higher, HSP70 was expressed acutely in RPE, and GFAP upregulation in Muller cells was observed at 1 month. Damage appeared starting at 40% setting. Subretinal fluid resolved completely in 81% and partially in 19% of the CSCR patients, and visual acuity improved by 12 +/- 3 letters. Lacunae in the majority of MacTel patients decreased while preserving the retinal thickness, and vision improved by 10 letters.

Conclusions: Heat shock protein expression in response to hyperthermia helps define the therapeutic window for NRT. Lack of tissue damage enables high-density treatment to boost clinical efficacy, therapy in the fovea, and retreatments to manage chronic diseases.

Significance: The Endpoint management (EPM) software allows for safe and efficient non-damaging retinal therapy in macular telangiectasia and chronic central serous chorioretinopathy, following customized titration for each patient. The lack of tissue damage achieved by EpM allows a higher density of treatment spots, potentially increasing the therapeutic response. In addition, the express of HSP70 and upregulation of GFAP, suggests that NRT may potentially be useful for other outer retina disorders.

Link: <http://iovs.arvojournals.org/article.aspx?articleid=2521898>

PASCAL® Laser Systems – Pascal versus Other Photocoagulation Systems

Marlecha S, Nagpal M, Nagpal K, editors. Comparison of Efficacy and Collateral Damage of Laser Burns Using Single Spot Argon Laser and Pattern Scan Laser (PASCAL) in Proliferative Diabetic Retinopathy. AIOC; 2009

Advent of retinal laser photocoagulation in the early 1970s provided a noninvasive modality for the treatment of proliferative retinal conditions. Relatively low complication rates with a significant degree of success led to its widespread acceptance. This was furthered with the aid of the Diabetic Retinopathy Study (DRS) and the Early Treatment Diabetic Retinopathy Study (ETDRS) taken on to evaluate the effects of laser treatment on diabetic retinopathy. Panretinal photocoagulation (PRP) was found to reduce the progression to severe visual loss (<5/200) by more than 50%. ETDRS was conducted to identify the optimal stage of intervention. The study results showed that treatment benefit was found in stages before the high risk characteristics developed. When PRP was done as the patients approached high risk characteristic disease, severe visual loss was reduced by more than 90% to 5% over 5 years. PRP involves applying laser burns over the entire retina, sparing the central macular area. This may be performed using one of several available laser delivery systems, the slit lamp and indirect ophthalmoscope based systems being most prevalent for out-patient indications. Application starts in a circumference of 500 µm from the disc and 2 disc diameters from the fovea to wall off the central retina. Moderate intensity burns of 200-500 µm (gray-white burns) are placed 1 spot size apart, except in areas of neovascularisation where the entire frond is treated. This procedure is continued peripherally to achieve a total of 1200-1600 applications over 2-3 sessions.

PRP could result in onset or exacerbation of previously existing macular edema, choroidal detachment, foveal burn, retinal tears, accommodation loss, accidental burn to cornea, iris or lens. Single sitting panretinal photocoagulation is reported to have exaggerated macular edema. Several attempts have been made to decrease requirement on operator dexterity and inconvenience of multiple, interrupted laser applications placed one at a time with the help of multi spot laser modalities. Recently a semiautomated, fully integrated, slit lamp based pattern scan retinal photocoagulator (PASCAL, Optimedica inc.), has been introduced into clinical use. It uses frequency doubled Nd:YAG diode pumped solid state laser with wavelength of 532nm. Scanning function in this modality is achieved by mirrors mounted on a two-axis galvanometric scanner. In a single burst, a collection of adjustable predetermined pattern shapes and sizes, including lines, squares, circular arcs, as well as user-defined patterns, and an adjustable “foveal exclusion zone” can be delivered. Pulse durations are in the 10- to 20-millisecond range. In this study, we hoped to compare the PASCAL with the conventional slit lamp delivery system which delivers single spot in one foot pedal depression. It is 532 nm solid state green laser, (GLX, Iridex). The parameters which we wanted to compare included: Total time required for complete PRP; Patient comfort while; undergoing PRP; Clinical regression of retinopathy; Spread of laser spot beyond the actual spot size; Retinal sensitivity with the help of full; threshold 30-2 Humphery visual fields.

Link: [No link available](#)

Nagpal M, Marlecha S, Nagpal K. Comparison of laser photocoagulation for diabetic retinopathy using 532-nm standard laser versus multispot pattern scan laser. Retina. 2010 Mar; 30(3):452-8.

Purpose: The purpose of this study was to compare the efficacy, collateral damage, and convenience of panretinal photocoagulation for proliferative diabetic retinopathy or severe nonproliferative diabetic retinopathy using a 532-nm solid-state green laser (GLX) versus a multispot 532-nm pattern scan laser (PASCAL®).

Methods: This study was a prospective randomized clinical trial. Sixty patients with bilaterally symmetrical proliferative diabetic retinopathy or severe nonproliferative diabetic retinopathy participated. Each patient underwent panretinal photocoagulation: one eye with GLX and the other with PASCAL®, two sittings per eye. Grade 3 burns with a 200-µm spot size were placed with both modalities. The fluence, pain using the visual analog scale, time, laser spot spread with infrared images, and retinal sensitivity were compared.

Results: Pattern scan laser and GLX required an average fluence of 40.33 vs 191 J/cm² respectively. Average time required per sitting was 1.43 minutes with PASCAL and 4.53 minutes with GLX. Average visual analog scale reading for GLX was 4.6, whereas that for PASCAL was 0.33. Heidelberg retinal angiography images showed the spot spread as being 430 versus 310 micron at 3 months with GLX and PASCAL. The eyes treated with PASCAL showed higher average retinal sensitivity in the central 15 degrees and 15 degrees to 30 degree zones (25.08 and 22.08 dB, respectively) than the eyes treated with GLX (23.16 and 17.14 dB), respectively.

Conclusion: Pattern scan laser showed lesser collateral damage and similar regression of retinopathy compared with GLX. Pattern scan laser treatment was less time consuming and less painful for the patient compared with GLX.

Significance: This study demonstrates the efficiency and safety of the PASCAL® photocoagulation system compared to single spot conventional laser. In addition, the PASCAL® system allowed faster procedures and induced less discomfort. The authors state that “PASCAL has ushered in a paradigm shift in retinal photocoagulation delivery systems”.

Link:http://journals.lww.com/retinajournal/Abstract/2010/03000/COMPARISON_OF_LASER_PHOTOCOAGULATION_FOR_DIABETIC.12.aspx

Salman AG. Pascal laser versus conventional laser for treatment of diabetic retinopathy. Saudi Journal of Ophthalmology. 2011 Apr;25(2):175-9.

Purpose: To compare the safety and efficacy of Pascal laser photocoagulation in comparison with the conventional laser photocoagulation in the treatment of diabetic retinopathy.

