

High-Resolution Optical Coherence Tomography Imaging of Selective Retina Therapy Laser Lesions in the Retinal Pigment Epithelium

P. Steiner^{1A,2}, Ch. Meier², C. Framme^{1B}, S. Wolf^{1B}, J.H. Kowal^{1A,1B}

^AARTORG Center Ophthalmic Technologies, ^BDepartment of Ophthalmology,

¹University of Bern, Inselspital, Switzerland

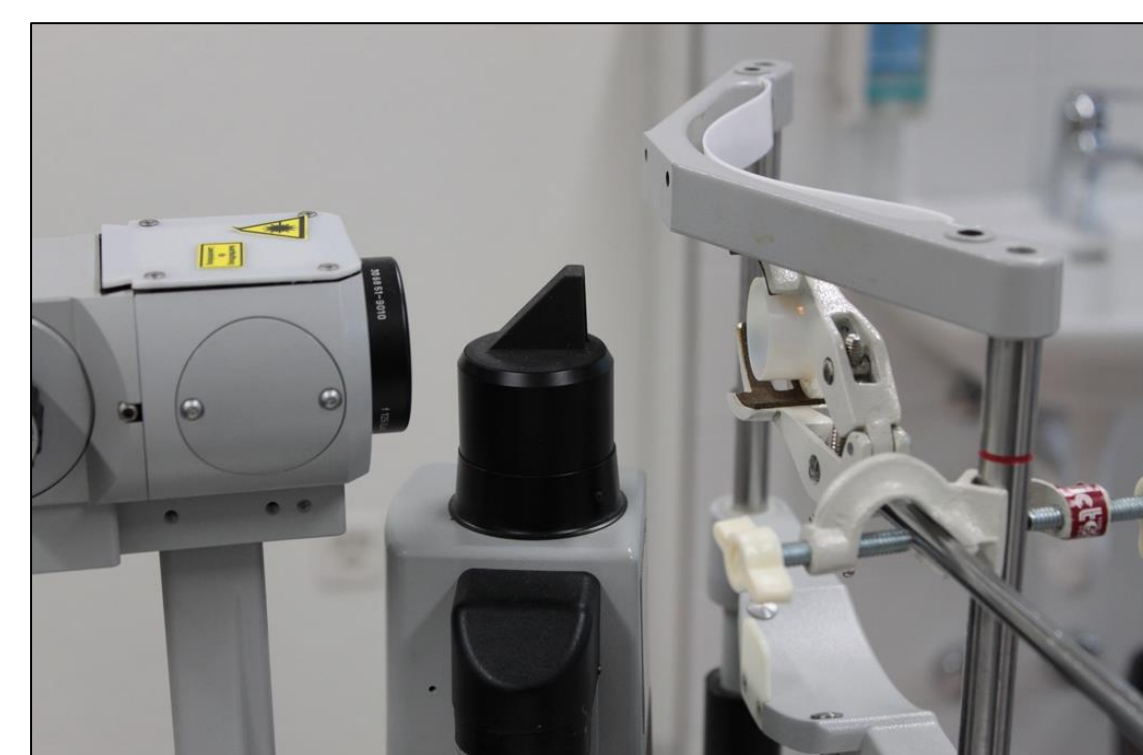
²OptoLab, Berne University of Applied Sciences, Biel, Switzerland

PURPOSE

Recently, the selective retina therapy (SRT), a new approach to conventional photocoagulation, has been introduced for treatment of diabetic retinopathy, age-related maculopathy and a variety of other eye diseases. The SRT confines the induced laser lesions to the retinal pigment epithelium (RPE), leaving the neural retina unaffected. If the proper dose of energy is applied during SRT, the lesions remain ophthalmologically invisible. In this study, Optical Coherence Tomography (OCT) is evaluated as a new approach for dosimetry and therapy control during SRT using samples of dissected porcine eyes.

METHODS

Selective Retina Therapy Laser



To induce laser lesions, a SRT Lasersystem was used:

- First generation SRT Laser (Laser-center Lübeck, Germany)
- 527 nm treatment laser, 635 nm target laser
- patterns with varying pulse energy levels



Laboratory SRT laser system and slit-lamp based optical delivery system used for the experiments.

