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Wide field swept source OCT angiography of multifocal retinal and choroidal occlusions from embolic triamcinolone acetonide

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ABSTRACT

Purpose: Multifocal retinal arterial occlusions and choroidal infarctions due to embolic triamcinolone acetonide (TA) administered during a septoplasty were imaged using swept source OCT angiography (SS-OCTA) to demonstrate the utility of this imaging modality for the diagnosis and longitudinal follow-up of retinal and choroidal vascular diseases.

Observations: A 37-year-old man presented with vision loss in his left eye upon awakening from a left-sided septoplasty during which TA was injected. Examination of the left eye demonstrated retinal whitening in the macula, white material in the distal lumen of retinal arterioles, and multifocal hypopigmented choroidal lesions. SS-OCTA imaging showed the absence of detectable flow in areas of retinal and choroidal whitening. Corresponding B-scans demonstrated hyperreflective material, thought to be embolic TA, within the retinal vessels and inner choroid.

Conclusions: Wide field SS-OCTA was sufficient for the diagnosis and longitudinal evaluation of retinal and choroidal occlusions without the need for dye-based angiography.

1. Introduction

The arterial vascular network of the face is interconnected. The nasal septum is supplied from both the internal and external carotid arteries.[1,2] Kiesselbach's plexus, in the anterior nasal septum, is a common site of epistaxis and an anastomosis between the internal and external carotid arteries.[3]

Injection into the face and inadvertent intraoperative cannulation of an artery within the nasal septum can lead to retrograde flow into the ophthalmic artery. This can lead to embolic retinal arterial and choroidal occlusions. Previous reports in the literature have described retinal artery[4–11] and choroidal occlusions[5,12,13] after hyaluronic acid filler, periocular steroid, and autologous fat injections around the face. Within the field of otolaryngology, intraoperative injections during septoplasties and other rhinological surgeries can also lead to retinal arterial[14–18] and choroidal occlusions.[16,19]

Traditionally, fluorescein angiography (FA) has been used to diagnose and longitudinally follow patients with retinal arterial and choroidal occlusions.[20] However, swept source optical coherence tomography angiography (SS-OCTA) offers a fast, non-invasive, safe, and easily repeatable alternative to FA for the diagnosis and monitoring of retinal and choroidal occlusions.[21,22] Furthermore, boundary-specific segmentation strategies with OCTA can be used to isolate and evaluate different layers of retinal and choroidal vasculature.

The present report describes SS-OCTA imaging of a case of retinal and choroidal arterial occlusion after intraoperative triamcinolone acetonide injection during a septoplasty.

2. Case report

A 37-year-old man presented to the Bascom Palmer Eye Institute with decreased vision in his left eye. Earlier that day, the patient underwent a left-sided septoplasty. Upon awakening, he immediately noted a fixed central scotoma in his left eye. He denied any ocular history, trauma, or pain.

On initial examination, vision acuity was 20/20 in the right eye and 20/40 in the left. Pupillary response, intraocular pressure, and anterior segment examination were normal in both eyes. Posterior examination of the right eye was normal. Fundus examination of the left eye showed multifocal whitening of the macula along with white material at the distal ends of retinal arterioles (Fig. 1A and B). In addition, multifocal, hypopigmented foci were present deep to the retina throughout the

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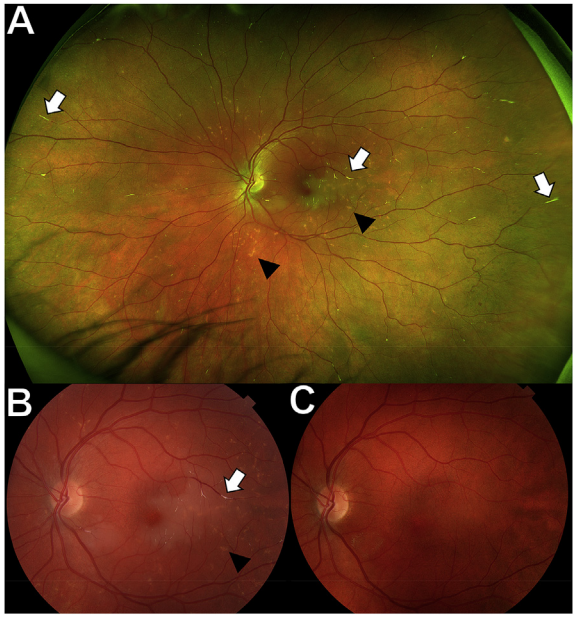

