Anterior segment optical coherence tomography angiography

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SUMMARY

Corneal diseases are among the most common causes of blindness in the world. Vascularization of the cornea is a common and potentially vision-threatening problem; the healthy cornea has no vessels and vascularization is the result of every inflammatory process in which the cornea is involved. From the clinic, there is a great need to be able to capture and quantify vascularization of the cornea. Although optical coherence tomography (OCT) is often used to image the eye, this technique is not capable of properly imaging blood vessels. The current gold standard for imaging vascularization is invasive; it requires injection of an intravenous contrast fluid (indocyanine green, ICG). OCT angiography (OCTA) is a new, non-invasive imaging technique that has been developed to visualize the vessels of the retina. However, the current OCTA systems are not optimized for the cornea.

The main goals of my PhD thesis are (1) to establish that OCTA systems designed for the retina (posterior segment of the eye) can also be used to image the cornea (anterior segment of the eye), (2) to to design a method to analyze and quantify OCTA images of the cornea and (3) to compare OCTA with the current gold standard, ICG angiography (ICGA), histology, and confocal microscopy.

First I described how a retinal OCTA system can be adapted to make images of the vessels of the cornea and the limbus, in healthy human eyes (chapter 2). I then outlined a method for obtaining good images of abnormal corneal vessels in vivo and for performing image analysis for quantifying those vessels (chapter 3). The logical next step was to determine whether OCTA was comparable to ICGA for corneal vessels. The agreement between OCTA and ICGA was good (chapter 4). Subsequently, OCTA was successfully used in a longitudinal study of treated eyes with abnormal corneal vessels, to determine changes (chapter 5). An existing animal model for corneal vascularisation was then used to demonstrate that OCTA is able to detect smaller blood vessels than ICGA (Chapter 6). Finally, in Chapter 7, I compared two different OCTA systems and found that, although good quality scans were obtained, both systems were not directly comparable.

The research described in this thesis opens the possibility for a new, non-invasive and rapid imaging technique to evaluate the cornea and corneal vessels simultaneously. The results support that this new technique is capable of evaluating corneal vessels in a fast, safe, and reliable manner, with a good correlation with other clinical tools used in our practice, and with a possibility to observe changes over time. The technique can be used in a wide range of corneal diseases. The same technique could also be used in a broader range of clinical applications in ophthalmology such as glaucoma and glaucoma operations, abnormal iris vessels and in different systemic diseases. Before that can be the case, however, improvements are needed to reduce motion artefacts and improve segmentation, and an automated image analysis must be developed.