Patients and Methods: A prospective randomized case series study was done on 120 procedures done in 120 patients divided into two main groups, group A, patients undergoing focal or modified grid macular laser and group B, patients undergoing panretinal photocoagulation (PRP). Each of the two groups were subdivided into two subgroups randomly in the first we used conventional laser photocoagulation (groups A1 and B1) and in the other we used Pascal laser photocoagulation (groups A2 and B2).

Results: Procedures in groups A1,2 and in groups B1,2 had successful outcomes. Significantly higher powers were required with the Pascal (groups A2 and B2) than with conventional laser (groups A1 and B1) ($p < 0.001$) in eyes that underwent PRP and focal/modified grid macular treatment with both systems. No adverse events were noted in all groups.

Conclusion: The Pascal photocoagulator is safe, rapid, effective, with rapid learning and had short exposure time. Although the shorter pulse duration of the Pascal necessitates the use of a higher power, it is not associated with adverse effects.

Significance: PASCAL® enables faster but equally safe and efficacious treatments. The short pulse duration requires a higher laser power but the cumulative power is significantly less and is therefore not associated with adverse effects.

Link: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3729574/>

Muraly P, Limbad P, Srinivasan K, Ramasamy K. Single session of Pascal versus multiple sessions of conventional laser for panretinal photocoagulation in proliferative diabetic retinopathy: a comparative study. Retina. 2011 Jul-Aug;31(7):1359-65.

Background: Panretinal photocoagulation remains the gold standard for treatment of proliferative diabetic retinopathy, which can be done in a single session or in multiple sessions. However, because of different reasons, single session is less frequently practiced. We describe the results of a single session of pattern scan laser versus multiple sessions of conventional laser in cases of proliferative diabetic retinopathy.

Methods: A prospective study was performed on 50 patients (100 eyes), in whom proliferative diabetic retinopathy was diagnosed recently. Two eyes of an individual patient were randomly assigned, one for a single session of panretinal photocoagulation using pattern scan laser and the other for multiple sessions of conventional laser.

Results: Our study confirms that single session is effective and even better than conventional laser in relation to the effect of treatment.

Conclusion: Complications and the associated pain are less; thus, the patient's acceptance of PASCAL was high, and a single session was well tolerated with topical anesthesia alone.

Significance: This study confirms the safety and efficiency of single session panretinal photocoagulation using the PASCAL® system. Patients demonstrate higher tolerance to PASCAL® treatment because of the reduced pain.

Link:http://journals.lww.com/retinajournal/Abstract/2011/07000/SINGLE_SESSION_OF_PASCAL_VERSUS_MULTIPLE_SESSIONS.17.aspx?trendmd-shared=0

Jojo V, Mohamed M. Re: Single session of Pascal versus multiple sessions of conventional laser for panretinal photocoagulation in proliferative diabetic retinopathy: a comparative study. Retina. 2012 Sep;32(8):1697-8; author reply 8-9.

Letter to: Muraly P, Limbad P, Srinivasan K, Ramasamy K. Single session of Pascal versus multiple sessions of conventional laser for panretinal photocoagulation in proliferative diabetic retinopathy: a comparative study. Retina. 2011 Jul-Aug;31(7):1359-65

Significance: The authors comment on the methodologic differences between the treatments performed with the PASCAL® and the conventional laser. They argue that the outcomes reported can not be supported by the methodology used.

Link: http://journals.lww.com/retinajournal/Citation/2012/09000/To_The_Editor.45.aspx

Yamakawa M, Nozaki M, Sato R, Morita H, Yoshida M, Ogura Y. Comparison of outcomes of conventional laser versus pascal laser for diabetic retinopathy. *Nippon Ganka Gakkai Zasshi*. 2014 Apr;118(4):362-7.

Purpose: To assess the efficacy and outcomes of PASCAL laser versus conventional laser for panretinal photocoagulation (PRP) in the treatment of diabetic retinopathy.

Methods: A retrospective chart review of 26 eyes at Nagoya City University Hospital which had undergone PRP with a follow-up of at least 6 months. The study endpoints were change in visual outcome, central retinal thickness (CRT), laser setting parameters, and total number of PRP and complications.

Results: Ten eyes of conventional laser-treated patients and 16 eyes of PASCAL-treated patients were reviewed. There were significant differences in the laser treating parameters between the PASCAL laser treatment and conventional laser treatment in power, duration, number of sessions and total spot counts including additional treatments ($p < 0.01$). Among the patients who had undergone PRP in the PASCAL group there was an average of 4195 spots, larger than the conventional laser group ($p < 0.0001$). There were no significant differences between PASCAL group and conventional laser group in complications and in ability to prevent visual loss and CRT.

Conclusion: Our data suggested that PASCAL laser might need tighter spacing and more total spot counts to achieve an effect equal to traditional conventional laser treatment.

[Article in Japanese]

Link: [No article available](#)

Seymenoglu RG, Ulusoy MO, Baser EF. Safety and efficacy of panretinal photocoagulation in patients with high-risk proliferative diabetic retinopathy using pattern scan laser versus conventional YAG laser. The Kaohsiung Journal of Medical Sciences. 2016 Jan;32(1):22-6.

Abstract: The purpose of the study was to compare the results of panretinal photocoagulation (PRP) using the pattern scan laser (PASCAL) in a single setting versus multiple sessions of standard YAG laser in patients with proliferative diabetic retinopathy. Charts of 35 eyes that were treated with the PASCAL and an equal number of eyes that were treated with conventional laser were retrospectively reviewed. The whole PRP treatment was performed in one session in the PASCAL group, whereas all the patients in the conventional-laser group completed the entire PRP treatment in two or three sessions. Persistence and/or recurrence of neovascularization, complications encountered, total number of laser spots, and mean power used were compared. Patients treated with the PASCAL received significantly higher number of laser spots than those treated with conventional laser (2885 vs. 1642, $p < 0.001$). The PASCAL and conventional-laser systems required an average power of 650 mW and 330 mW, respectively ($p < 0.001$). Patients treated with the PASCAL showed similar rates of treatment failure within 12 months of follow-up compared with patients treated with conventional laser (14% vs. 11%, $p > 0.05$). In the PASCAL group, vitreous hemorrhage, neovascular glaucoma, retinal hemorrhage, and choroidal detachment were reported in two, two, one, and two patients, respectively, whereas only one each vitreous hemorrhage and neovascular glaucoma were encountered in the conventional-laser group. Our study reports that single-session PRP with the PASCAL has similar efficacy compared with conventional laser, and has a favorable side-effect profile.

Significance: This study shows additional evidence about the safety and efficiency of single session panretinal photocoagulation with PASCAL® system compared to multisession conventional YAG photocoagulation.

Link: <http://www.sciencedirect.com/science/article/pii/S1607551X15002788>

Mahgoub MM, Macky TA. The Effect of Laser Panretinal Photocoagulation on Diabetic Macular Edema Using the Pascal® Photocoagulator versus the Conventional Argon Laser Photocoagulator. Ophthalmologica. 2016;235(3):137-40.