Fig. 1. Fundus photographs of multifocal retinal and choroidal triamcinolone acetonide emboli at presentation(A) Ultrawide-field fundus photograph of the left eye at presentation demonstrated multifocal whitening of the macula along with diffuse deposition at the distal ends of retinal arterioles with white material (white arrows). Multifocal, hypopigmented areas deep to the retina were also present (black arrowheads). Fundus photographs at presentation (**B**) and one month (**C**) demonstrated resolution of the retinal whitening, multifocal retinal emboli, and foci of choroidal hypopigmentation. There was subtle retinal atrophy at one month that was most prominent temporally (**C**).

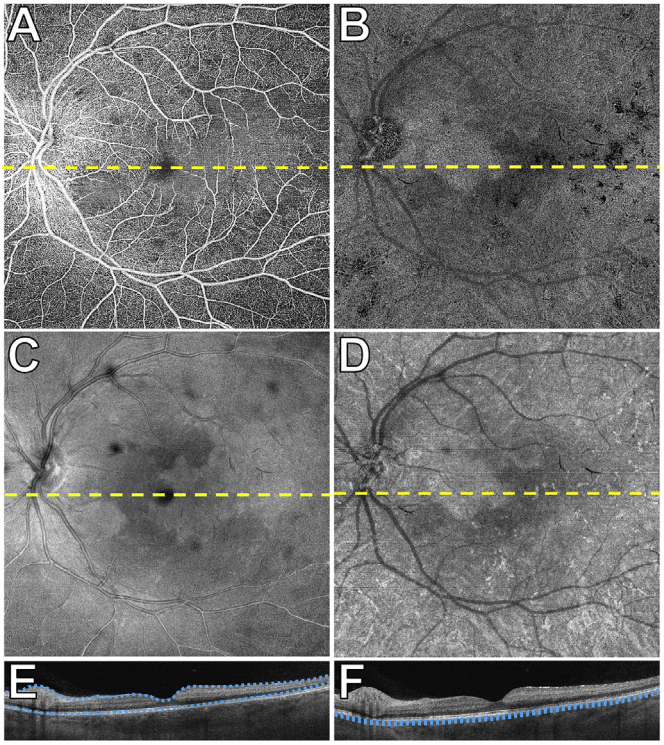

Fig. 2. Wide field swept source OCT angiography (WF SS-OCTA) of multifocal retinal and choroidal triamcinolone emboli at presentation(A) WF SS-OCTA 12 × 12mm en face OCTA slabs show detectable flow within the total retina and demonstrate multifocal retinal flow deficits (**A**) that correspond to material in distal retinal arterioles on the corresponding OCT en face structural image (**C**) (see Fig. 3 Legend for explanation of why these lesions appeared hyporeflective). Paracentral acute middle maculopathy was seen on the B-scan (**E**) and manifested as geographic areas of increased signal reflectivity on the OCT en face structural image (**C**) corresponding to areas of retinal whitening seen on fundus photographs (Fig. 1B). SS-OCTA of the choriocapillaris demonstrated multifocal flow deficits (**B**) that corresponded to stellate areas of hyperreflectivity seen on the en face structural image (**D**). There was relative decreased signal on choriocapillaris OCTA slab and decreased reflectivity on the choriocapillaris structural slab in the areas of PAMM. Yellow dashed lines depict the locations of corresponding B-scans. Blue dotted lines in **E** and **F** depict segmentation for the total retinal (**A, C**) and choriocapillaris (**B, D**) slabs, respectively. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

posterior pole (Fig. 1A and B).

