

Case report

Detection of retrobulbar blood vessels in optical coherence tomography angiographic images in eyes with pathologic myopia



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ABSTRACT

Purpose: To report the detection of retrobulbar blood vessel in the optical coherence tomography angiographic (OCTA) images of two eyes with pathologic myopia.

Observations: Two eyes of 2 cases with pathologic myopia were examined by OCTA (RTVue XR Avanti, Optovue, and Cirrus 5000, Zeiss). Case 1 was a 64-year-old man, and Case 2 was a 65-year-old woman. In Case 1, the thickness of the subfoveal choroid was 38 μm and the sclera was 274 μm , and they were 17 μm and 214 μm , respectively, in Case 2. The axial length was 35.8 mm in Case 1 and 29.5 mm in Case 2. The choroidal vessels were clearly visible in the choriocapillary slab in both the RTVue and the Cirrus images. The vessels were visible in the area of the retinal pigment epithelial and choriocapillaris atrophy due to the pathologic myopia. The retrobulbar blood vessels temporal to fovea were seen in the OCTA images at the level of the outer aspect of the sclera in both cases. Cross sectional images of the retrobulbar blood vessel in both cases were observed under the sclera in serial scan images overlaid with blood flow.

Conclusions and Importance: These *in situ* images of the retrobulbar blood vessels that were obtained by OCTA was possible because of the thinness of the choroid and sclera and atrophy of the choriocapillaris in these eyes with pathologic myopia. We conclude that OCTA might have utility to study the retrobulbar vascular alterations in eyes with pathologic myopia.

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1. Introduction

The retrobulbar vasculature is generally not visible by the conventional imaging methods including optical coherence tomography (OCT) because a large part of the energy of the examining light is blocked by the choroid and sclera. Even with enhanced depth imaging (EDI) and swept source (SS) OCT with longer wavelength examining light, only images of the choroid can be observed in normal eyes.^{1–5}

In contrast, the choroid and the sclera can be observed in eyes with pathologic myopia with a long axial length by EDI and SS OCT.^{6–11} Moreover, the orbital fat and even retrobulbar blood vessels including the short and long posterior ciliary artery (SPCA and LPCA) posterior to the sclera can be seen in some eyes with pathologic myopia.⁸

OCT angiography (OCTA) is new technique that can detect the retinal blood vessel patterns in *en face* images. However, there are few studies on the choroidal blood pattern using OCTA because the

vessels are generally not visible in eyes with normal choroidal and scleral thicknesses.^{12,13} However, Spaide et al.¹⁴ were able to examine the choroidal vessels in the OCTA images of eyes with retinal pigment epithelial (RPE) atrophy.

We report two eyes with pathologic myopia in which images of not only the choroidal but also the retrobulbar blood vessels were visible in the OCTA images.

2. Findings

2.1. Case 1

Case 1 was a 64-year-old man who noted a gradual reduction in the vision of both eyes. He had had cataract surgery and intraocular lens implantation about five years earlier. His reflective error was -3.25 diopters (D) in the right eye and -2.50 D in the left eye, and the axial length was 35.1 mm in the right eye and 35.8 mm in the left eye. His decimal best-corrected visual acuity (BCVA) was 1.0 in both eyes. Ophthalmoscopy showed a tigroid fundus with fovea-sparing RPE atrophy in the left eye (Fig. 1A). The thickness of the

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subfoveal choroid was 38 μm , and that of the sclera was 274 μm measured in the SS-OCT (DRI-OCT, Topcon, Japan) images.

OCTA (RTVue XR Avanti, Optovue, Fremont, California) showed that the medium and large choroidal vessels pattern and extensive choriocapillaris loss within the area of RPE atrophy (Fig. 1B). However, some of the vessels were seen as unavoidable projection artifacts. The OCTA images manually segmented at the level of the outer aspect of the sclera showed a blood vessel temporal to the fovea as a white vessel although it was not seen at the standard level of the choroidal capillary bed (Fig. 1C, Red arrows). Cross sectional images of the vessel were also observed posterior to the sclera in serial cross sectional scans overlaid with the blood flow pattern (Supplemental File 1). En face OCT at the level of the outer aspect of the sclera also shows a blood vessel structure (Fig. 1H, White arrows) corresponding to OCTA images. We determined that the vessel was a retrobulbar blood vessel, probably the SPCA, because the vessel passed temporal to the fovea longitudinally.

