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

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Footnotes

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Abstract

Purpose : 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.

Methods : Aimed at differentiating between the aqueous veins and intrascleral veins, we perfused enucleated porcine eyes with optical contrast agent in red. A multispectral photoacoustic microscopy system with laser illuminations at 532 nm 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 thermoelastic effect of the illumination generates acoustic waves in the targeted tissue components, which are captured by an ultrasound transducer. The temporal resolution of the transducer, in addition to the 2-dimension optical scanning, forms a 3 dimensional representation of the anatomies in the tissue sample.

Results : 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. 1 shows a representative image of aqueous veins in a porcine eye by assembling images acquired at multiple locations. Details of the aqueous veins anatomies are shown in the subpanels.

Conclusions : 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.

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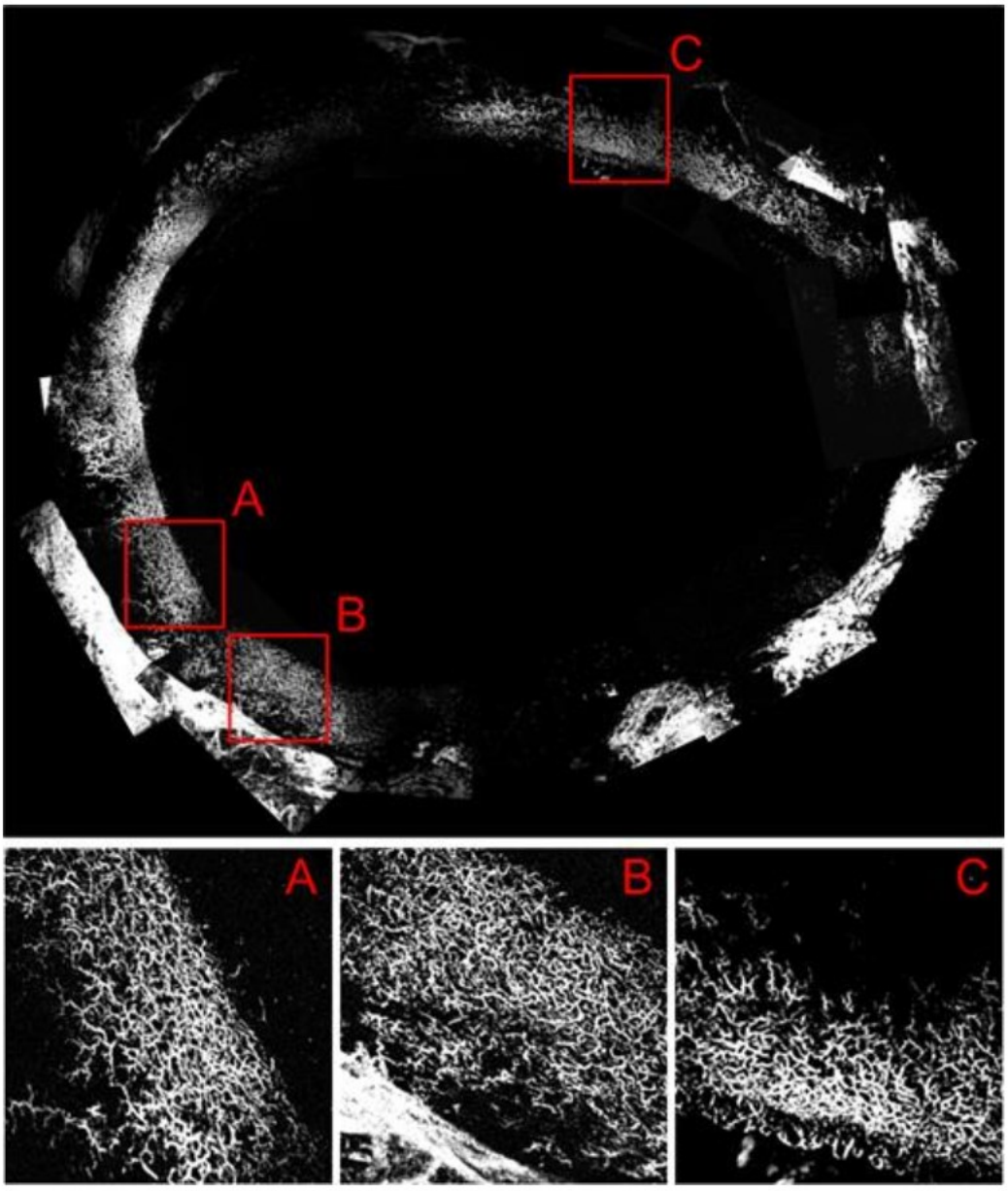

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