Resolving the anatomy of aqueous veins and perilimbal sclera using multispectral photoacoustic imaging

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Background and Objective

The lack of risk factors and biomarkers to predict the outcome in lowering intraocular pressure (IOP) is a critical barrier to provide safe and effective surgical interventions for patients with glaucoma. Beyond the trabecular meshwork, which represents the proximal tissue for aqueous humor drainage, there is limited knowledge on the resistance mechanisms of distal drainage including Schlemm's canal, collector channels, and downstream aqueous and intrascleral veins in the perilimbal sclera. The purpose of this study is to resolve the complex anatomy in the aqueous vein-sclera tissue complex. We apply multispectral photoacoustic technology to image the dynamic anatomy of these tissues and their role in IOP regulation.

Statement of Contribution/Methods

Aimed at differentiating between the aqueous veins and intrascleral veins, we perfused enucleated porcine eyes with optical contrast agent in red and green. A multispectral photoacoustic microscopy system with laser illuminations at 532, 790 and 1200 nm was fabricated targeting the contrast agents in aqueous veins, and the collagen and lipid content in the perilimbal sclera. The laser beams are collimated to 3 mm in diameter in separate light paths, merged by a dichroic mirror, and focused at the tissue sample surface by an objective lens with a focal length of 30 mm. A galvanometer orients the laser beams in 2-dimension before the objective lens, forming a 10 mm x 10 mm field of view. The photoacoustic signals are captured using an ultrasound transducer with a central frequency of 35MHz.

Results/Discussion

The system was examined with optical phantoms. Images at the two optical wavelengths show the capability to distinguish the aqueous veins and the scleral tissue. Fig. 1a shows the aqueous veins and perilimbal sclera resolve in parallel in a small region of interest. Fig. 1b shows a full circumferential image of aqueous veins in a porcine eye.

Photoacoustic imaging demonstrates proof-of-concept for the ability to distinguish and resolve anatomy of the aqueous veins and perilimbal sclera. Coupled with tools for manipulating and monitoring IOP, this technology can advance knowledge of the aqueous humor dynamics and the biomechanics of the aqueous vein and perilimbal sclera tissue complex.

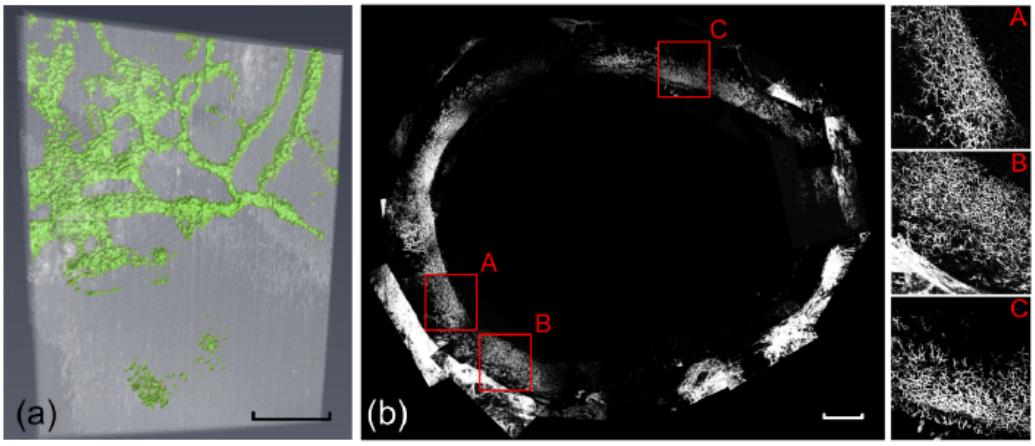

Fig. 1. PA images of aqueous veins and perilimbal sclera. (a) A small region with both aqueous veins (green) and perilimbal sclera (white) resolved. Scale bar: 500 μm. (b) Aqueous veins at full circumference. Scale bar: 2 mm.

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