FOCAL NAVIGATED LASER PHOTOCOAGULATION IN RETINOVASCULAR DISEASE

Clinical Results in Initial Case Series

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Purpose: To evaluate clinical results after the use of a novel integrated imaging and laser device to perform focal retinal navigated laser photocoagulation in perifoveal abnormalities and retinovascular disease.

Methods: Interventional case series of 25 consecutive eyes with perifoveal and retinovascular diseases treated with a navigated laser photocoagulator Navilas (OD-OS, Berlin, Germany). We treated eyes with perifoveal telangiectasia (n = 3), central serous chorioretinopathy (n = 2), and diabetic macular edema with focal leakage (n = 20).

Results: The treatments were performed without a contact lens and without topical anesthesia. There was no inadvertent photocoagulation of the fovea, and all laser applications accurately hit the preplanned points. Mean (± standard deviation) foveal thickness at baseline was 535 ± 171 μm and 402 ± 152 μm, respectively. Mean (± standard deviation) foveal thickness at 6 months was 318 ± 112 μm and 221 ± 127 μm, respectively. This represents a statistically significant decrease in foveal thickness (P = 0.003). Mean and median visual acuity at baseline was 20/80 and 20/50, respectively. Mean and median visual acuity at 6 months was 20/50 and 20/40, respectively, which represents a significant improvement (P = 0.011).

Conclusion: Precise retinal targeting with a navigated laser photocoagulator resulted in highly accurate perifoveal laser application and no foveal damage. At 6 months after the treatment, significant decreases in central foveal thickness and significant improvements in visual acuity were identified.

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Retinal photocoagulation is a therapeutic option for numerous retinovascular abnormalities. Despite the advances in the speed of delivery and modifications in the duration of laser applications, the precision of treatment is dependent on multiple factors, including physician’s experience and patient’s cooperation. Integration of image and laser modalities has been recently applied to retinal photocoagulation, potentially enabling superior treatment accuracy.1

The recently introduced Navilas (OD-OS, Berlin, Germany) integrates retinal imaging and a photocoagulation laser in a single device, providing image-guided and computer-assisted prepositioning, otherwise referred to as retinal navigation. The integrated device combines high-speed image capture (with wide-angle fluorescein angiography, and color and infrared imaging modes) with a therapeutic laser that is pannable across the fundus. The system consists of a fundus camera–style base unit, laser operated through a touch screen user interface, and a foot switch to fire the laser. Preoperative images are acquired with the same device, and notations on a selected fluorescein angiogram are made on the screen. These notations allow treatments to be individually tailored to the abnormality during the planning phase.
During the patient treatment phase, the same screen captures a live retinal image. A previously saved fluorescein angiogram and or a color image with the physician’s customized treatment plan is dragged onto the screen, aligned, and superimposed onto the live retinal image. The composite image is then used to confirm the marked positions for laser treatment. After removal of the previously captured image, the marked positions remain registered on the live fundus image of the patient. A contact lens can be used if desired but is not necessary for accurate treatment. The aiming beam is automatically prepositioned to the first planned laser spot, and the treatment is initiated by pressing on the foot switch. After the laser spot has been delivered, the aiming beam moves to the next marked spot, with the surgeon able to modify the position, as needed using either the joystick or touch screen. The physician can treat using either infrared or full-color illumination. Imaging of eyes with clear lenses or pseudophakic eyes is comparable with other camera systems. Infrared imaging used with this instrument penetrates mild cataracts, yielding good images, but image quality is decreased with very dense cataracts. To check the intensity of the laser application while operating in the infrared mode (which is more comfortable to the patient), the surgeon can toggle to the color mode and adjust the treatment power and or pulse width to titrate the uptake in tissue (if necessary). Posttreatment color images can also be obtained and printed or saved electronically along with the report detailing the number and location of spot and total laser energy used.

We previously described the instrument and its safety and accuracy.\(^1\) We report our initial efficacy results with the use of this new technique for the treatment of selected retinovascular abnormalities in a consecutive series of eyes with macular disease requiring focal laser in whom 6-month follow-up was obtained. For eyes with diabetic macular edema, we did not use grid laser treatment. We demonstrate that navigated laser photocoagulation is safe and effective in perifoveal disease, achieving excellent structural and functional outcomes.