High-resolution OCT System

For sample imaging, a Fourier-Domain OCT system was used:

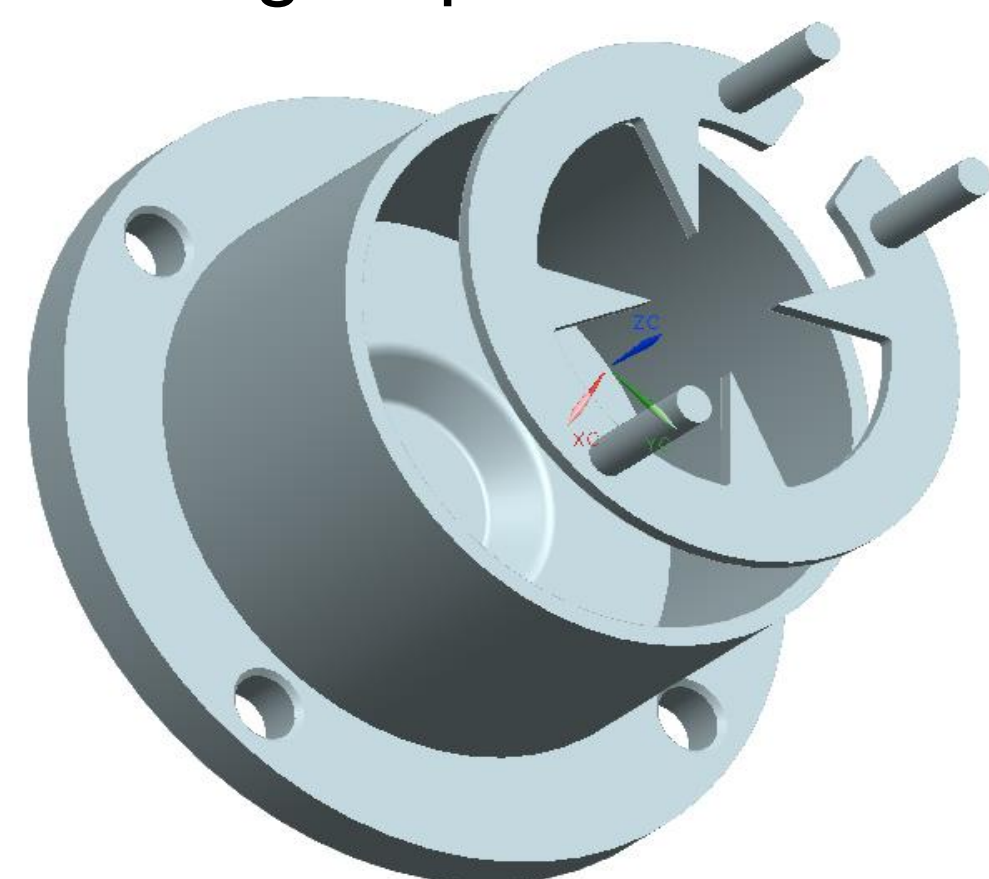
- High-resolution, self-designed benchtop system (OptoLab, Berne University of Applied Sciences, Switzerland)
- imaging at 800 nm with an axial resolution of 2.3 μ m and a lateral resolution of 25 μ m.



Experimental OCT system on a 19" rack including light source, galvo scanning unit and evaluation software.

Sample Preparation

As samples for the experiment, fresh porcine eyes samples with detached anterior segment were fixated in a sample holder and irradiated with the SRT laser. All samples were treated with a predefined lesion energy pattern. Porcine eyes were less than 12h old and samples were stored on crushed ice and covered in PBS to prevent unwanted cell death. During OCT scans, the samples were covered in 2 cm of PBS to avoid strong OCT signal peaks at the air / liquid interface.