Supplementary video related to this article can be found at <http://dx.doi.org/10.1016/j.ajoc.2016.09.006>

2.2. Case 2

A 65-year-old woman complained of metamorphopsia in her left eye. Her decimal BCVA was 0.2 in the left eye. She reported that she has been myopic in both eyes since she was a child. She was diagnosed earlier with myopic retinoschisis with a posterior staphyloma and underwent vitrectomy combined with cataract surgery. The axial length was 29.5 mm in the left eye. A second vitrectomy with gas tamponade was performed for a retinal detachment within the area of a posterior staphyloma two months after the first surgery. Finally, her decimal BCVA improved to 0.4 in the left eye. Ophthalmoscopy showed a tigroid fundus with large RPE atrophy in the papillary and macular area in the left eye (Fig. 2A).

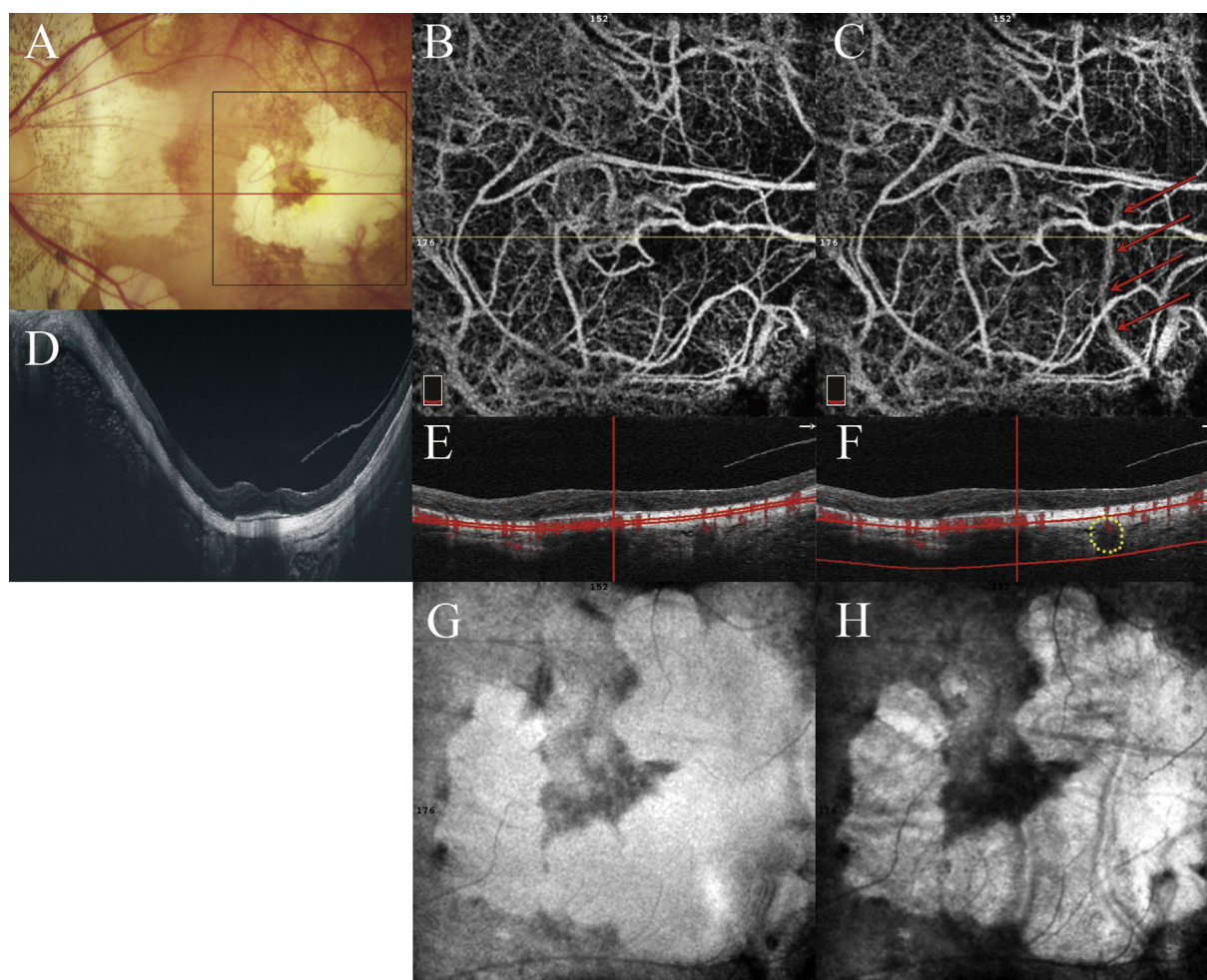


Fig. 1. Case 1. Images of the left eye of a 64-year-old man with pathologic myopia. The axial length of the left eye was 35.8 mm. **A.** Fundus photograph shows a tigroid appearing fovea with retinal pigment epithelium atrophy in the shape of a hoof print. **B.** Optical coherence tomography angiography of a standard slab of the choroid capillary. Choroidal vessels are observed within the area of retinal pigment epithelium atrophy although some retinal vessels are unavoidable projection artifacts. **C.** Optical coherence tomography angiography manually segmented at the level of the outer aspect of the sclera. Retrobulbar vessels appear inferior-temporal to fovea and run longitudinally. Red arrows indicate the retrobulbar vessel. **D.** Image of a cross sectional scan of swept source optical coherence tomography shows thin choroid and sclera. **E.** Cross sectional scan overlaid with blood flow corresponding to the yellow line shown of optical coherence tomography angiography (B). Red lines indicate the offsets (upper offset 31 μm and lower offset 59 μm from retinal pigment epithelium reference; default setting). **F.** Cross sectional scan overlaid with blood flow corresponding to yellow line of optical coherence tomography angiography (C). Dashed yellow circle indicates the retrobulbar blood flow. Red lines indicate the offsets (upper offset 59 μm and lower offset 425 μm from retinal pigment epithelium reference). **G.** En-face images of optical coherence tomography of a standard slab of the choroid capillary. No choroidal vessel structure is observed even in the retinal pigment epithelium atrophy. **H.** En-face images of optical coherence tomography at the level of the outer aspect of the sclera. A blood vessel structure (White arrows) is observed at the corresponding area of optical coherence tomography angiography images (C). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