Having undergone his septoplasty earlier that morning and distressed by his complication, the patient refused further invasive testing including fluorescein angiography. Instead, wide field SS-OCTA imaging was performed using the PLEX® Elite 9000 instrument (Carl Zeiss Meditec, Inc., Dublin, CA). At presentation, SS-OCTA imaging showed evidence of multifocal retinal flow deficits (Fig. 2A). At the areas of the white material within the retinal arterioles (Fig. 1B), OCT en face structural images showed hyporeflectivity (Fig. 2C), the angiographic images showed a decrease in surrounding retinal perfusion, and B-scans showed superficial hyperreflective material associated with the white material (Fig. 3B) (see Fig. 3 Legend for an explanation for this discordance). SS-OCTA of the choriocapillaris demonstrated multifocal flow deficits (Fig. 2B) that corresponded to the deep hypopigmented foci seen on color imaging and the stellate areas of hyperreflectivity seen on the en face structural SS-OCT images (Fig. 2D).

On SS-OCT B-scans, hyperreflectivity in the inner nuclear layer (INL) representing paracentral acute middle maculopathy (PAMM) was seen corresponding to the areas of retinal whitening on clinical exam (Fig. 3B and D). Hyperreflective material within superficial retinal vessels was seen with associated shadowing (Fig. 3B). At baseline, these vessels were associated with flow deficits (Fig. 3B). Moreover, the hyperreflective material associated with shadowing seen within the inner choroid (Fig. 4C) corresponded with areas of choriocapillaris flow deficits (Fig. 4A).

The patient's surgeon was contacted and disclosed that an intraoperative injection of TA into the septal mucosa had been performed. Since the patient lost vision upon awakening after TA injection and lacked systemic risk factors, the etiology of his multifocal retinal and choroidal arterial occlusions was concluded to have been due to embolic TA.

The patient underwent neuroimaging to ensure that larger vessels were not involved, and no cerebral emboli were identified. Computed tomography (CT) of the head and CT angiography of the head and neck did not reveal any abnormalities. An electrocardiogram and echocardiogram with bubble study did not demonstrate any abnormalities to suggest an alternative embolic source.

Fundus examination at one week and one month demonstrated total resolution of the white material occluding the retinal arteries (Fig. 1C). Repeat SS-OCTA also demonstrated resolution of the hyperreflective material previously seen filling the retinal arterioles (Fig. 3F) and in the choriocapillaris (Fig. 4F). Over the course of one month, the areas of PAMM evolved into inner retinal atrophy (Figs. 1C and 3F). Repeat SS-OCTA at 1 week and 1 month demonstrated restoration of flow within the retinal capillaries and choriocapillaris (Fig. 5). The patient's vision in the affected eye remained 20/40 with a fixed scotoma.

3. Discussion

Traditionally, dye-based angiography (FA and indocyanine green angiography) has been used to characterize retinal and choroidal vascular occlusions. Dye-based angiography is time consuming and requires intravenous access, necessitates selection of a transit eye that limits interpretation of arterial perfusion of the non-transit eye, cannot