Purpose: The aim of this study was to compare the effect of panretinal photocoagulation for proliferative diabetic retinopathy (PDR) on diabetic macular edema (DME) using a Pascal® Photocoagulator (PP) or a conventional argon laser photocoagulator (CALP).

Methods: Eighty eyes with PDR and center-involving DME were randomized to PP or CALP. Both groups had baseline assessment of best-corrected visual acuity (BCVA) and were examined with optical coherence tomography and fluorescein angiography.

Results: The mean number of laser shots for the PP and CALP groups was 1,726.10 and 752.00 at session 1 and 1,589.00 and 830.00 ($p < 0.001$) at session 2, respectively. The mean central foveal thickness (CFT) at baseline was 306 +/- 100 and 314 +/- 98 for the PP and CALP groups, respectively. At 8 weeks, the mean CFT was 332 +/- 116 and 347 +/- 111 for the PP and CALP groups, respectively ($p > 0.05$). The mean BCVA was similar during the study period with no significant difference between the groups ($p > 0.05$).

Conclusion: PP and CALP had similar effects on DME in PDR eyes and were equally safe with no significant increase in CFT.

Significance: This is another study confirming the advantages of the photocoagulation procedure using the PASCAL® system over a conventional (single spot) laser. Although visual and structural parameters showed similar results, the PASCAL® allowed for faster and less painful treatments, while maintained the safety of the procedure.

Link: <http://www.karger.com/Article/Abstract/444594>

PASCAL Photocoagulation System – Pascal Imaging

Muqit MM, Gray JC, Marcellino GR, Henson DB, Young LB, Charles SJ, et al. Fundus autofluorescence and Fourier-domain optical coherence tomography imaging of 10 and 20 millisecond Pascal retinal photocoagulation treatment. *British Journal of Ophthalmology*. 2009 Apr;93(4):518-25.

Aim: To report the evolution of pattern scanning laser (Pascal) photocoagulation burns in the treatment of diabetic retinopathy, using Fourier-domain optical coherence tomography (FD-OCT) and fundus autofluorescence (AF), and to evaluate these characteristics with clinically visible alterations in outer retina (OR) and retinal pigment epithelium (RPE).

Methods: Standard red-free and colour fundus photography (FP), FD-OCT, and fundus camera-based AF were performed in 17 eyes of 11 patients following macular and panretinal photocoagulation (PRP).

Results: One hour following Pascal application, visibility of threshold burns on FP was incomplete. AF enabled visualisation of complete treatment arrays at 1 h, with hypoautofluorescence at sites of each laser burn. AF signals accurately correlated with localised increased optical reflectivity within the outer retina on FD-OCT. AF signals became hyperautofluorescent at 1 week, and corresponded on FD-OCT to defects at the junction of the inner and outer segments of the photoreceptors (JI/OSP) and upper surface of RPE. A 10 ms macular laser pulse produced a localised defect at the level of JI/OSP and RPE. Macular and 20 ms PRP burns did not enlarge at 1 year's and 18 months' follow-up respectively.

Conclusions: We report the in-vivo spatial localisation and clinical correlation of medium-pulse Pascal photocoagulation burns within outer retina and RPE, using high-resolution FD-OCT and AF. Ophthalmoscopically invisible and threshold Pascal burns may be accurately localised and mapped by AF and FD-OCT, with monitoring over time.

Significance: Autofluorescence and optical coherence tomography showed that PASCAL 10-20 ms burns produce well-circumscribed and highly localized lesions. Analysis of individual spots of PASCAL arrays demonstrates a uniform effect within the outer retina and major effect in the retinal pigment epithelium. Burns do not enlarge over time.

Link: <http://bj.o.bmj.com/content/93/4/518.long>

Bolz M, Kriechbaum K, Simader C, Deak G, Lammer J, Treu C, et al. In vivo retinal morphology after grid laser treatment in diabetic macular edema. *Ophthalmology*. 2010 Mar;117(3):538-44.

Purpose: To analyze immediate in vivo intraretinal morphologic changes secondary to standardized grid photocoagulation using spectral domain optical coherence tomography (SD OCT).
DESIGN: Prospective clinical trial.

Participants: Thirteen consecutive patients with treatment-naive clinically significant diabetic macular edema (DME).

Methods: Before and 1 day after standardized grid photocoagulation using the PASCAL® system (Pattern Scan Laser, OptiMedica Corporation, Santa Clara, CA), Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany) examinations based on an eye-tracking system, infrared fundus imaging, color fundus photography, and biomicroscopy were performed. A standardized visual acuity assessment (Early Treatment Diabetic Retinopathy Study protocol) and fluorescein angiography were performed at baseline.

Main Outcome Measures: Morphologic changes secondary to grid laser treatment.

Results: One day after laser therapy, immediate morphologic alterations of only the outer retinal layers, that is, the retinal pigment epithelium (RPE), the photoreceptor layer (PRL), and the outer nuclear layer (ONL), were observed. The shape of the laser-induced lesions did not show a sagittal alteration pattern throughout all 3 of the layers, however, but rather seemed to follow an oblique pathway throughout the ONL, changing direction at the level of the external limiting membrane and proceeding sagittally through the PRL and RPE. These morphologic changes also induced biometric changes, such as a decrease in central retinal thickness combined with local thickening at the lesion site, especially in the PRL.

Conclusions: Spectral domain optical coherence tomography provides new insight into the immediate morphologic changes after laser treatment using the PASCAL laser system. Standardized grid photocoagulation induces characteristic homogenous alteration in the neurosensoric retinal layers. Biometric changes, indicating an immediate effect, were observed within 1 day after treatment.

Significance: This study demonstrates in-vivo that photocoagulation effects induced by the PASCAL system immediately after the photocoagulation are limited to the outer nuclear layer and retinal pigment epithelium. The specific localization is likely to relate to the short pulse duration which limits the spread of heat and minimizes collateral damage.

Link: <http://www.sciencedirect.com/science/article/pii/S0161642009008434>

Muqit MM, Gray JC, Marcellino GR, Henson DB, Young LB, Patton N, et al. In vivo laser-tissue interactions and healing responses from 20- vs 100-millisecond pulse Pascal photocoagulation burns. *Archives of Ophthalmology*. 2010 Apr;128(4):448-55.

Objectives: To compare in vivo burn morphologic features and healing responses of Pascal 20- and 100-millisecond panretinal photocoagulation (PRP) burns in proliferative diabetic retinopathy.

Design: Prospective randomized controlled trial with 24 eyes assigned to either 20- or 100-millisecond Pascal PRP. Fundus autofluorescence and Fourier domain optical coherence tomography (FD-OCT) were performed 1 hour and 2 and 4 weeks after treatment. Main outcome measures included burn morphologic features on FD-OCT and greatest linear diameter (GLD) of laser burns as evaluated in 6 standard Early Treatment of Diabetic Retinopathy Study photographic fields using autofluorescence.

