ABSTRACT: Optical coherence tomography angiography (OCTA) is a new imaging technology capable of providing three-dimensional (3-D) retinal and choroidal microvascular maps without a need for exogenous dye. In this study, the authors evaluate the retinal and choroidal microvascular architecture of the macula in a patient with choroidal hemangioma using OCTA. Widefield OCTA with tracking capability and segmentation was performed to provide images with a field of view at 9 × 9 mm². The en face maximum projection was used to generate 2-D angiograms of different layers with color-coded images. Variable levels of perfusion within the lesion were identified, which correlate well with the known vascular abnormalities of choroidal hemangiomas. OCTA demonstrated an accurate modality to measure the 3-D borders of this lesion. This is the novel utilization of OCTA imaging on choroidal hemangioma. OCTA may provide detailed vascular findings in circumscribed choroidal hemangiomas, which may aid in the diagnosis and evaluation of the treatment response.


INTRODUCTION

Choroidal hemangioma is a smooth, red-orange, typically unilateral, benign vascular tumor that occurs in either a circumscribed or a diffuse form, the latter of which is associated with Sturge-Weber syndrome.¹ The lesions have been suggested to be congenital; however, the pathogenesis and incidence is unknown.² Although the tumor may be asymptomatic and undetected by cursory fundus examination, submacular or juxtapapillary lesions often result in decreased visual acuity due to macular edema, serous retinal detachments, or subretinal fibrosis during the second to fifth decades of life.²⁻⁴ Histopathologically, lesions are classified by the vessels seen in the tumor — either as cavernous with large vessels, capillary with small vessels separated by loose connective tissue, or mixed.²

Treatment may be performed for symptomatic lesions. Photodynamic therapy currently is the most promising modality;¹,³,⁵ however, laser photocoagulation, transpupillary thermotherapy, plaque brachytherapy, external beam radiotherapy, proton beam radiation, gamma knife radiosurgery, and anti-vascular endothelial growth factor agents have also been employed.²

Multiple authors report imaging modalities used to evaluate choroidal hemangiomas, with variable
Given the location and vascularized nature of these tumors, it is difficult to ascertain with traditional imaging the depth and size, underlining the need for further imaging modalities to better evaluate this tumor. To date, findings from optical coherence tomography angiography (OCTA) have yet to be reported for a choroidal hemangioma. In this study, we present findings of a circumscribed choroidal hemangioma imaged via OCTA.

**PATIENTS AND METHODS**

One patient with a clinically confirmed diagnosis of choroidal hemangioma underwent a complete eye examination, including slit-lamp examination, dilated fundus examination, color funding imaging, Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany), fluorescein angiography (FA), indocyanine green angiography (ICGA), and MRI of the orbits with contrast. The patient also underwent imaging...
with swept-source OCTA (SS-OCTA) named with PLEX Elite 9000 (Zeiss, Dublin, CA) that operates at a central wavelength of 1,060 nm with the Optical Micro Angiography (OMAGc) algorithm to extract the blood-flow information. The use of PLEX Elite 9000 in the imaging of the patients was approved by the center’s institutional review board. The informed consent for the use of the unidentified personal and medical information for the publication of this case report and any accompanying images was obtained. All procedures adhered to the tenets of Declaration of Helsinki.

The PLEX Elite 9000 system operates at a central wavelength of 1,060 nm with an A-scan speed of 100,000 scans per second. Three scanning protocols were performed on the patient, which included a $512 \times 128$ macular raster scan, a single high-density B-scan with 1,024 A-scans, and a $9 \times 9 \text{mm}^2$ widefield OMAG scan. The $9 \times 9 \text{mm}^2$ OMAG scan, based on the built-in tracking line scanning ophthalmoscope system, was sampled by 500 A-lines $\times$ 500 B-frames with two repetitions in a single scan within 5 seconds. The OMAGc algorithm$^{9,11}$ was utilized to extract the vascular networks in the instruments.