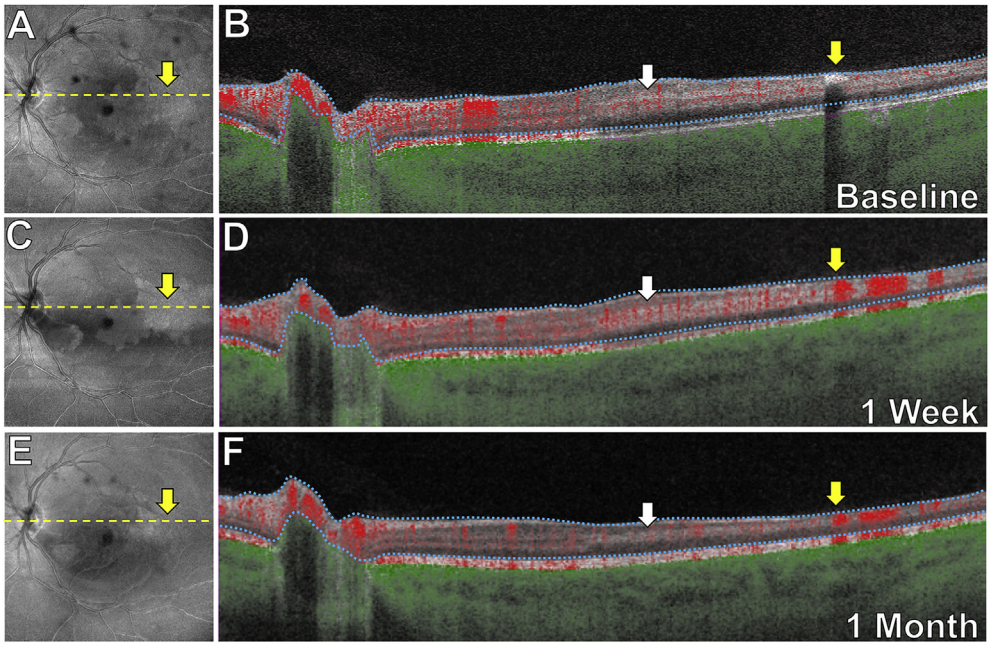

Fig. 3. Evolution of paracentral acute middle maculopathy and reperfusion of retinal vessels over time on wide field swept source OCT angiography (WF SS-OCTA) (A) WF SS-OCTA 12 × 12mm en face OCT structural slabs of the total retinal vasculature at baseline demonstrated geographic areas of hyperreflectivity corresponding to areas of paracentral acute middle maculopathy (PAMM; white arrow in **B**). Corresponding B-scans through areas of triamcinolone acetonide emboli in the distal retinal arterioles showed hyperreflective material (yellow arrow in **B**) within the superficial retina, and an absence of detectable flow. These hyperreflective lesions caused such intense shadowing of the PAMM that the lesions appeared hyporeflective on structural slabs (**A**). At one week (**C, D**), the PAMM persisted (white arrow in **D**) but the hyperreflective embolic material had disappeared and the retinal vessel had recanalized (yellow arrow in **D**). At one month (**E, F**), the PAMM had evolved into inner retinal atrophy (white arrow in **E**), and the vessel that had been occluded at baseline continued to have flow (yellow arrow in **F**). Yellow dashed lines depict the locations of corresponding B-scans. Blue dotted lines depict segmentation for the total retinal slabs. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

be performed in patients with certain allergies, and has side effects.[23] In this report, we have shown that an alternative form of angiography, SS-OCTA, can be used to diagnose and longitudinally evaluate retinal and choroidal arterial occlusions in a fast, safe, non-invasive, and repeatable manner.

Our case demonstrates the importance of utilizing both en face OCTA and OCT structural slabs for proper interpretation of SS-OCTA images. Structural slabs depict reflectivity, whereas OCTA slabs depict changes in blood flow due to changes in reflectivity of repeated scans at the same position. In areas where there are no changes in reflectivity detected on repeated scans, OCTA flow slabs are dark, indicating the absence of detectable flow. However, if the corresponding structural slab also shows dark areas, then the absence of detectable flow seen on the OCTA slab may be artefactual because of poor signal strength from media opacity or from the attenuation of the reflected signal due to overlying hyperreflective material (retinal vessels, retinal vascular emboli, drusen, etc.), which causes a shadowing artifact in the deeper slabs.

For example, the choriocapillaris OCTA slab in Fig. 2B shows two types of flow deficits: stellate areas most concentrated temporally and linear lesions superotemporal to the fovea. The stellate areas on the OCTA slab correlate with hyperreflective lesions on the corresponding structural slab (Fig. 2D). These lesions represent TA emboli within the inner choroid, likely lodged within individual lobules of the choriocapillaris, and therefore these flow deficits seen on the OCTA slab can be interpreted as genuine. In contrast, the linear flow deficits on the choriocapillaris OCTA slab (Fig. 2B) are associated with loss of reflectivity on the corresponding choriocapillaris structural slab (Fig. 2D). These lesions are an artifact of shadowing from TA emboli within superficial retinal vessels and do not reflect actual loss of choriocapillaris perfusion.