Results: The contemporaneous increase in autofluorescence is observed with increasing pulse duration. Differences in mean GLD between 100- and 20-millisecond burns were 63 μm at 1 hour and 198 μm at 4 weeks ($P < .001$ for both). At 4 weeks, all burns corresponded to defects at the junction of inner and outer segments of photoreceptors (JI/OSP) and apical retinal pigment epithelium. After 4 weeks, the GLD of 20-millisecond burns reduced significantly by 35% ($P < .001$), with no change in 100-millisecond burns.

Conclusions: All burns initially appear as equivalent square-edged, columnar foci of hyperreflectivity in the outer retina. Pascal 20-millisecond burns progressively reduce in size, and this suggests a novel healing response localized to the JI/OSP and apical retinal pigment epithelium. The higher-fluence 100-millisecond burns develop larger defects due to thermal blooming and collateral damage.

Significance: This study shows for the first time in humans that 20 millisecond burns, using the PASCAL® system, allows the tissues to undergo a healing response that does not occur after standard-duration photocoagulation. The healing process manifests itself by a reduction in burn size and no significant disruption in the inner retina and basal retinal pigment epithelium.

Link: <http://archophth.jamanetwork.com/article.aspx?articleid=425282>

Deak GG, Bolz M, Kriechbaum K, Prager S, Mylonas G, Scholda C, et al. Effect of retinal photocoagulation on intraretinal lipid exudates in diabetic macular edema documented by optical coherence tomography. *Ophthalmology*. 2010 Apr;117(4):773-9.

Purpose: To study the changes in the distribution and morphologic features of intraretinal microexudates after macular photocoagulation.

Design: Prospective cohort study.

Participants: Thirteen treatment-naive patients with clinically significant macular edema in type 2 diabetes.

Methods: Patients were treated with focal macular photocoagulation. Changes in the localization of hyperreflective foci were analyzed by spectral domain (SD) optical coherence tomography (OCT) during follow-up at day 1, week 1, and months 1, 2, 3, and 4 in defined areas. Further, fundus photography and infrared imaging were performed at all visits and findings were correlated to OCT results.

Main Outcome Measures: Changes in retinal morphologic features detected in OCT.

Results: A dynamic change in the distribution pattern of hyperreflective foci was observed over 4 months after the photocoagulation. With the decrease of retinal thickness, the dots either resolved completely or became confluent at the apical border of the outer nuclear layer, and finally formed ophthalmoscopically detectable hard exudates during extended follow-up. In the event of retinal thickening despite laser treatment, the hyperreflective dots maintained their previous distribution throughout all retinal layers. As a fourth response, dissemination of plaques of hard exudates into multiple, separate, hyperreflective foci were detected.

Conclusions: Hyperreflective foci in the retina seem to represent precursors or components of hard exudates. Their specific localization depends greatly on the presence of microvascular extravasation and intraretinal fluid accumulation. Retinal photocoagulation has a major impact on retinal edema and subsequently on the distribution of intraretinal lipid deposits.

Significance: This study demonstrates the effectiveness of PASCAL® laser in managing retinal edema, and shows an effect on intraretinal lipid deposits.

Link: <http://www.sciencedirect.com/science/article/pii/S0161642009010926>

Kriechbaum K, Bolz M, Deak GG, Prager S, Scholda C, Schmidt-Erfurth U. High-resolution imaging of the human retina in vivo after scatter photocoagulation treatment using a semiautomated laser system. *Ophthalmology*. 2010 Mar;117(3):545-51.

Purpose: To image the ultrastructural morphology of retinal laser effects and their healing response in vivo using spectral domain optical coherence tomography (SD-OCT).

Design: Prospective, interventional study.

Participants: Ten patients undergoing panretinal photocoagulation for proliferative diabetic retinopathy.

Methods: Panretinal photocoagulation (PRP) was performed using a semiautomated patterned scanning laser system providing a raster of effects with homogenous intensity. Retinal morphology and localization of effects owing to laser-tissue interaction were imaged at 1 day, 1 week, and at monthly intervals for 6 months. The characteristic, specific structural changes during the healing process were followed over time using an SD-OCT device (Spectralis OCT) allowing for high-resolution raster scanning of the entire lesion pattern with identification of identical retinal sites (tracking modality).

Main Outcome Measures: Retinal morphology and localization of effects of photocoagulation on SD-OCT images.

Results: At day 1 after PRP, the photocoagulation effects were sharply delineated from the surrounding unaffected retina and all spots seemed to be identical in size and location. The area of tissue destruction was confined to the outer retinal layers, extending from the outer nuclear layer (ONL) to the retinal pigment epithelium (RPE). At 1 week, images showed a progressive loss of the affected outer retinal layers, namely, the ONL and the outer plexiform layer. Concomitant distortion of the inner nuclear and plexiform layers generated a pattern of "archways" between adjacent laser spots. The photoreceptor layers (PRL) seemed to be eliminated in the photocoagulated area, particularly at the borders of each lesion. The lesion center contained a condensed RPE and PRL segment. The ONL recovered partially, but the PRL inner and outer segments remained absent. During the long-term follow-up, RPE cells migrated to the center of the lesion, forming a hyperplastic scar.

Conclusions: The characteristic morphology of retinal photocoagulation effects in vivo and over time was identified for the first time in human eyes using SD-OCT. The OCT imaging demonstrated a well-defined reproducible area of destruction confined to the outer retinal layers. Healing proceeded as the condensation of the RPE and PRL in the lesion center.

Significance: This study shows that the PASCAL® photocoagulation system enables regularly spaced and similarly structured spots according to SD-OCT. PASCAL® photocoagulation preserves inner retinal layers with the treatment effects being observed from the outer plexiform layer to the retinal pigment epithelium.

Link: <http://www.sciencedirect.com/science/article/pii/S0161642009008392>

Muqit MM, Gray JC, Marcellino GR, Henson DB, Young LB, Patton N, et al. Barely visible 10-millisecond pascal laser photocoagulation for diabetic macular edema: observations of clinical effect and burn localization. *American Journal of Ophthalmology*. 2010 Jun;149(6):979-86 e2.

Purpose: To investigate the morphologic features and clinical efficacy of barely visible Pascal® (Optimedica Corporation) photocoagulation burns in diabetic macular edema (DME) using Fourier-domain optical coherence tomography (FD OCT) and fundus autofluorescence (AF).

Design: Interventional case series.

Methods: Retrospective evaluation of 10 eyes with newly diagnosed DME that underwent barely visible Pascal photocoagulation using an array of 10-micron, 10-millisecond photocoagulation burns. FD OCT and camera-based AF was performed at baseline and at 1 hour, 2 weeks, 4 weeks, and 12 weeks after laser. Changes in retinal thickening after laser treatment were measured using retinal thickness maps within the treated sector and the central foveal subfield.

