Imaging the choriocapillaris with SS-OCT at MHz A-scan rates

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Poster# 3532344

PURPOSE

- Imaging and quantifying the choriocapillaris (CC) is believed to contribute to understanding disease pathogenesis, improving early diagnosis and monitoring disease progression.
- Most OCT angiography (OCTA) scans of the CC fail to resolve individual capillaries due to insufficient lateral resolution [1].
- We describe how OCTA may produce structures that misleadingly resemble the anatomy of the CC.
- We demonstrate how MHz A-scan rates paired with high lateral resolution can be applied to resolve individual CC vessels.

METHODS

- Simulated the effect a Gaussian point spread function (PSF) and / or Gaussian post-processing filters have when imaging sub-resolution structures
  - Convoluted a white noise frame with a Gauss kernel with varying size
  - Convoluted a white noise frame with superimposed random structures with a Gauss kernel with varying size
- Developed a 1060 nm SS-OCT prototype
  - 1060 nm
  - 1.7 MHz A-scans rate
  - 9 µm axial resolution
  - 8 µm / 15 µm switchable lateral resolution
- Acquired CC angiograms
  - 12 mm x 12 mm, 1024 x 1024 x 6 (b-scan repetitions), 15 µm lateral resolution
  - 1.6 mm x 1.5 mm, 320 x 300 x 10 (b-scan repetitions), 8 µm lateral resolution
- Acquired PLEX® Elite 9000 (ZEISS, Dublin, CA) CC angiograms
  - 12 mm x 12 mm, 100 kHz A-scan rate
  - 3 mm x 3 mm, 100 kHz A-scan rate

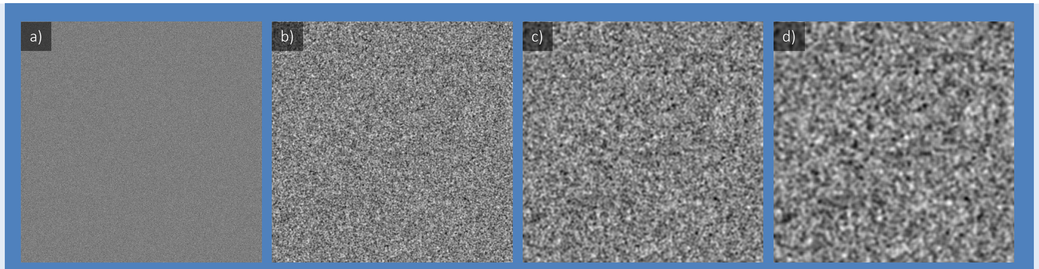


Figure 1 Effect of Gaussian PSF and/or Gaussian spatial filters when imaging sub-resolution structures. a) white noise input image, b)-d) input image (b) convoluted with Gaussian kernel of size 5 (b), 10 (c) and 15 (d) pixels.

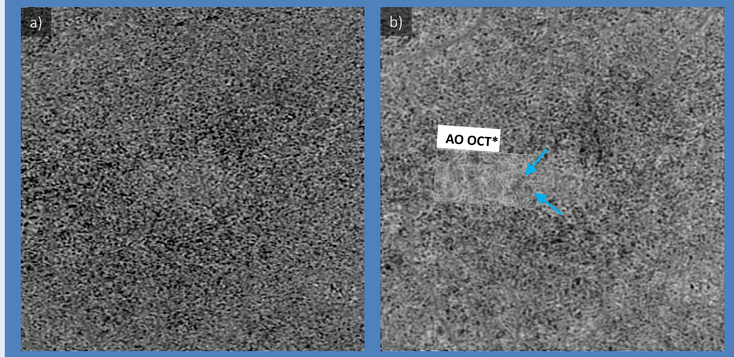


Figure 2 3 mm x 3 mm OCTA scans of the choriocapillaris.

a) single scan

b) average of 7 scans
*overlaid AO OCTA scan of the same eye. AO OCTA image from [2]

Figure 3 Wide field MHz SS-OCTA scan of the choriocapillaris.

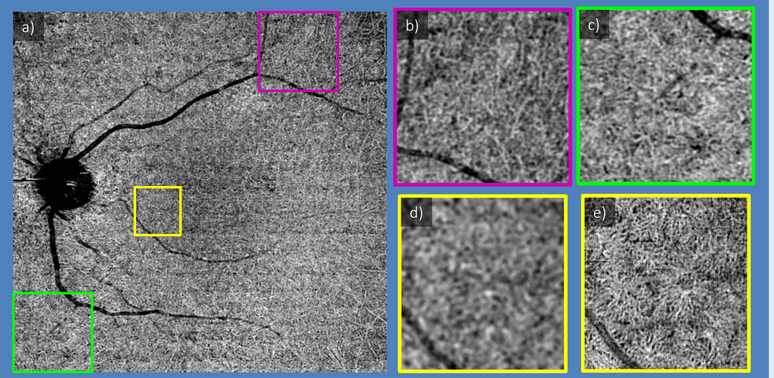
a) 12 mm x 12 mm single scan

b) Zoom in at the location indicated by the pink box

c) Zoom in at location indicated by the green box

d) Zoom in at the location indicated by the yellow box

e) 1.6 mm x 1.5 mm high resolution MHz SS-OCTA scan at the location indicated by the yellow box



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Disclosures: TS (E), MN (C), AB (C), PM (C), SB (E), SK (E), WD (C, F), RAL (C, F)

RESULTS

- Fig. 1 demonstrates how a convolution of a simple white noise frame (a) with a Gaussian kernel generates structures that resemble CC capillary patterns. Varying the kernel size ((b) through (d)) enables the generation of images that look like OCTA CC scans (Fig. 2 a-e).
- Fig. 2 shows the effect averaging multiple enface OCTA images of the choriocapillaris has on the resolution of the capillary network.
- The overlaid AO OCT scan from [2] proofs that the resolved pattern truly corresponds to the CC.
- Individual capillaries could be resolved in the periphery of single shot 12 mm x 12 mm scans using the MHz SS-OCT system (Fig. 3).
- When zooming into the macula (Fig. 3d) one however discovers a pattern very similar to the simulated images in Fig. 1.
- The high-resolution scan in Fig. 3 e) underlines that the lower resolution wide field scan fails to resolve individual capillaries in the macula (Fig. 3d).

CONCLUSIONS

- Special attention must be paid to the lateral resolving capabilities and post processing steps when trying to resolve the vascular network of the CC.
- Averaging multiple OCTA scans as well as high resolution OCTA imaging enables the resolution of individual capillaries in the CC.

REFERENCES

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[2] K. Kurokawa, Z. Liu, D.T. Miller, "Adaptive optics optical coherence tomography angiography for morphometric analysis of choriocapillaris," Biomed. Opt. Express 2017