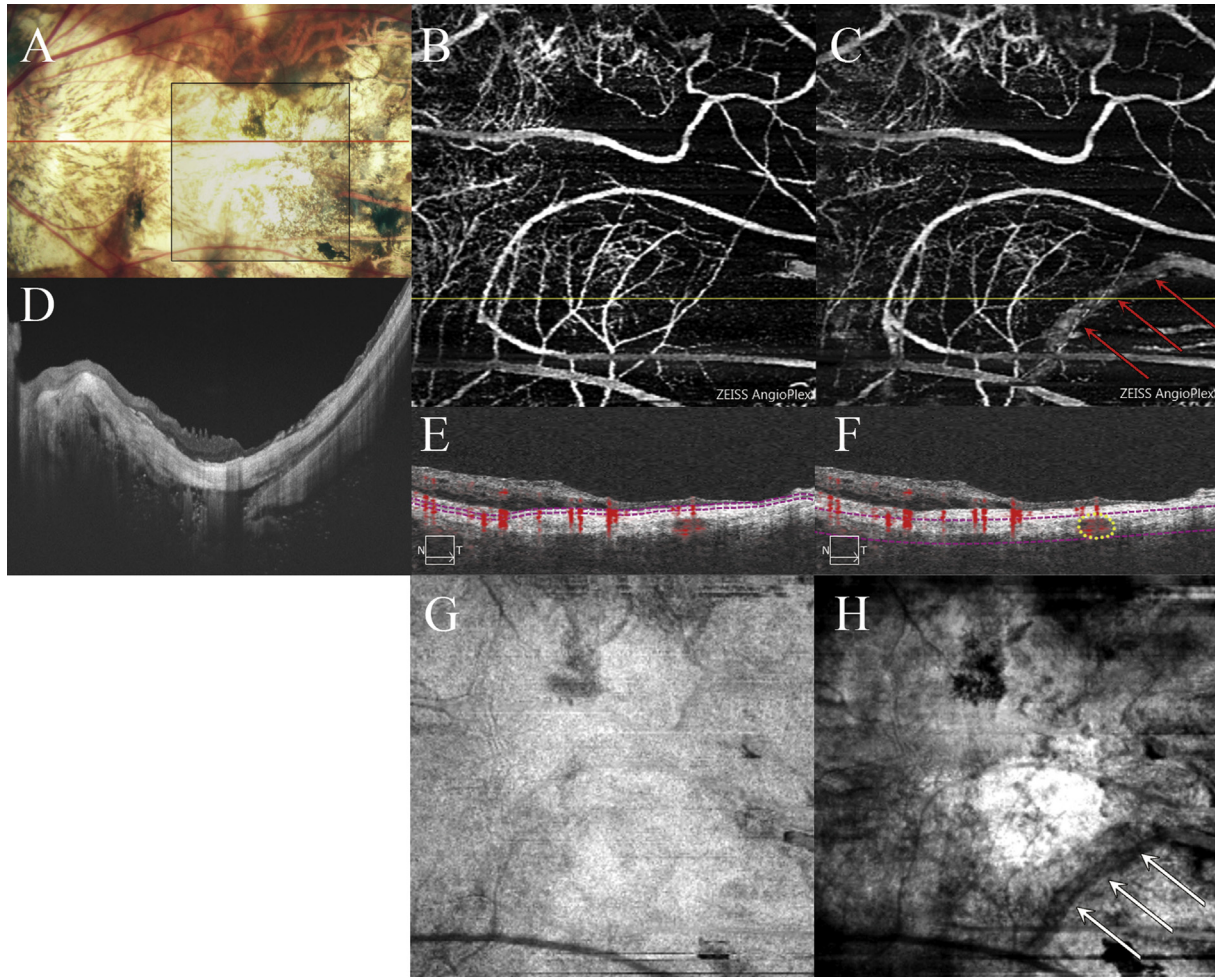


Fig. 2. Case 2: The left eye of a 65-year-old woman with pathologic myopia. Axial length was 29.5 mm. **A.** Fundus photograph showing a tigroid appearance with large area of retinal pigment epithelium atrophy including the papilla and macular area. **B.** Optical coherence tomography angiography of a choriocapillaris slab. Choroidal vessels are observed within the area of the retinal pigment epithelium atrophy although some retinal vessels are seen as the unavoidable projection artifacts. **C.** Optical coherence tomography angiography manually segmented at the level of the outer aspect of the sclera. A retrobulbar vessel appears inferior-temporal to fovea passing longitudinally. Red arrows indicate the retrobulbar vessel. **D.** Image of cross sectional scan of swept source optical coherence tomography shows the thin choroid and sclera. **E.** Cross sectional scan overlaid with blood flow corresponding to the yellow line in the optical coherence tomography angiography. Red lines indicate the offsets (upper offset 29 μm and lower offset 49 μm from retinal pigment epithelium reference; default setting). **F.** Cross sectional scan overlaid with blood flow corresponding to yellow line in the optical coherence tomography angiography. Dashed yellow circle indicates the retrobulbar blood vessel. Red lines indicate the offsets (upper offset 23 μm and lower offset 254 μm from retinal pigment epithelium reference). **G.** En-face images of optical coherence tomography of a standard slab of the choroid capillary. No choroidal vessel structure is observed at al. **H.** En-face images of optical coherence tomography at the level of the outer aspect of the sclera. A blood vessel structure (White arrows) is observed at the corresponding area of optical coherence tomography images (C). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

OCTA (Cirrus 5000 HD-OCT, Zeiss, Germany) showed the retinal and choroidal vessels without choriocapillaris, but some of the vessels within the area of the RPE atrophy were unavoidable projection artifacts (Fig. 2B). OCTA also showed a vessel running longitudinally (Fig. 2C, Red arrows) as a white vessel in the OCTA images manually segmented at the level of the outer aspect of the sclera. This vessel was not seen at the level of the choriocapillaris. Cross sectional images of the vessel were also observed under the sclera in serial cross sectional scans overlaid with the blood flow (Supplemental file 2). En face OCT at the level of the outer aspect of the sclera also shows a blood vessel structure (Fig. 2H, White arrows) corresponding to OCTA images. It was confirmed that the vessel was a retrobulbar blood vessel probably the SPCA.