Results: At 1 hour after treatment, burns were visualized partially with clinical biomicroscopy. AF demonstrated spots lacking autofluorescence that confirmed effective laser uptake within the Pascal arrays. Sequential changes in hyperreflectivity on FD OCT correlated with morphologic alterations seen on AF. Burns became increasingly hyperautofluorescent between 2 and 4 weeks. There were significant reductions in the retinal thickness within treated sectors on FD OCT at 2 weeks (26 +/- 32 micron; P = .012) and 3 months after laser (20 +/- 21 micron; P = .02) compared with baseline. Clinical biomicroscopic reduction of DME was the most common finding in 80%.

Conclusions: Barely visible 10-millisecond Pascal laser seems to produce an effect at the level of the inner and outer photoreceptor segments and apical retinal pigment epithelium, with minimal axial and lateral spread of burns. FD OCT confirmed spatial localization of AF signal changes that correlated with laser burn-tissue interactions over 3 months. The technique of lower-fluence barely visible 10-millisecond laser may reduce retinal edema within affected sectors and effectively treat DME with minimization of scar formation.

Significance: Barely visible short pulse PASCAL® photocoagulation of the macula, produces highly localized retinal lesions and effective treatment outcomes for patients with diabetic macular edema. Decreasing the cumulative laser power by the use of short pulse durations, induces less tissue damage while retaining the therapeutic effect.

Link: <http://www.sciencedirect.com/science/article/pii/S0002939410000747>

Muqit MM, Denniss J, Nourrit V, Marcellino GR, Henson DB, Schiessl I, et al. Spatial and spectral imaging of retinal laser photocoagulation burns. *Invest Ophthalmol Vis Sci.* 2011 Feb;52(2):994-1002.

Purpose: To correlate in vivo spatial and spectral morphologic changes of short- to long-pulse 532 nm Nd:YAG retinal laser lesions using Fourier-domain optical coherence tomography (FD OCT), autofluorescence (AF), fluorescein angiography (FA), and multispectral imaging.

Methods: Ten eyes with treatment-naive preproliferative or proliferative diabetic retinopathy were studied. A titration grid of laser burns at 20, 100, and 200 milliseconds was applied to the nasal retina and laser fluence titrated to produce four grades of laser lesion visibility: subvisible (SV), barely visible (BV, light-gray), threshold (TH, gray-white), and suprathreshold (ST, white). The AF, FA, FD-OCT, and multispectral imaging were performed 1 week before laser, and 1 hour, 4 weeks, and 3 and 6 months post-laser. Multispectral imaging measured relative tissue oxygen concentration.

Results: Laser burn visibility and lesion size increased in a linear relationship according to fixed fluence levels. At fixed pulse durations, there was a semilogarithmic increase in lesion size over 6 months. At 20 milliseconds, all grades of laser lesion were reduced significantly in size after 6 months: SV, 51%; BV, 54%; TH, 49%; and ST, 50% ($P < 0.001$), with retinal pigment epithelial proliferation and photoreceptor infilling. At 20 milliseconds, there was healing of photoreceptor inner segment/outer segment junction layers compared with 100- and 200-millisecond lesions. Significant increases in mean tissue oxygenation (range, four to six units) within the laser titration area and in oxygen concentration across the laser lesions ($P < 0.01$) were detected at 6 months.

Conclusions: For patients undergoing therapeutic laser, there may be improved tissue oxygenation, higher predictability of burn morphology, and more spatial localization of healing responses of burns at 20 milliseconds compared with longer pulse durations over time.

Significance: This study demonstrated significant healing responses with reduction in burn size at lower levels of clinical visible burn using the PASCAL® system with 20 milliseconds pulse. This evidence highlights the positive role of shorter pulse durations in photocoagulation.

Link: <http://iovs.arvojournals.org/article.aspx?articleid=2128368>

Han DP, Croskrey JA, Dubis AM, Schroeder B, Rha J, Carroll J. Adaptive optics and spectral-domain optical coherence tomography of human photoreceptor structure after short-duration Pascal macular grid and panretinal laser photocoagulation. *Archives of Ophthalmology*. 2012 Apr;130(4):518-21.

Abstract: To understand the effect of therapeutic doses of laser application on the neurosensory retina, detailed histologic and optical coherence tomographic (OCT) evaluations have been used in both animal models and the human eye. We sought to evaluate photoreceptor structure associated with laser photocoagulation lesions using 2 high-resolution retinal imaging tools: adaptive optics (AO) and spectral-domain OCT (SD-OCT).

Significance: Retinal imaging after Pascal photocoagulation shows that photoreceptors mosaic outside the lesion area are unaffected, indicating that the PASCAL® laser does not produce lesions beyond the intended area.

Link: <http://archophth.jamanetwork.com/article.aspx?articleid=1150910>

Inagaki K, Ohkoshi K, Ohde S. Spectral-domain optical coherence tomography imaging of retinal changes after conventional multicolor laser, subthreshold micropulse diode laser, or pattern scanning laser therapy in Japanese with macular edema. *Retina*. 2012 Sep;32(8):1592-600.

Purpose: To perform optical coherence tomography imaging of retinal healing after conventional multicolor laser, pattern scanning laser, or micropulse laser treatment and compare the characteristics of each method.

Methods: This was a single-center interventional case series study. Twenty-nine patients with macular edema underwent laser photocoagulation. Changes of retinal morphology because of laser-tissue interaction were assessed within 3 months by using a spectral-domain optical coherence tomography.

Results: Immediately after conventional multicolor laser or pattern scanning laser treatment, a hyperreflective band appeared at the laser sites. The photoreceptor inner segment-outer segment line disappeared in all the patients treated with a conventional multicolor laser, but was intact in 22.2% (2/9 eyes) after pattern scanning laser. From 1 week to 1 month, the bands resolved. At 3 months, recovery of the inner segment-outer segment line surrounding the laser site was seen in all patients after conventional grid photocoagulation and pattern scanning laser. Retinal morphology did not change at any time during the observation period after subthreshold micropulse diode laser photocoagulation.

Conclusion: The characteristic in vivo effects of retinal photocoagulation were monitored over time by spectral-domain optical coherence tomography. Changes of retinal morphology appeared less intense after pattern scanning laser than conventional grid laser treatment.

Significance: Pascal photocoagulation appears to cause less structural change in the outer retina than conventional laser photocoagulation. The lack of any detectable change in retinal morphology after micropulse laser treatment suggests a limited therapeutic effect in some patients and may relate to the absence of titration with micropulse, resulting in some treatments falling below the therapeutic range.

Link: <http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=2012&issue=09000&article=00020&type=abstract>

Mylonas G, Bolz M, Kriechbaum K, Treu C, Deak G, Lammer J, et al. Retinal architecture recovery after grid photocoagulation in diabetic macular edema observed in vivo by spectral domain optical coherence tomography. *Retina*. 2013 Apr;33(4):717-25.

