Age Dependent Effects of Retinal Blood Flow by MRI

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INTRODUCTION Although there are many studies of age-dependent effects on BF on the brain, similar BF studies of age-dependent effects on the retina are limited. Quantitative blood flow (BF) in the retina was recently made possible by arterial spin labeling MRI technique at high spatial resolution to allow visualization of the retina (3). By contrast, optical imaging techniques to study BF have limited field of view and are qualitative which limited comparison across patient groups. The objective of this study was to evaluate the age-dependent effects on the retina-choroidal BF of healthy humans using high-resolution BF MRI techniques. We aim to test the hypothesis that BF in the retina reduces with age.

METHODS Seven healthy subjects (5 males, 2 female, 25–66 years old) participated in the study. Their right eye was imaged and each subject was imaged multiple times (1 to 4) with each trial lasted 3-4 min. Subjects were instructed to maintain stable eye fixation on a target inside the magnet bore and synchronize eye blinking during the sound cue generated by the scanner during the data readout from every dynamic. BF MRI was performed on a 3.0 T Philips Achieva System using a custom-fit receive-only surface coil (~7 cm in diameter). High resolution BF MRI (0.5x0.8x6 mm^3) was acquired on a single central axial slice bisecting the optic nerve head and fovea using the pseudo-continuous ASL technique with background suppression and single-shot turbo-spin echo (TSE) for the image acquisition.

The following parameters were used: 0.2s labeling duration and 1.5s post-labeling delay; the labeling plane was 7 cm inferior to the imaging plane at the level of the Internal carotid artery. The background suppression employed two inversion pulses at 2061 and 3405 ms after the initial saturation pulse, which was placed before the labeling (4). The single-shot TSE sequence used a TR/TE of 4.6s/30ms, 6mm slice thickness, 12.8kHz bandwidth, TSE factor of 28, a FOV=50x43mm, and matrix size=100x53 (in plane resolution of 500x800μm). In addition, a reference scan with TR=15s was used to derive M0 for BF quantification. The mean basal BF was analyzed from the ROI intensity in ml/100ml/min.

Images were analyzed with Matlab algorithms written aligned ASL images and corrected for motion (5). Intensity profiles across the retinal thickness were automatically drawn from the motion-corrected ASL images by radially projecting lines perpendicular to the retina. The BF values for the entire retinal/choroidal vasculature were taken at full width half max of the peaks from the projection profiles.

RESULTS **Figure 1A and B** shows the anatomical MRI and a representative BF image the human retina. BF was high around the macular and dropped off distally. **Figure 1C** shows a plot of retina-choroid BF versus age. A significant negative correlation (R = - 0.77) between mean blood flow and subject's age was observed. One-way ANOVA indicated statistical significance with $P < 0.05$.

DISCUSSION In contrast to the brain, studies on age-related effects on BF are limited. A blue field entoptoscopy (6) reported a negative correlation between the retinal macular microcirculation and age. A laser Doppler flowmetry (7) reported negative correlation between choroidal blood flow and age. An indocyanine green (ICG) angiography (8) showed a decrease of the choroidal arterioles and the fluorescent intensity in the macular region with age. The above-mentioned studies reported blood flow in arbitrary units and were limited to the macular area or the optic nerve head. By contrast, BF MRI offers large FOV that is depth limited (3). Moreover, BF MRI provides tissue perfusion in quantitative classical unit instead of blood velocity or blood flow index.

In conclusion, BF MRI of the retina offers some unique advantages and can complement existing optical imaging technique to study the retina. Future studies will include more subjects, investigate nearsightedness and farsightedness, and evoked fMRI responses as a function of healthy aging. BF MRI has the potential serve as an objective imaging biomarker for early detection, disease staging and longitudinal monitoring of therapeutic interventions.

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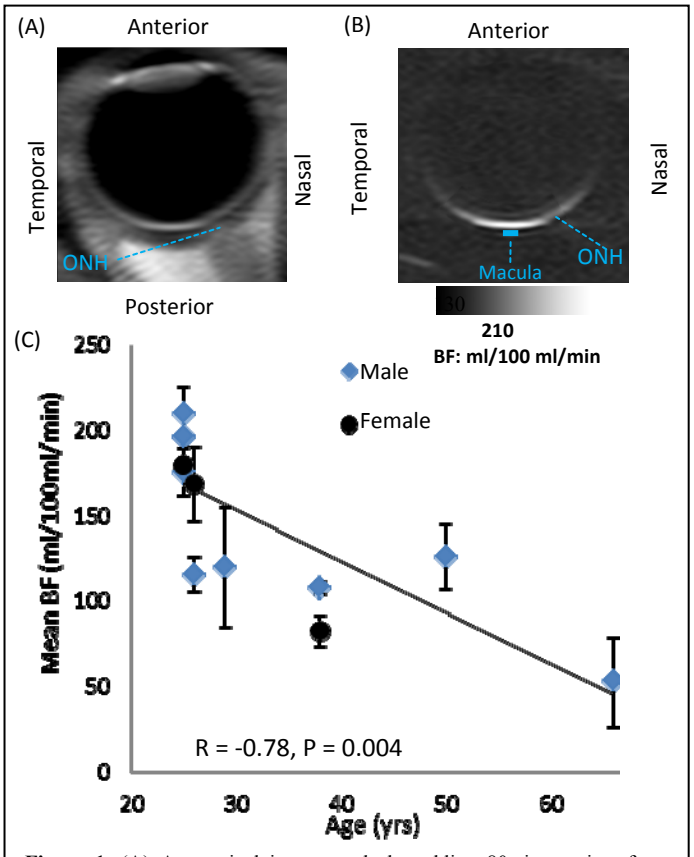

Figure 1. (A) Anatomical image made by adding 80 time points from pcASL dynamic images after motion correction. (B) Basal BF of the retina. (C) Quantitative BF MRI of retina/choroidal and age of subjects.