Methods

This cohort represents a review of the medical records of a consecutive interventional case series of eyes with perifoveal retinal disease treated with a navigated laser photocoagulator (Navilas; OD-OS, Berlin, Germany). The study was approved by the Institutional Review Board of the University of California at San Diego and was performed at the UCSD Jacobs Retina Center. We treated eyes with perifoveal telangiectasia (n = 3), central serous chorioretinopathy (n = 2), and diabetic macular edema with focal leakage (n = 20). None of the eyes have been previously treated. All consecutive eyes had preoperative and postoperative spectral-domain optical coherence tomography (OCT) and 6 months of follow-up. The laser parameters used is this study were a spot size of 70 \(\mu m\) to 120 \(\mu m\), duration of 100 milliseconds, and power between 70 mW and 110 mW. This was based on the size of the microaneurysm or retinovascular lesion and the energy uptake by the retinal tissue during treatment. Pretreatment and posttreatment (6 months) visual acuity was measured using ETDRS (Early Treatment Diabetic Retinopathy Study) charts. Central foveal and extrafoveal retinal thickness was measured from images captured by spectral-domain OCT (Spectralis; Heidelberg Engineering, Heidelberg, Germany). A paired \(t\)-test was used for statistical comparisons before and after operation (SAS version 9.2, Cary, NC).

Results

We treated 25 eyes of 21 patients (8 women). The mean age was 46 years (range, 28–64 years). The treatments were performed without contact lens and without topical anesthesia. There was no inadvertent photocoagulation of the fovea, and all laser applications hit the preplanned points of focal leakage in all eyes. Mean (± standard deviation) central foveal thickness at baseline (before treatment) was 535 ± 171 \(\mu m\) and 402 ± 152 \(\mu m\), respectively. Mean (± standard deviation) foveal thickness at 6 months was 318 ± 112 \(\mu m\) and 221 ± 127 \(\mu m\), respectively. This represents a statistically significant decrease in foveal thickness after the treatment (\(P = 0.003\)). Mean and median visual acuity at baseline was 20/80 and 20/50, respectively. Mean and median visual acuity at 6 months was 20/50 and 20/40, respectively, which represents a significant thinning of the retina and reduction in macular edema (\(P = 0.011\)).

Exemplary Cases

Case 1: Parafoveal Telangiectasia

A 56-year-old man experienced a reduction in vision of the right eye to 20/32 associated with perifoveal telangiectasia. Medical evaluation was negative for diabetes, past radiation, or other causes of macular edema. Clinical ophthalmoscopy revealed a blunt foveal reflex in the right eye, a small lesion in the macula, and a normal examination in the left eye (Figure 1A). Fluorescein angiography demonstrated a macular lesion with a spot of hyperfluorescence next to it (Figure 1B). Spectral-domain OCT showed that the lesion...
was a macular cyst adjacent to intraretinal telangiectasia (Figure 1C, upper panel). The main leaking lesion was a retinal microaneurysm of 500 μm from the fovea. Based on the clinical and fluoroangiographic characteristics, this was diagnosed as unilateral idiopathic parafoveal telangiectasia (Group 1B).  

After explanation, the patient agreed to laser photocoagulation treatment of his right eye. Using fluorescein angiographic images, the treatment was planned on the monitor screen to target telangiectasia and use grid pattern to the adjacent area (Figure 1A). The treatment plan was superimposed onto live retina during photocoagulation.

Fig. 1. A. Left panel: pretreatment color fundus photography showing patient’s right eye with an aneurysm (arrow) and 2 foci of hard exudates in the macula. Right panel: treatment plan on fluorescein angiogram used for navigated laser photocoagulation showing where laser applications will be delivered. B. Left panel: venous laminar flow phase of fluorescein angiogram showing a macular lesion (arrow) with a hyperfluorescent spot superiorly. Right panel: late phase of fluorescein angiogram showing macular lesion with slightly enlarging hyperfluorescent spot superiorly. C. Upper panel: spectral-domain OCT macular scan showing a solitary microaneurysm (arrow) with adjacent cystic spaces corresponding to fluorescein angiographic findings. Middle panel: follow-up macular scan 3 months after the treatment showing occlusion of microaneurysm (arrow) and a laser application in the outer retina. The cystic space is filled with hyporeflective substance. Lower panel: follow-up macular scan 6 months after laser photocoagulation showing thrombosed and regressed microaneurysm (arrow) with disappearance of cystic spaces and a continuous photoreceptor layer. D. Left panel: venous laminar flow phase of fluorescein angiogram of the same eye 7 months after the treatment. Right panel: late phase of fluorescein angiogram showing lesion-free macula with mild changes at the level of the retinal pigment epithelium (arrow).
Targeted laser applications were delivered in the area outlined on the treatment plan using the following parameters: spot size, 120 μm; duration, 100 milliseconds; power, 100 mW. No topical anesthetic was used because this was a non–contact lens treatment. After 3 months, retinal cysts began to regress, and 6 months after the treatment, they disappeared entirely; one of the treated microaneurysms was documented to be thrombosed (Figure 1C, lower panel). Final visual acuity was 20/20 without distortion of the vision. Six-month follow-up fluorescein angiography showed only a mild retinal pigment epithelial disturbance. Three months after the treatment, both telangiectasia and cyst showed filling with hyperreflective substance on spectral-domain OCT. After 6 months, there was a regression in vascular lesion and a complete resolution of the cystic spaces with restoration of foveal contour. The patient’s distortion disappeared, and at 1 year, his vision is maintained.