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3. Discussion

The ophthalmic artery divides into the central retinal artery and the ciliary arteries, and the ophthalmic artery enters the optic nerve to supply the inner retina including the optic disc. The second one branches into the SPCAs and LPCAs. The SPCAs enter the eye through the sclera to connect to the choroidal artery which supplies the posterior pole including the peripapillary and macular regions. The LPCA penetrates the sclera obliquely and passes to the anterior segment to supply the ciliary body and iris. Although it is not possible to observe the SPCAs and LPCAs on standard ophthalmic examinations, it can be seen in eyes with pathologic myopia by ophthalmoscopy and OCT.

OCTA is new technique that can image the retinal blood vessel patterns in *en face* images. There are only a few reports on the choroidal vasculature because it is difficult to observe it in eyes without RPE disorders such as RPE atrophy.^{12–14} In eyes with

pathologic myopia, diffuse and multiple myopic chorioretinal atrophy is often seen in the macular area by ophthalmoscopy. In these cases, OCTA can detect the choroidal vessels as it did in our two cases where numerous choroidal vessels were observed around the fovea in the 3 × 3 mm OCTA images. In addition, retrobulbar vessels were seen in the OCTA images at the level of the outer aspect of the sclera. Because the penetrating site of the ciliary arteries are varied, it is difficult to determine whether the retrobulbar vessels were the SPCAs or LPCAs. However, we suggest that these vessels were probably the SPCAs because the LPCAs should course in a horizontal direction.

There are several weaknesses in this study. This was a study of only two cases. However, Ohno-Matsui et al.⁸ reported that even SS-OCT can view the cross sections of blood vessels within the sclera in only 5.4% of eyes with pathologic myopia. The detection rate of blood flow under or within the sclera might be much lower especially by OCTA based on standard spectral domain OCT system. Earlier, we examined 58 eyes with pathologic myopia using SS-OCT and reported the mean subfoveal scleral thickness was 335 μm.⁷ The current cases showed very thin scleras, e.g., 274 μm in Case 1 and 214 μm in Case 2. This is why the retrobulbar vessels were visible. There are not many opportunities to observe these vessels even in eyes with pathologic myopia. On the other hand, the characteristics of each OCTA instrument are important. The RTVue XR Avanti is based on Split Spectrum Amplitude Decorrelation Angiography (SSADA) and the Cirrus 5000 HD-OCT is based on Optical Micro Angiography (OMAG), and both had almost equal performance for imaging the choroidal and retrobulbar vasculatures. We should also consider the artifacts such as the projection artifacts. In the current cases, several retinal blood vessels were projected even at the level of the retrobulbar depth segmentation in some areas. These artifacts are important for imaging studies, however we do not have any method to remove all of the artifacts. It is important to evaluate the origin of the blood flow signals even at the level of the retrobulbar depth segmentation.

In conclusion, the retrobulbar blood vessel can be detected and studied but mainly in pathologically myopic eyes or eyes with RPE and scleral atrophy. These findings indicate that OCTA can detect the blood vessel pattern in the retina, choroid, or the outer aspect of the sclera in cases with pathologic myopia without blockage of light by the RPE.

4. Patient consent

Ethical approval and Patient consent: This retrospective study was conducted according to the tenets of the Declaration of Helsinki. The institutional review board at Tokyo Women's Medical University School of Medicine approved the study, which included OCT observation of eyes with macular and retinal disorders, observational study of age-related macular degeneration, and similar disorders (including high myopia). The patients have consented orally to submission of this case series to the journal.