En face SS-OCT structural slabs were also helpful in delineating borders of paracentral acute middle maculopathy (PAMM). PAMM, which is defined by hyperreflectivity of the INL,[24,25] caused an overall

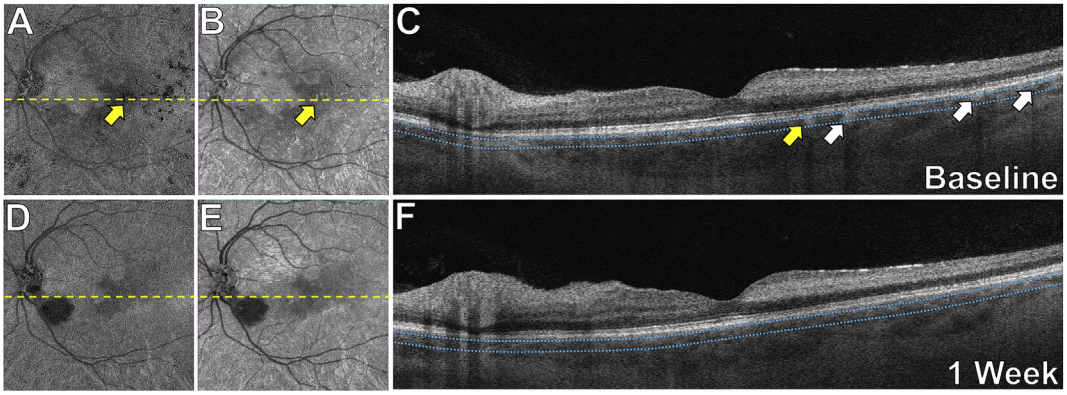

Fig. 4. Resolution of choriocapillaris triamcinolone acetonide emboli and corresponding flow deficits over time on wide field swept source OCT angiography (WF SS-OCTA)(A) Flow deficits seen on the WF SS-OCTA 12 × 12mm choriocapillaris slab at presentation corresponded to hyperreflective lesions on the en face structural images (**B**) and B-scans (**C**). The B-scan (**C**) illustrates shadowing from the hyperreflective lesions that represent embolic triamcinolone acetonide. At the one-week visit, the choriocapillaris flow deficits had resolved (**D**) and the hyperreflective lesions had resolved on the structural image (**E**) and B-scan (**F**). Paracentral acute middle maculopathy in the temporal macula caused shadowing with consequent geographic areas of hyporeflectivity on structural slabs and artefactual hypoperfusion on OCTA slabs. Yellow dashed lines depict the locations of corresponding B-scans. Blue dotted lines depict segmentation for the choriocapillaris slabs. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

