# Optical coherence tomography of retinal vessels, blood flow, and blood composition

*On September 5, 2020, Anne Willerslev defended her thesis titled "Non-invasive assessment of changes in retinal vessels, blood flow and blood composition" at the University of Copenhagen. Her supervisors were Professor Michael Larsen, Copenhagen, Denmark; Professor Michel Paques, Sorbonne Université, France; and Dr. Simon Rothenbühler, University Hospital Basel, Switzerland.*

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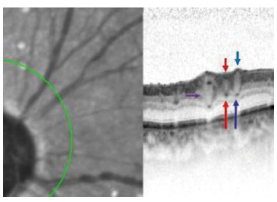
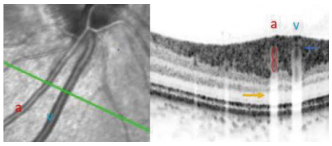
The transparency and the relatively sparse vascularization of the retina make retinal vessels amenable to non-invasive and non-destructive bio-microscopy and photography. Repeated examinations can be made over time, both in health and disease and under various forms of local or systemic perturbation, be they spontaneous or experimentally induced. In addition to direct and indirect ophthalmoscopy, as well as conventional fundus photography, optical coherence tomography (OCT) and other new advanced imaging modalities have become available to diagnose and monitor the retina. The primary aim of the thesis was to determine whether information about blood flow could be extracted from in vivo OCT scans in healthy human subjects and patients with abnormalities of flow induced by retinal and rheological conditions. The thesis was based on five clinical imaging studies in humans.[1-5]



***Fundus photography (left) and OCT (right) scan from a patient with ocular ischemic syndrome and severely reduced retinal perfusion. The cross-sectional scans of the retinal vessels show distinct anterior and posterior vessel wall reflexes (red and blue arrows), structureless intravascular reflectivity profiles (purple arrow) and very weak shadowing behind the vessels.***



***Fundus photography (left) and corresponding SD-OCT scan of a retinal artery (a) and vein (v) in a healthy subject. The cross-sectional OCT scans of the vessels show the anterior vessel wall reflex (blue arrow), the intraluminal figure-eight reflectivity pattern (red 8) and the shadowing behind the vessel (orange arrow) which masks the structures posterior to the vessel.***

The studies showed that cross-sectional SD-OCT scans of healthy retinal vessels give rise to a characteristic figure-eight intravascular reflectivity pattern. The observed pattern was in agreement with in vitro and in vivo measurements and corresponded to the theory of shear-flow induced, anisotropic properties of red blood cells in laminar blood flow. The structured profile was absent in patients with severe hypoperfusion of the retinal vessels. At venous compression sites, OCT could help distinguish between ordered, laminar blood flow and disturbed flow. In patients with marked leukocytosis and severe hyperviscosity, the vascular reflectivity profile seen in healthy subjects was absent. Together, these studies showed that OCT scans of retinal vessel may contain more information than previously thought. The OCT reflectivity profile of the vessel is altered in the setting of flow turbulence, occlusive vascular disease, leukocytosis, and hyperviscosity.

### *Key points:*

- Cross-sectional SD-OCT scans of healthy retinal vessels give rise to a characteristic figure-eight, intravascular reflectivity pattern.
- The structured OCT reflectivity profile of the vessel is absent in the setting of flow turbulence, occlusive vascular disease, leukocytosis, and hyperviscosity.
- OCT scans of retinal vessel may contain more information than previously thought.

***Articles in the dissertation***

1. Willerslev A, et al. Retinal and choroidal intravascular spectral-domain optical coherence tomography. *Acta Ophthalmol.* 2014;92(2):126-32.
2. Willerslev A, et al. Flow patterns on spectral-domain optical coherence tomography reveal flow directions at retinal vessel bifurcations. *Acta Ophthalmol.* 2014;92(5):461-4.
3. Willerslev A, et al. Relation between Fluorescein Angiographic and Spectral Domain Optical Coherence Tomography Findings of Blood Flow Turbulence at Arteriovenous Crossings in the Retina. *Retin Cases Brief Rep.* 2019; 13(1):61-66.
4. Willerslev A, et al. Non-invasive imaging of retinal blood flow in myeloproliferative neoplasms. *Acta Ophthalmol.* 2017;95(2):146-152.
5. Willerslev A, et al. Spectral-domain optical coherence tomography of retinal vessels in Waldenström's macroglobulinemia. *Acta Ophthalmol.* 2020; 98(2):153-157.