Purpose: To identify the morphologic changes secondary to macular grid photocoagulation in diabetic macular edema in vivo using spectral domain optical coherence tomography.

Methods: In this prospective cohort study, 13 consecutive patients with vision loss because of clinically significant macular edema associated with diabetes mellitus Type 2 underwent grid laser treatment (PASCAL). Best-corrected visual acuity, Spectralis optical coherence tomography, infrared fundus imaging, and biomicroscopy were performed at baseline, Day 1, Week 1, and Months 1, 2, and 3 after treatment. Fluorescein angiography was performed at baseline and at 3 months.

Results: Mean central 1-mm thickness decreased significantly from 438 +/- 123 μm (mean +/- SD) at baseline to 391 +/- 111 μm ($P < 0.05$) at 3 months with a nonsignificant trend of best-corrected visual acuity improvement. A wipeout of the photoreceptor layer and the inner segment/outer segment line together with an alteration of the overlaying outer nuclear layer and external limiting membrane was seen at Day 1. The lesion was reduced to a focal hyperreflective deposit on the retinal pigment epithelium boundary. In 55% of lesions, the external limiting membrane as well as the previously interrupted inner segment/outer segment line revealed intact continuity at Month 3. In some areas, repair was incomplete indicated by a focal condensation interrupting the inner segment/outer segment line in the lesion center.

Conclusion: In vivo imaging of morphologic lesion repair in human eyes after PASCAL grid laser of diabetic macular edema demonstrates progressive restoration of the external limiting membrane and inner segment/outer segment integrity as previously described in animal models.

Significance: This study demonstrates that PASCAL® photocoagulation system is effective in resolving diabetic macular edema with the localized nature of the burns allowing for rearrangement of the neurosensory retina and some degree of retinal recovery.

Link: http://journals.lww.com/retinajournal/Abstract/2013/04000/RETINAL_ARCHITECTURE_RECOVERY_AFTER_GRID.5.aspx

Lammer J, Bolz M, Baumann B, Pircher M, Gotzinger E, Mylonas G, et al. Imaging retinal pigment epithelial proliferation secondary to PASCAL photocoagulation in vivo by polarization-sensitive optical coherence tomography. *American Journal of Ophthalmology*. 2013 Jun;155(6):1058-67 e1.

Purpose: To image the retinal pigment epithelium (RPE) after macular laser and to monitor healing responses over time in vivo in patients with diabetic maculopathy using polarization-sensitive optical coherence tomography (OCT). DESIGN: Prospective, nonrandomized clinical trial.

Methods: In this single-center trial (Department of Ophthalmology and Optometry, Medical University of Vienna, Vienna, Austria), 13 patients (13 eyes) underwent grid photocoagulation for diabetic maculopathy. Retinal healing processes were continuously followed over the course of 3 months. A polarization-sensitive OCT prototype was used, allowing detection and measurement of the RPE changes based on their specific polarization-scrambling qualities.

Results: After 1 day, the intraretinal photocoagulation lesions were sharply demarcated, whereas RPE changes were rather subtle. At 1 week, all lesions exhibited traction of the inner retinal layers toward the RPE and loss of photoreceptor cells. In tissue-sensitive polarization-sensitive OCT imaging, polarization-scrambling columns were found at the level of the RPE. During follow-up, different healing responses were seen in the polarization-scrambling RPE layer, ranging from hyperproliferation to focal atrophy.

Conclusion: Because of the properties of the polarization state of backscattered light, polarization-sensitive OCT revealed specific morphologic changes in the RPE and outer retinal layers secondary to retinal laser treatment undetectable with intensity-based spectral-domain OCT. The increase in polarization-scrambling tissue over the course of 3 months indicates a more intense healing reaction and proliferation of RPE cells than previously characterized in rodent studies.

Significance: The present study uses an imaging technique (Polarization sensitive OCT) to show the dynamics in healing response after PASCAL® photocoagulation. The PASCAL® system is effective in limiting the photocoagulation effect to the RPE and outer retina.

Link: <http://www.sciencedirect.com/science/article/pii/S0002939413000196>

Paulus YM, Kaur K, Egbert PR, Blumenkranz MS, Moshfeghi DM. Human histopathology of PASCAL laser burns. *Eye (Lond)*. 2013 Aug;27(8):995-6.

Abstract: We present the first human histopathological and immunohistochemical correlation after laser injury with semi-automated pattern scanning retinal photocoagulation (PASCAL).

Significance: Photocoagulation lesions induced by PASCAL® preserve inner retinal layers in contrast to the common damage of these layers induced by conventional photocoagulation.

Link: <http://www.nature.com/eye/journal/v27/n8/full/eye2013100a.html>

Mitsch C, Pemp B, Kriechbaum K, Bolz M, Scholda C, Schmidt-Erfurth U. Retinal morphometry changes measured with spectral domain- optical coherence tomography after pan-retinal photocoagulation in patients with proliferative diabetic retinopathy. Retina. 2015 Nov 11.

Purpose: To identify the effects of pan-retinal laser treatment on the integrity of neurosensory retinal layers.

Methods: Patients were examined with fluorescence angiography after a standardized examination for diabetic retinopathy and a peripapillary ring scan with spectral domain optical coherence tomography. A single-session pan-retinal photocoagulation was performed using the PASCAL pattern scanning argon laser applying a minimum of 1,500 spots. Optical coherence tomography was evaluated more than 6 months.

Results: Eighteen eyes of 12 consecutive patients with new onset, treatment-naive proliferative diabetic retinopathy secondary to diabetes Type 2 were treated and retinal optical coherence tomography morphology evaluated. Retinal nerve fiber layer thickness increased statistically significantly from baseline to week 1, when it reached its peak. The combined thickness of the outer plexiform and the inner nuclear layers and the combined thickness of the inner plexiform and the ganglion cell layers showed no relevant changes. The combined thickness of the retinal pigment epithelium and the photoreceptor cell layers decreased at month 1 followed by a steady increase in thickness, which remained below baseline values over time.

Conclusion: Pan-retinal photocoagulation in proliferative diabetic retinopathy leads to a slowly reversible, marked biological response with statistically significant morphometric changes detected by spectral domain optical coherence tomography. Swelling of the retinal nerve fiber and outer nuclear layers induce an increase in peripapillary total retinal thickness. Simultaneously, the photoreceptor and retinal pigment epithelium layers decrease in thickness. These changes indicate diffuse retinal inflammation after pan-retinal laser therapy.

Significance: This study reports morphometric changes of the retinal nerve fiber layers after panretinal photocoagulation with the Pascal® Laser System, with a peak in retinal thickness one week after treatment.

