Dynamic OCT signal loss in microsecond microsurgery

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State-of-the-art treatment for retinal diseases by laser photocoagulation (LPC) leads to collateral damage to all retinal layers. This work investigates the optimal parameters for optical coherence tomography (OCT) based irradiation dosimetry for the new and gentler selective retina therapy (SRT). An experimental treatment setup was built for the improvement of this dosimetry method.

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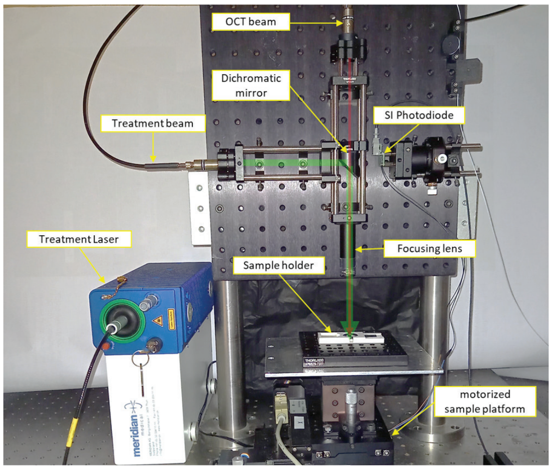
Introduction

LPC is currently the most common treatment method for retinal diseases. During LPC Long laser pulses (several hundred milliseconds) are absorbed by the retinal pigment epithelium (RPE) which leads to thermal cell destruction. Unfortunately, the heating process leads to collateral damage to all retinal layers including healthy, non-regenerative photoreceptors. The emerging selective retina therapy (SRT) is a gentler method, where laser pulses in the low-microsecond range cause rapid heating of melanosomes. This leads to microbubble formation (MBF) on the melanosome surface without heating the surrounding layers. The consequence is selective RPE cell death while leaving the surrounding tissue intact.

Goal

A remaining challenge in reaching truly selective cell death is the RPE's strongly varying melanin concentration. To avoid insufficient or excessive exposure, the irradiation energy must be closely controlled. This can be achieved with OCT imaging. During SRT, time-resolved OCT Mscans show dynamic signal changes, so-called washouts, that correlate to the size and occurrence of treatment lesions. The goal of this work is to investigate the optimal OCT parameters to reliably detect OCT signal washouts and therefore achieve higher accuracy in the future with this dosimetry method.



The experimental testbench which combines SRT and OCT, that was developed during this master's thesis.

Method

During this master's thesis, an experimental SRT testbench was built, that combines an interchangeable OCT system with the modified MERILAS 532 Short pulse laser (Meridian, Thun, CH) which allows SRT treatment. Additionally, a treatment software was developed that gives full control over all treatment and OCT parameters. A variety of experiments were conducted on ex-vivo porcine eyes to investigate the influence of various OCT parameters on the detectability of signal washouts.

Results

Changes in the OCT spectrometer camera recording speed from 1.5 kHz to 77 kHz did not affect the outcome of the washout detection as long as the Signal to Noise Ratio was high enough. However, the results imply that in combination with the treatment pulse timing, the recording speed could change the detectability of MBF with OCT. Further, a high sensitivity should be preferred over a high axial resolution in an SRT dosimetry OCT system.

Conclusion and Outlook

This work showed, that a simpler and less expensive OCT system could be used for SRT dosimetry control. In the future, the setup could be improved by integrating a scanning head, which would allow cross-sectional OCT imaging of the samples. Furthermore, additional dosimetry methods such as reflectometry and optoacoustic in combination with OCT could allow a deeper investigation of the MBF.