Case 2: Central Serous Chorioretinopathy

A 39-year-old male Hispanic patient presented with complaint of decreased visual acuity in his left eye, which was 20/40 on examination. He had similar episodes in the same eye in the past that resolved without treatment. Fundus biomicroscopy showed dome-shaped elevation in the macula. Fluorescein angiography revealed late leakage in the macula and an additional leak superotemporally (Figure 2A, left panel). Spectral OCT

Fig. 2. A. Left panel: late phase of fluorescein angiogram of multifocal central serous chorioretinopathy showing leakage of dye during active disease. Right panel: late phase of fluorescein angiogram of the same eye 6 months after navigated laser photocoagulation showing window defect in the retinal pigment epithelium without fluorescein leakage. B. Upper panel: spectral-domain OCT scan of an eye with central serous chorioretinopathy showing subfoveal fluid (left) and extrafoveal subretinal fluid (right) with corresponding scanning laser ophthalmoscopy images with orientation scans. Arrowhead shows a breach in the retinal pigment epithelium in extrafoveal serous exudation. Lower panel: spectral-domain OCT scan of the same eye 6 months later demonstrating resolution of subfoveal (left) and extrafoveal (right) fluid after navigated laser photocoagulation. Arrow shows a laser application to the area of retinal pigment epithelium breach.
demonstrated subretinal fluid with a retinal pigment epithelial defect (Figure 2B, upper right panel). Navigated laser photocoagulation was performed at the site of the extrafoveal retinal pigment epithelial leak. Six months later, visual acuity improved to 20/25 with residual symptoms of color desaturation and the subretinal fluid and fluorescein angiographic leakage resolved (Figure 2B, lower panel) (Figure 2A, right panel).

Case 3: Diabetic Macular Edema

A 45-year-old white male patient with Type 2 diabetes presented with a decreased visual acuity of 20/40 in his left eye associated with macular edema. His ocular examination revealed mild preproliferative diabetic retinopathy bilaterally with clinically significant macular edema in the left eye. Spectral OCT showed a significant retinal fluid (Figure 3, left panel). The navigated laser treatment was directed by a preoperative fluorescein angiogram acquired on the Navilas device and annotated by the physician with the treatment plan. Subthreshold (not visible) treatment was used for his perifoveal disease within 500 μm from the foveal center and threshold (visible) treatment for all extrafoveal microaneurysms. Six months after the treatment, his visual acuity improved to 20/20, and he was symptom free. The perifoveal swelling disappeared. Spectral OCT after photocoagulation showed extrafoveal (threshold) laser spots in the outer retinal structures (Figure 3, right panel).

Discussion

Incorporation of retinal navigation is a significant milestone in the technique of laser photocoagulation, potentially increasing safety when treating close to the fovea (e.g., parafoveal telangiectasia) and increases accuracy when treating elsewhere (e.g., multifocal chronic central serous chorioretinopathy). The system delineates a “no-treatment zone” for physician’s reference, which surgeon places (on the screen) over the fovea during the treatment phase. Subsequently, all treatment spots are placed outside this zone, and laser applications are delivered outside this zone.

Macular edema is a common denominator for several pathophysiological processes, including retinovascular disease, inflammation, or exudation because of age-related macular degeneration. Fluorescein angiography demonstrated that macular edema can be focal, diffuse, or combined. The standard therapy for focal retinovascular disease, as outlined by randomized clinical trials, is slit lamp–based laser photocoagulation. Our initial experience with a navigated photocoagulation device, which precisely aligns preplanned treatment locations annotated on the acquired image to locations on the retina, has been favorable. Naturally, precise treatment planning tailored to individual patient’s retinal disease and careful completion of photocoagulation with laser power adjustment depend entirely on the physician and his or her skills.

In all our patients with central serous chorioretinopathy and parafoveal telangiectasia, a single treatment was enough to flatten the retina or regress the retinal disease, respectively. In the group of diabetic macular edema eyes, we have observed a decrease in the retinal thickness and improvement in central vision. In the macular area, we have used focal treatment only. The microaneurysm closure after focal laser photocoagulation is a delayed process with
75% of the preselected microaneurysms close at the end of 12 weeks. These eyes were treatment naive, and therefore, more treatment response is expected compared with eyes with previous treatments. Previously treated eyes have higher risk of retinal damage, blood–retina barrier disruption, or macular ischemia as a result of various treatments. In this first clinical case series to evaluate efficacy, we have demonstrated that an integrated imaging and laser device can be used to successfully treat macular lesions with high accuracy and efficiency, leading to improvement in retinal structure and function. While our initial results with the device were for selected diagnoses requiring focal treatment, the spectrum of retinovascular or chorioretinal disease likely would benefit from more accurate treatment.

**Key words:** perifoveal retinal disease, integrated imaging and laser device, navigated laser photocoagulation.

**References**