Link: <http://journals.lww.com/retinajournal/pages/articleviewer.aspx?year=9000&issue=00000&article=97721&type=abstract>

PASCAL® Laser Systems – Patterned Scanning Laser Trabeculoplasty (PSLT)

Chung HJ, Park HY, Kim SY. Comparison of laser iridotomy using short duration 532-nm Nd: YAG laser (PASCAL) vs conventional laser in dark irides. *International Journal of Ophthalmology*. 2015;8(2):288-91.

Aim: To evaluate the outcome of laser iridotomy using 532-nm Nd: YAG laser (PASCAL) with short pulse duration and Nd: YAG laser compared to conventional combined laser iridotomy.

Methods: Retrospective, nonrandomized, comparative case series. Forty-five eyes of 34 patients underwent laser iridotomy. Twenty-two eyes underwent iridotomy using short duration PASCAL and Nd: YAG laser, and 23 eyes underwent iridotomy using conventional combined laser method. The average settings of PASCAL were 60 micron and 700-900 mW with a short duration of 0.01s to reduce the total applied energy. The conventional laser was 50 micron and 700-900 mW for 0.1s. After photocoagulation with these laser, the Nd: YAG laser was added in each group. Endothelial cell counts of pre-iridotomy and 2mo after iridotomy were measured and compared.

Results: All eyes completed iridotomy successfully. The total energy used in the PASCAL group was 1.85+/-1.17 J. Compared to conventional laser 13.25+/-1.67 J, the energy used was very small due to the short exposure time of PASCAL. Endothelial cell counts were reduced by 0.88% in the PASCAL group and 6.72% in the conventional laser group (P=0.044). The change in corneal endothelial cell counts before and after iridotomy was significant in conventional combined laser iridotomy group (P=0.004).

Conclusion: Combined PASCAL and Nd:YAG laser iridotomy is an effective and safe technique in the dark brown irides of Asians. Furthermore, the short duration of exposure in PASCAL offers the advantages of reducing the total energy used and minimizing the corneal damage.

Significance: The low cumulative energy associated with the short pulse duration PASCAL® laser provides a safe alternative to conventional laser iridotomy, with the advantage of better preserving the corneal endothelial cells.

Link: http://www.ijo.cn/gjyken/ch/reader/view_abstract.aspx?file_no=20150213&flag=1

PASCAL® Laser Systems – Application to Anterior Eye

Park YM, Lee JE, Lee JS. Efficacy of Pattern Scan Laser photocoagulation for superficial conjunctival nevi ablation. *Lasers Medical Science*. 2016 Jul;31(5):1037-9.

Abstract: This study reports the efficacy and safety of Pattern Scan Laser (PASCAL) photocoagulation in the removal of superficial conjunctival nevi. Superficial conjunctival nevi were removed from 10 eyes of 10 patients using PASCAL. The laser spots were 200 µm in size, and the power delivered ranged from 250 to 300 mW. The duration of the laser pulse was kept at the minimum needed for adequate lesion removal. The duration of the laser pulse administered to the patients varied from 100 to 200 ms. Complete removal of the conjunctival nevus was observed in all the patients after PASCAL photocoagulation. Six months after treatment, complete re-epithelialization of the overlying conjunctiva was noted. No signs of recurrence or scarring were found in any of the patients during the follow-up period. Pure thermal denaturation is the main mechanism of PASCAL photocoagulation for removal of superficial conjunctival nevi. PASCAL can be considered as an alternative to conventional argon laser treatment or surgery.

Significance: Pascal® is safe and effective for the treatment of superficial conjunctival nevi, representing a therapeutic alternative to conventional argon laser or surgery. The reduction in pulse duration enhances the predictability of the lesion size and reduces the collateral injuries.

Link: <http://link.springer.com/article/10.1007%2Fs10103-016-1915-x>

General Laser Photocoagulation Articles

Brucker AJ, Qin H, Antoszyk AN, Beck RW, Bressler NM, Browning DJ, et al. **Observational study of the development of diabetic macular edema following panretinal (scatter) photocoagulation given in 1 or 4 sittings.** *Archives of Ophthalmology.* 2009 Feb;127(2):132-40

Objective: To compare the effects of single-sitting vs 4-sitting panretinal photocoagulation (PRP) on macular edema in subjects with severe nonproliferative or early proliferative diabetic retinopathy with relatively good visual acuity and no or mild center-involved macular edema.

Methods: Subjects were treated with 1 sitting or 4 sittings of PRP in a nonrandomized, prospective, multicentered clinical trial. Main Outcome Measure Central subfield thickness on optical coherence tomography (OCT).

Results: Central subfield thickness was slightly greater in the 1-sitting group (n = 84) than in the 4-sitting group (n = 71) at the 3-day (P = .01) and 4-week visits (P = .003). At the 34-week primary outcome visit, the slight differences had reversed, with the thickness being slightly greater in the 4-sitting group than in the 1-sitting group (P = .06). Visual acuity differences paralleled OCT differences.

Conclusions: Our results suggest that clinically meaningful differences are unlikely in OCT thickness or visual acuity following application of PRP in 1 sitting compared with 4 sittings in subjects in this cohort. More definitive results would require a large randomized trial. Application to Clinical Practice These results suggest PRP costs to some patients in terms of travel and lost productivity as well as to eye care providers could be reduced.

Significance: This study suggests that panretinal photocoagulation in one sitting is as effective as multiple sittings (assuming full patient compliance). Performing PRP in one sitting is generally preferable for the patient and is not associated with a clinical disadvantage. The PASCAL® laser allows for single session PRP due to its reduced treatment time and minimal patient discomfort.

Link: <http://archophth.jamanetwork.com/article.aspx?articleid=421038>

Reviews of Laser Treatment

Alasil T, Waheed NK. Pan retinal photocoagulation for proliferative diabetic retinopathy: pattern scan laser versus argon laser. *Current Opinion in Ophthalmology*. 2014 May;25(3):164-70.

Purpose of the Review: Diabetic retinopathy is the leading cause of visual impairment in working-age adults worldwide. Pan retinal photocoagulation (PRP) has provided an effective treatment to decrease the risk of severe vision loss in patients with proliferative diabetic retinopathy for the past four decades. Pattern scan laser (PASCAL) was developed to minimize the side effects of PRP. The purpose of this review is to discuss the differences between the traditional argon laser and the PASCAL.

Recent Findings: PASCAL can achieve comparable results with the conventional argon PRP in the treatment of patients with diabetic retinopathy. The PASCAL delivery system creates well aligned arrays of retinal lesions in a shorter period. PASCAL provides amore comfortable profile when compared to the argon laser.

Summary: The PASCAL is now being substituted for the conventional argon laser for PRP in many clinics. Ophthalmologists should keep in mind that adjusting the PASCAL settings (including the duration, number, and size of laser burns) might become necessary to maintain regression and eliminate recurrence of neovascularization in patients with proliferative diabetic retinopathy. Further studies are needed to determine the parameters for optimal safety and efficacy on the PASCAL.