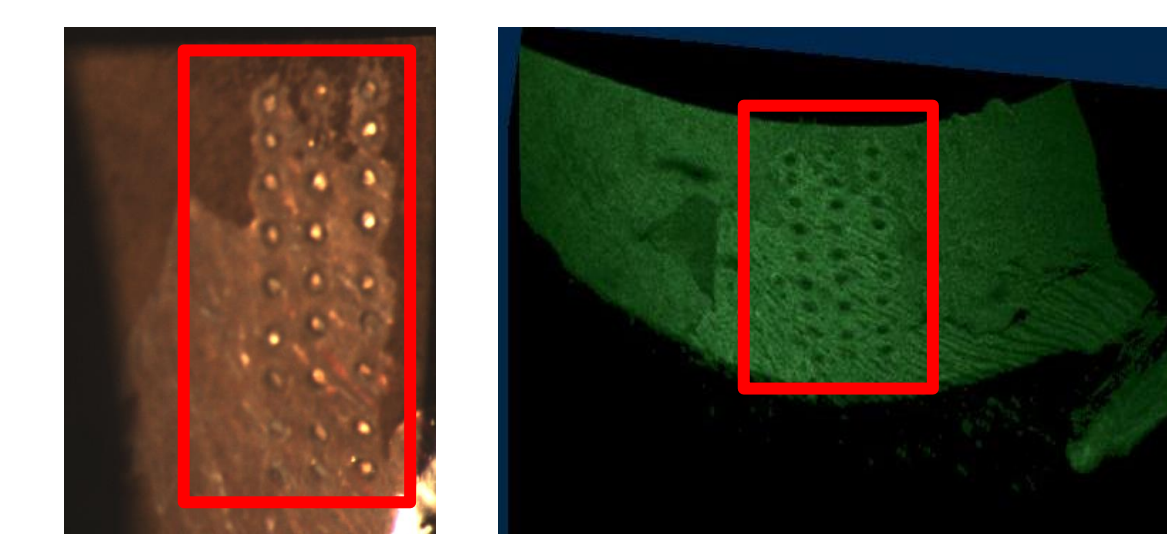


Self-designed and rapid-prototyped sample holder used for the experiments (left) and dissected porcine eye sample in front of the slitlamp-based SRT treatment system (right). Lesions were set according to a predefined energy pattern.



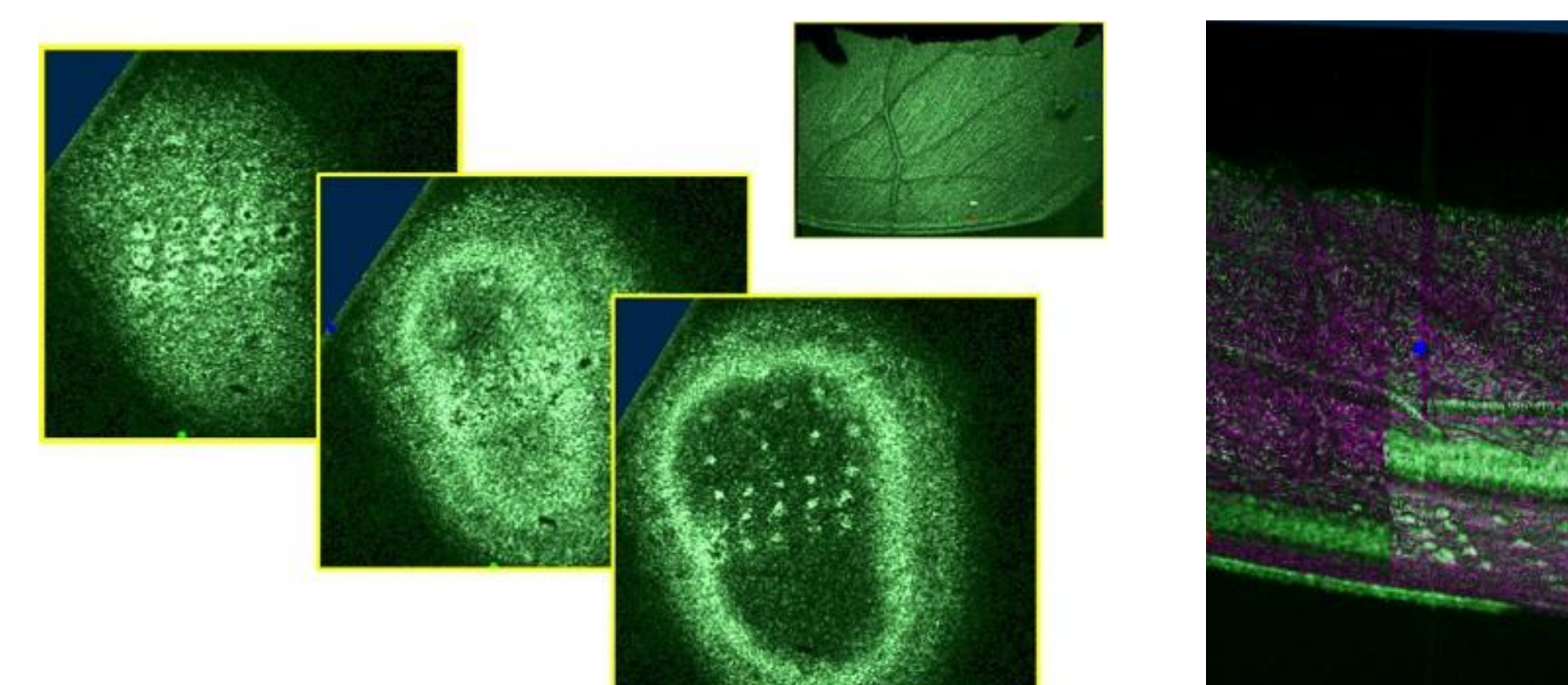
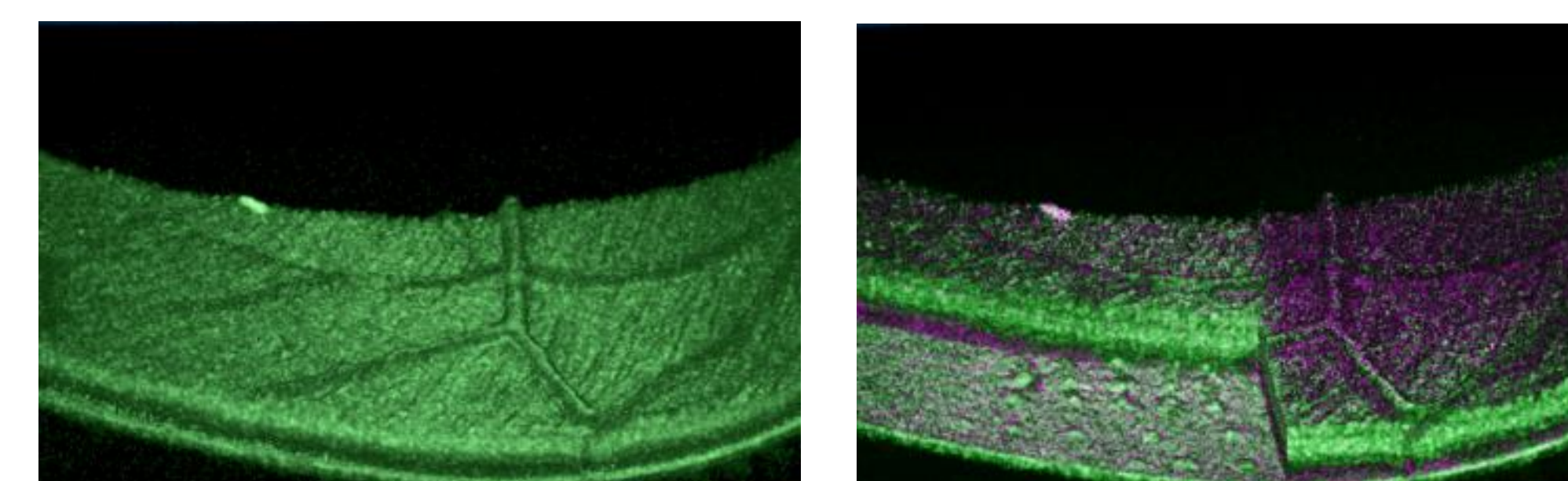
RESULTS