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Conflict of interest

Dr. Maruko reports personal fees from Novartis Pharma K.K., personal fees from Bayer Yakuhin, Ltd., personal fees from Santen

Pharmaceutical Inc., personal fees from Alcon Japan, Ltd., personal fees from Topcon Co., Ltd., personal fees from Senju Pharmaceutical Co., Ltd., personal fees from NIDEK Co., Ltd., outside the submitted work.

Dr. Koizumi reports personal fees from Novartis Pharma K.K., personal fees from Bayer Yakuhin, Ltd., personal fees from Santen Pharmaceutical Inc., personal fees from Alcon Japan, Ltd., personal fees from Topcon Co., Ltd., personal fees from Senju Pharmaceutical Co., Ltd., personal fees from HOYA Corp., personal fees from Canon Inc., personal fees from Wakamoto Pharmaceutical Co., Ltd., personal fees from NIDEK Co., Ltd., outside the submitted work.

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Dr. Hasegawa has nothing to disclose.

Authorship

All authors attest that they meet the current ICMJE criteria for Authorship.

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References

- Spaide RF, Koizumi H, Pozzoni MC. Enhanced depth imaging spectral-domain optical coherence tomography. *Am J Ophthalmol*. 2008;146:496–500.
- Margolis R, Spaide RF. A pilot study of enhanced depth imaging optical coherence tomography of the choroid in normal eyes. *Am J Ophthalmol*. 2009;147:811–815.
- Ikuno Y, Maruko I, Yasuno Y, et al. Reproducibility of retinal and choroidal thickness measurements in enhanced depth imaging and high-penetration optical coherence tomography. *Invest Ophthalmol Vis Sci*. 2011;52:5536–5540.
- Hirata M, Tsujikawa A, Matsumoto A, et al. Macular choroidal thickness and volume in normal subjects measured by swept-source optical coherence tomography. *Invest Ophthalmol Vis Sci*. 2011;52:4971–4981.
- Agawa T, Miura M, Ikuno Y, et al. Choroidal thickness measurement in healthy Japanese subjects by three-dimensional high-penetration optical coherence tomography. *Graefes Arch Clin Exp Ophthalmol*. 2011;249:1485–1492.
- Imamura Y, Iida T, Maruko I, Zweifel SA, Spaide RF. Enhanced depth imaging optical coherence tomography of the sclera in dome-shaped macula. *Am J Ophthalmol*. 2011;151:297–302.
- Maruko I, Iida T, Sugano Y, Oyama H, Akiba M, Sekiryu T. Morphologic analysis in pathologic myopia using high-penetration optical coherence tomography. *Invest Ophthalmol Vis Sci*. 2012;53:3834–3838.
- Ohno-Matsui K, Akiba M, Ishibashi T, Moriyama M. Observations of vascular structures within and posterior to sclera in eyes with pathologic myopia by swept-source optical coherence tomography. *Invest Ophthalmol Vis Sci*. 2012;53:7290–7298.
- Ohno-Matsui K, Kasahara K, Moriyama M. Detection of Zinn-Haller arterial ring in highly myopic eyes by simultaneous indocyanine green angiography and optical coherence tomography. *Am J Ophthalmol*. 2013;155:920–926.
- Hayashi M, Ito Y, Takahashi A, Kawano K, Terasaki H. Scleral thickness in highly myopic eyes measured by enhanced depth imaging optical coherence tomography. *Eye Lond*. 2013;27:410–417.
- Invernizzi A, Giani A, Cigada M, Staurengi G. Retrobulbar structure visualization with enhanced depth imaging optical coherence tomography. *Invest Ophthalmol Vis Sci*. 2013;54:2678–2684.
- Kim DY, Fingler J, Zawadzki RJ, et al. Optical imaging of the chorioretinal vasculature in the living human eye. *Proc Natl Acad Sci U. S. A*. 2013;110:14354–14359.
- Jia Y, Bailey ST, Hwang TS, et al. Quantitative optical coherence tomography angiography of vascular abnormalities in the living human eye. *Proc Natl Acad Sci U. S. A*. 2015;112:E2395–E2402.
- Spaide RF, Fujimoto JG, Waheed NK. Image artifacts in optical coherence tomography angiography. *Retina*. 2015;35:2163–2180.