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Development of novel diagnostic tools for dry-eye disease using optical coherence tomography (OCT) and confocal microscopy

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Summary

Infrared (IR) meibography is a well-established method to analyse Meibomian glands (MG). However, the manual analysis of the acquired images requires user interaction. Therefore, our objective is to implement an automated MG analysis software. Unlike, the IR meibography, OCT-meibography produce high-resolution and three-dimensional images which enables a new level of analysis. Currently, OCT-angiography focused on retinal vascular disease. However, our aim is to design and implement novel software algorithms in order to enable quantification of inflammation-related parameters of ocular surface, namely blood flow in conjunctiva and pathologically vascularized cornea and thus specify the diagnosis of the dry eye disease.

State-of-the-art

IR meibography is commonly used in the clinical setting for the MG analysis. However, the detailed anatomic structure of MG cannot be clearly elucidated. Therefore, 3D meibography imaging via OCT was developed to resolve the problems. The OCT system uses a long coherence wavelength of 1300 nm close to that of IR light to enhance the OCT imaging depth range.

OCT-angiography applies high-speed OCT scanning to detect blood flow by analysing signal decorrelation between scans. OCT-angiography uses dense volumetric scanning to provide depth-resolved visualization of the retinal and choroidal vasculature. It may also have the potential to dissect the long-debated origin and microvascular anatomy of neovascularization in AMD.

In vivo confocal microscopy has been used to analyze the morphological–functional unit of the ocular surface such as corneal epithelium and conjunctival inflammatory cells. Structural changes of these units are correlated with functional alterations and severity of DED. It provides high resolution and 3D enface images and the optical ability provides magnification images with better rejection of out-of-focus information than conventional light microscopy.

Left: HSM and Telesto (high resolution OCT & fluorescence imaging), Right-top: HRA-OCT (clinical retinal OCT), Right-bottom: Animal holder

Techniques

- IR meibography
- OCT-meibography
- OCT-angiography
- Confocal microscopy
- Image processing and segmentation (intensity, region-growing and machine/deep learning)
- Image data analysis and interpretation

Task description

- Assesment of clinical needs
  - Evaluation of unmet clinical needs
  - Software evaluation
  - Data collection
- Implementation and testing of novel methods in commercial devices
  - Optimization of the acquision software
  - Data analysis and data interpretation
  - Implementation in the commercial device
- Use of novel imaging-based tools in pre-clinical and clinical settings
  - Clinical studies on healthy volunteers and dry eye patients
  - Image analysis from patient cohorts