Fig. S1. Diagram of data processing (phase-variance processing; Left) and visualization (Right) for phase-variance optical coherence tomography (pvOCT). Three OCT B-scans (cross-sectional scans) were acquired at the same position, called a BM-scan, to calculate phase variance. Cross-correlation of consecutive B-scans corrected axial motion. We averaged three intensity images and calculated phase changes, subtraction of successive B-scans, within a BM-scan (multiple B-scans at the same position) (1). Time separation between each B-scan is 3.5 ms where any flows include Brownian motion induced phase shifts. Phase unwrapping (2) was required to calculate the phase changes due to a given phase range (−π ∼ π). Bulk sample motion based upon the variations in axial motion was calculated using the histogram-based bulk motion estimation method (3, 4) and compensated in phase values across the B-scan (5). Intensity thresholding was applied for the phase changes based on averaging intensity less than 10 dB above the noise level (6). The phase variance was calculated within a BM-scan. Two-dimensional Gaussian smoothing (σ = 0.7) and stack registration of both the intensity and the phase-variance data were applied over the entire volumetric data. En face cross-sections were produced by Gaussian averaging of 50 axial depths at the absolute location, where each slice has ~1-μm separation after flattening the posterior structure based on the retinal pigment epithelium (RPE). We manually selected the retinal layer and three different choroidal layers from the en face stacks and generated maximum or minimum projection images. Superimposing different depth projections, finally, generated pseudocolor-coded perfusion networks (7).


**Fig. S2.** Fundus angiographic images of a normal subject. The full-size (30° × 30°) photographs of fluorescein angiography (early venous stage, Left) and indocyanine green angiography (Right) from a 60-y-old healthy male volunteer. The images were acquired from the Heidelberg Spectralis (HRA + OCT, trademarked product). The yellow dashed rectangles indicate the selected regions presented in Fig. 1 A and B.

**Fig. S3.** OCT intensity and pvOCT images. (A) Averaged OCT intensity cross-sectional B-scan. (B) Phase-variance OCT contrast cross-sectional image. (C) Composite of OCT intensity (A) and pvOCT images (B). Manually segmented yellow, green, and blue dashed rectangles of volumetric data for en face visualization of retinal vasculature, choriocapillaris, and the large feeder vessels in the choroid, respectively. (D) Minimum projection view of the pvOCT data segmentation of the blue dashed region in the image (C) for visualizing larger choroidal vessels. (Scale bar, 200 μm.) CC, choriocapillaris; GCL, ganglion cell layer; HL, Haller's layer; INL, inner nuclear layer; IPL, inner plexiform layer; I/OS, inner/outer segment junction; OLM, outer limiting membrane; ONL, outer nuclear layer; OPL, outer plexiform layer; RNFL, retinal nerve fiber layer; RPE, retinal pigment epithelium; SL, Sattler's layer; Bruch’s membrane (BM) is located in between the RPE and the CC.
Fig. S4. Reproducibility of pvOCT and pulsation during imaging. Acquired additional pvOCT volumetric data (scan 2) at the same location and for the same subject shown in Fig. 1 (scan 1). En face maximum projection of the segmented pvOCT data in the retinal layers (A) and the CC layer (B). The segmented en face plane includes 6-μm depths below the RPE. The combined color-coded image (C) of (A, red) and (B, green). The reconstructed image was separated by eight horizontal regions due to discontinuous phase-variance values during the volume scan, indicating BM-scan frame numbers of the transition points taken by scan 2 of the graph (D). The graph (D) shows mean phase-variance profiles of two segmented volume scans (scans 1 and 2) in the z axis. The segmented pvOCT data for visualizing CC, the green dashed rectangle in Fig. S3C, were averaged in each BM-scan, resulting in phase-variance value fluctuation in the CC layer by time (BM-scan frames). The identified frame numbers at the lowest phase-variance value allows calculation of alternation periods, where the time separation between two BM-scans is 10.56 ms. The mean alternation periods for scans 1 and 2 are 0.987 s (~60 cycles per minute) and 0.967 s (~62 cycles per minute), respectively. The measured heart rate of the subject with a pulse meter was 60 cycles per minute under these conditions. Scanning size, 1.5 (horizontal, H) × 3 (vertical, V) mm². Scanning direction is top to bottom. (Scale bars, 200 μm.)
Fig. S5. Fundus photographs of left eye of patient with geographic atrophy (GA). (A) Color fundus photograph. (B) Autofluorescence. An early phase (C) and a late phase (D) of fluorescein angiograph. The yellow dotted rectangle (3 H × 1.5 V mm²), green dotted squares (1.5 × 1.5 mm²), and purple dotted rectangle (3 H × 1.5 V mm²) are scanned regions for Figs. 2, 3, and 4, respectively. A, C, and D were acquired from the Topcon (TRC-50IX) camera with a 50°, 35° and 35° field of view, respectively, and B, a 30° × 30° image, acquired with the Heidelberg Spectralis (HRA + OCT).
Fig. S6. pvOCT scanning (1.5 × 1.5 mm²) for magnification of the CC structure with the right eye (visual acuity 20/20) of the patient with GA. The yellow dotted squares of fundus autofluorescence (A) and color (B) photographs indicate the location of the pvOCT scan (6° nasal and 12° inferior retina eccentricity). (A) A 30° × 30° image acquired from the Heidelberg Spectralis (HRA + OCT). (B) A 35° × 35° image obtained with the Topcon (TRC-50IX) fundus camera. High-magnification image (C) of the color fundus photograph cropped from the location indicated at the yellow dotted square in B. En face projection (D) of retinal layers from pvOCT data. The diameter of the retinal capillary at the yellow arrow is ~12 μm. In vivo imaging (E) of human choriocapillaris. The size of CC (red arrow) is ~30 μm in diameter. The combined image (F) of retinal vasculature (red) and CC (green). En face fly-through imaging of pvOCT data are included (Movie S7). (Scale bars, 200 μm.)
Movie S1. *En face* fly-through images of pvOCT data shown in Fig. 1. The movie demonstrates perfusion maps of *en face* planes from the retinal layers to the choroid in normal subject’s macula, $1.5 \times 3 \text{ V mm}^2$.
Movie S2.  *En face* fly-through images of pvOCT data shown in Fig. 2. The movie demonstrates perfusion maps of *en face* planes from the retinal layers to the choroid in 3 H × 1.5 V mm².

Movie S2

Movie S3.  *En face* volume of depth color-coded (red, green, blue, RGB) images with pvOCT shown in Fig. 3. Red, retinal vasculature; green, vessels in the inner choroidal layer; and blue, vessels in the outer choroidal layer.

Movie S3
Movie S4. *En face* fly-through images of pvOCT data shown in Fig. 4. The movie demonstrates perfusion maps of *en face* planes from the retinal layers to the choroid in $3 \times 1.5 \text{ V mm}^2$ macula with the patient with GA.
Movie S5. Combined B-scans of standard OCT intensity (gray) and pvOCT (red) shown in Fig. S A–D. The composite provides depth-resolved imaging of the vasculature.
Movie S6. Combined B-scans of standard OCT intensity (gray) and pvOCT (red) shown in Fig. 5 E–H. The composite provides depth-resolved imaging of the vasculature in the GA region.
Movie S7. En face fly-through images of pvOCT data shown in Fig. S6. The movie demonstrates perfusion maps of en face planes from the retinal layers to the choroid in the peripheral retina, $1.5 \times 1.5 \text{ mm}^2$. 

Movie S7