Super resolution microvessel imaging for assessing the deep vasculature of the eye

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Background, Motivation and Objective: Optical coherence tomography angiography (OCT-A), a non-invasive technique for imaging the retinal/choroidal microvasculature, is the dominant modality in ophthalmology. However, a limitation of OCT is its inability to penetrate optical opacities, such as monitoring the retinal flow with retinal prosthetic implants and occlusion in the orbital vasculature beyond the sclera. In addition, OCTA has limited ability to depict the flow velocity. Owing to the valuable diagnostic purpose of the deep choroidal and orbital microvasculature in diabetic and vascular occlusive eyes, a new imaging technique with both high spatial resolution and deep penetration depth is desired.

Methods: The super-resolution (SR) ultrasonic microvessel imaging technique were evaluated with the Verasonics Vantage system (Verasonics Inc.) using a 18 MHz linear array transducer. Ultrafast compounding plane wave imaging technique (6 angles ranging from -7.5° to 7.5° at the PRF of 12 kHz) was implemented to identify the motion filtered microbubble signals followed by an optimal deconvolution based localization algorithm. The microvasculature image was reconstructed by accumulating localized bubble signal in successive frames. The technique was initially tested via experiment on Dutch Belted Pigmented rabbits *in vivo*.

Results/Discussion: The SR microvessel imaging of the posterior segment of the rabbit eye *in vivo* are shown in Figure 1. The imaging scan plane cuts through the optic nerve under the guidance of real-time B-mode image. Compared to the conventional color Doppler image, the SR microvessel imaging presented more vascular details at a spatial resolution of 10 μm. The organization of the choroidal (top layer structure in Fig. 1c) and the posterior ciliary artery (arising from the optic nerve with a larger diameter) vasculature were clearly visible. These results demonstrated that SR ultrasonic microvessel imaging offers a new insight to obtain high resolution depiction of deep ocular vasculature, which might be clinical important in detecting diabetic and vascular occlusive eyes.

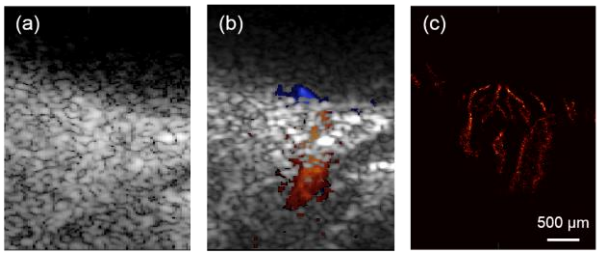

Fig. 1. The posterior segment of the rabbit eye *in vivo* centered at the optic nerve disk. (a) B-mode image, (b) Color Doppler image superimposed, (c) The super-resolution microvessel image.