Four layers in the retina were automatically segmented and provided by the device, including a vitreous-retinal layer (inner limiting membrane [ILM] - 50 µm to ILM), superficial retinal layer (ganglion cell layer + inner plexiform layer), deep retinal layer (inner nuclear layer + outer plexiform layer), and avascular retinal layer (outer nuclear layer + external limiting membrane). Color-coded images were offered to depict the depth of vascular flow. Two layers were automatically segmented in the choroid, including a choriocapillaris layer (retinal pigment epithelium [RPE] to RPEfit + 20 µm), and a choroid layer (RPEfit + 20 µm to RPEfit + 200 µm). The en face maximum projection was used to generate two-dimensional (2-D) angiograms of different layers and color-coded images. Flow and structure images were combined for cross-sectional view.

**RESULTS**

A 66-year-old male without prior ocular history was referred for routine diabetic eye exam. The patient had no visual complaints. His best-corrected visual acuity was 20/20 in the right eye and 20/30 in the affected left eye. His intraocular pressures were 17 mm Hg in the right eye and 18 mm Hg in the left eye. Extraocular movements were full, visual fields were symmetrically intact, and there was no afferent pupillary defect. Slit-lamp examination of the anterior segment was unremarkable. Dilated fundus exam revealed bilateral drusen and trace mass effect of the macula creating a slight convexity to the posterior pole in the left eye, difficult to see on clinical exam and fundus photography (Figure A), but pronounced on Spectralis OCT (Figure B). MRI imaging during the workup was performed to correlate the mass and the ocular imaging in addition to evaluating the extent of the tumor (Figure C). Superimposed FA and ICGA images of the lesion revealed normal retinal vasculature and filling without leakage but with patchy underlying choroidal vascular changes. OCTA imaging was acquired, which demonstrated relatively normal superficial and deep retinal vasculature overlying the tumor. The deeper segments of OCTA demonstrated choroidal involvement with clear borders in both the choriocapillaris and choroid layer (Figure D). OCTA also offered excellent visualization of intrinsic vessels of the lesions surrounded by a lack of filling best seen in the choroid layer (Figures E-G).

**DISCUSSION**

Choroidal hemangiomas are uncommon lesions found on clinical exam. Numerous imaging modalities have been utilized to assist in evaluating these lesions and ruling out less likely diagnoses. Ultrasoundography demonstrates a high internal acoustic reflectivity and is helpful in differentiating choroidal hemangiomas from other tumors. ICGA is also a helpful imaging modality, typically demonstrating strong hyperfluorescence of the tumor in the late phases, compared to the surrounding choroid. Spectral-domain OCT may demonstrate retinal changes superficial to the lesion including photoreceptor atrophy, intraretinal/subretinal fluid, subretinal fibrosis, and/or a homogenous hyporeflective appearance with intrinsic spaces in the inner surface of the tumor. SS-OCT has recently been proposed as a beneficial imaging modality to more accurately measure the size of the tumor in comparison with ultrasonography and to provide a distinct multi-lobular, sponge-like pattern with a hyperreflective halo surrounding the tumor.

OCTA is a noninvasive imaging modality capable of acquiring 3-D retinal and choroidal microvascular maps without the use of exogenous dye. It also provides information about vascular flow in various diseases including vascular lesions. It may be particularly helpful in providing detailed angiographic imaging of vascular choroidal lesions. To our knowledge, this is the first description of OCTA findings in a choroidal hemangioma. We find OCTA to be particularly useful in evaluating the tumor boundaries and the vascular filling pattern, particularly in comparison to ICGA. Additionally, OCTA may help differentiate choroidal hemangioma from atypical presentations of choroidal metastasis, amelanotic...
melanoma, or other rare choroidal lesions. Further studies demonstrating the differences in vascular response following treatment of such lesions are of interest. OCTA may become a useful image modality for assessing treatment efficacy for this vascular lesion.

REFERENCES