After deposition of the laser energy to spots with 200 μ m diameter, a 10 mm x 10 mm x 3 mm OCT scan with 512 x 512 x 2048 pixels was recorded. The recorded scans were post-processed using a standard LabView environment and a software framework of the OptoLab, Berne University of Applied Sciences. From the processed scans, the 3D tomogram of the retina samples was reconstructed and analyzed manually. Scans were taken from both samples with and without neural retina in order to quantify the effect of the neural layer on the energy deposition and image quality. The scans taken from the samples without neural retina show very clear lesions in close agreement with the surface images taken by a conventional slit-lamp (Haag-Streit BQ 900). However, the applied dose for those test lesions was rather high and noticeable



Early scans of laser lesions on porcine samples with removed neural retina. Pulse energy was set to 160 μ J.

tissue ablation can be seen on both images. In the samples including the neural retina, the surface view of the OCT tomogram contains no visible lesion whereas cut-through slices at the RPE level show clearly visible changes in the optical properties of the RPE caused by the laser lesions. In a last step, the recorded datasets were segmented at the RPE tissue border using software developed at the ARTORG Ophthalmic Technology Lab in Bern. The segmented datasets show that OCT can be used to detect Selective Retina Therapy laser lesions that are not ophthalmologically visible.



OCT scan of a porcine retina sample including neural retina and ophthalmologically invisible laser lesions pattern. The images on top represent the porcine sample without (left) and with (right) segmentation. On the bottom left, a set of cut-through slices at the position of the RPE is shown. The images on the bottom right shows a different viewing angle on the segmented dataset with the laser lesion pattern being visible at the RPE level.

CONCLUSION

The presented work depicts the preliminary stage of the proposed dosimetry control for SRT treatment. We were able to show that OCT is capable of detecting SRT lesions beneath the neural retina.

However, there are still some major obstacles to overcome since for an automated detection of therapy success, a quality assessment of OCT scans needs to be performed and a threshold value for a completed therapy needs to be defined. Last but not least, the OCT system needs to be coupled to the existing laser therapy setup without reducing the performance of either system.

Nevertheless, the resolving power of the OCT system proved to be sufficient to reliably detect the induced lesions under laboratory conditions thus making it a promising approach for SRT therapy monitoring.