Link: http://journals.lww.com/co-ophthalmology/Abstract/2014/05000/Pan_retinal_photocoagulation_for_proliferative.4.aspx

Evans JR, Michelessi M, Virgili G. Laser photocoagulation for proliferative diabetic retinopathy. *The Cochrane Database of Systematic Review*. 2014;11:CD011234.

Background: Diabetic retinopathy is a complication of diabetes in which high blood sugar levels damage the blood vessels in the retina. Sometimes new blood vessels grow in the retina, and these can have harmful effects; this is known as proliferative diabetic retinopathy. Laser photocoagulation is an intervention that is commonly used to treat diabetic retinopathy, in which light energy is applied to the retina with the aim of stopping the growth and development of new blood vessels, and thereby preserving vision.

Objectives: To assess the effects of laser photocoagulation for diabetic retinopathy compared to no treatment or deferred treatment.

Search Methods: We searched CENTRAL (which contains the Cochrane Eyes and Vision Group Trials Register) (2014, Issue 5), Ovid MEDLINE, Ovid MEDLINE In-Process and Other Non-Indexed Citations, Ovid MEDLINE Daily, Ovid OLDMEDLINE (January 1946 to June 2014), EMBASE (January 1980 to June 2014), the metaRegister of Controlled Trials (mRCT) (www.controlled-trials.com), ClinicalTrials.gov (www.clinicaltrials.gov) and the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/search/en). We did not use any date or language restrictions in the electronic searches for trials. We last searched the electronic databases on 3 June 2014. **Selection Criteria:** We included randomised controlled trials (RCTs) where people (or eyes) with diabetic retinopathy were randomly allocated to laser photocoagulation or no treatment or deferred treatment. We excluded trials of lasers that are no longer in routine use. Our primary outcome was the proportion of people who lost 15 or more letters (3 lines) of best-corrected visual acuity (BCVA) as measured on a logMAR chart at 12 months. We also looked at longer-term follow-up of the primary outcome at two to five years. Secondary outcomes included mean best corrected distance visual acuity, severe visual loss, mean near visual acuity, progression of diabetic retinopathy, quality of life, pain, loss of driving licence, vitreous haemorrhage and retinal detachment.

Data Collection and Analysis: We used standard methods as expected by the Cochrane Collaboration. Two review authors selected studies and extracted data.

Main Results: We identified a large number of trials of laser photocoagulation of diabetic retinopathy (n = 83) but only five of these studies were eligible for inclusion in the review, i.e. they compared laser photocoagulation with currently available lasers to no (or deferred) treatment. Three studies were conducted in the USA, one study in the UK and one study in Japan. A total of 4786 people (9503 eyes) were included in these studies. The majority of participants in four of these trials were people with proliferative diabetic retinopathy; one trial recruited mainly people with non-proliferative retinopathy. Four of the studies evaluated panretinal photocoagulation with argon laser and one study investigated selective photocoagulation of non-perfusion areas. Three studies compared laser treatment to no treatment and two studies compared laser treatment to deferred laser treatment. All studies were at risk of performance bias because the treatment and control were different and no study attempted to produce a sham treatment. Three studies were

considered to be at risk of attrition bias. At 12 months there was little difference between eyes that received laser photocoagulation and those allocated to no treatment (or deferred treatment), in terms of loss of 15 or more letters of visual acuity (risk ratio (RR) 0.99, 95% confidence interval (CI) 0.89 to 1.11; 8926 eyes; 2 RCTs, low quality evidence). Longer term follow-up did not show a consistent pattern, but one study found a 20% reduction in risk of loss of 15 or more letters of visual acuity at five years with laser treatment. Treatment with laser reduced the risk of severe visual loss by over 50% at 12 months (RR 0.46, 95% CI 0.24 to 0.86; 9276 eyes; 4 RCTs, moderate quality evidence). There was a beneficial effect on progression of diabetic retinopathy with treated eyes experiencing a 50% reduction in risk of progression of diabetic retinopathy (RR 0.49, 95% CI 0.37 to 0.64; 8331 eyes; 4 RCTs, low quality evidence) and a similar reduction in risk of vitreous haemorrhage (RR 0.56, 95% CI 0.37 to 0.85; 224 eyes; 2 RCTs, low quality evidence). None of the studies reported near visual acuity or patient-relevant outcomes such as quality of life, pain, loss of driving licence or adverse effects such as retinal detachment. We did not plan any subgroup analyses, but there was a difference in baseline risk in participants with non-proliferative retinopathy compared to those with proliferative retinopathy. With the small number of included studies we could not do a formal subgroup analysis comparing effect in proliferative and non-proliferative retinopathy.

Authors' Conclusions: This review provides evidence that laser photocoagulation is beneficial in treating proliferative diabetic retinopathy. We judged the evidence to be moderate or low, depending on the outcome. This is partly related to reporting of trials conducted many years ago, after which panretinal photocoagulation has become the mainstay of treatment of proliferative diabetic retinopathy. Future Cochrane Reviews on variations in the laser treatment protocol are planned. Future research on laser photocoagulation should investigate the combination of laser photocoagulation with newer treatments such as anti-vascular endothelial growth factors (anti-VEGFs).

Link:

<http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD011234.pub2/abstract;jsessionid=3356E58E5E341DA272EEC1D08AA1A140.f04t03>

Yun SH, Adelman RA. Recent developments in laser treatment of diabetic retinopathy. Middle East African Journal of Ophthalmology. 2015 Apr-Jun;22(2):157-63.

Summary: Laser photocoagulation has been the mainstay of diabetic retinopathy treatment since its development in mid-20th century. With the advent of antivascular endothelial growth factor therapy, the role of laser therapy appeared to be diminished, however many advances in laser technology have been developed since. This review will describe recent advances in laser treatment of diabetic retinopathy including pattern scan laser, short-pulse duration and a reduced fluence laser, and navigated laser system for proliferative diabetic retinopathy and macular edema.

Kozak I, Luttrull JK. Modern retinal laser therapy. Saudi Journal of Ophthalmology. 2015 Apr-Jun;29(2):137-46.

Abstract: Medicinal lasers are a standard source of light to produce retinal tissue photocoagulation to treat retinovascular disease. The Diabetic Retinopathy Study and the Early Treatment Diabetic Retinopathy Study were large randomized clinical trials that have shown beneficial effect of retinal laser photocoagulation in diabetic retinopathy and have dictated the standard of care for decades. However, current treatment protocols undergo modifications. Types of lasers used in treatment of retinal diseases include argon, diode, dye and multicolor lasers, micropulse lasers and lasers for photodynamic therapy. Delivery systems include contact lens slit-lamp laser delivery, indirect ophthalmoscope based laser photocoagulation and camera based navigated retinal photocoagulation with retinal eye-tracking. Selective targeted photocoagulation could be a future alternative to panretinal photocoagulation.

Link: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4398802/>