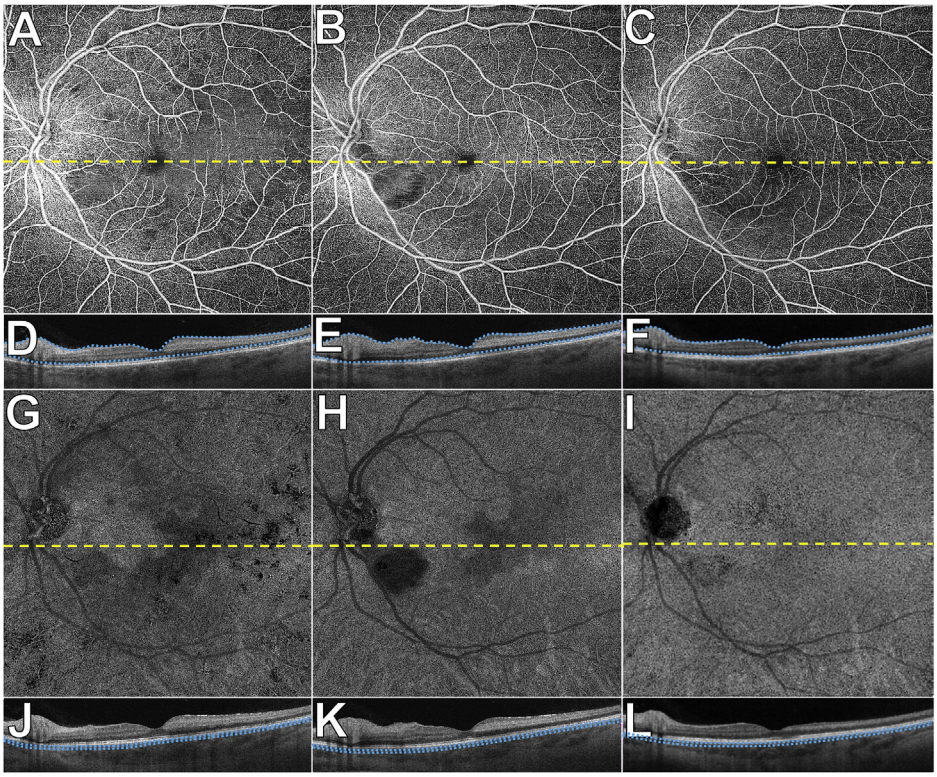

Fig. 5. Wide field swept source OCT angiography (WF SS-OCTA) of multifocal retinal and choroidal flow deficits over one month(A) WF SS-OCTA 12 × 12mm total retinal vessel slabs at presentation, 1 week (**B**), and 1 month (**C**) demonstrated resolution of retinal flow deficits. Choriocapillaris slabs at presentation (**G**), 1 week (**H**), and 1 month (**I**) demonstrated resolution of choriocapillaris flow deficits. Paracentral acute middle maculopathy (PAMM) in the temporal macula (**J**) caused shadowing with consequent geographic areas of hyporeflectivity on structural slabs and artefactual hypoperfusion on OCTA slabs at baseline (**G**) and 1 week (**H**). At 1 week a new area of PAMM appeared inferotemporal to the optic disc that caused shadowing and artefactual choriocapillaris hypoperfusion (**H**) that had nearly resolved by 1 month (**I**). Yellow dashed lines depict the locations of corresponding B-scans. Blue dotted lines depict segmentation for the total retinal (**D-F**) and choriocapillaris (**J-L**) slabs. . (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.sss

increase in reflectivity of the total retinal slab. Areas of PAMM on the total retinal structural slab (Fig. 2C) matched the distribution of retinal whitening on fundus photography (Fig. 1B). These areas of PAMM were detectable even on OCTA slabs segmented for the choriocapillaris (Fig. 4A and D) because the hyperreflective inner retina caused shadowing, but these areas of relatively low signal were distinguishable from genuine choriocapillaris flow deficits because of hyporeflectivity on the corresponding choriocapillaris structural slabs (Fig. 4B and E).

The repeatability of SS-OCTA enabled us to perform angiography at the 1 week and 1 month visits, which would not have been practical for dye-based angiography. We were thus able to characterize interval disappearance of retinal and choroidal emboli, resolution of PAMM, and restoration of retinal and choriocapillaris flow. Unlike edema of the inner retinal layers that is often seen in retinal arterial occlusion and results from superficial capillary ischemia, PAMM is thought to be associated with ischemia in the intermediate and deep retinal capillary plexuses and may be the only sign of retinal ischemia and evolving retinal artery occlusion.[26,27] In our case, the initial area of PAMM progressed to inner retinal atrophy over the course of 1 month. However, there was also a new area of PAMM (Fig. 5H) that developed by the 1 week follow up visit and eventually resolved by the 1 month follow up visit (Fig. 5I). This new PAMM lesion may have occurred secondary to breakdown and/or migration of triamcinolone particles into downstream retinal vessels. The ease of repeating the OCTA allowed us to capture these dynamic changes over time.

Restoration of retinal flow is known to occur after retinal arterial occlusion, but restoration of choriocapillaris flow has been harder to study prior to the advent of OCTA. It is generally accepted that if retinal circulation is not restored within about 90 minutes, the damage from retinal ischemia becomes irreversible.[28] Whether the same is true for the function of the outer retina and retinal pigment epithelium (RPE) supplied by choriocapillaris perfusion is less well characterized. We observed subtle loss of RPE on OCT at the 1 month visit that corresponded to areas of choriocapillaris ischemia on presentation (Fig. 5G, L), suggesting that anatomic and possibly functional deficits can persist despite reconstitution of choriocapillaris flow.

An additional strength of WF SS-OCTA in this case was the ability to image the entire macula and beyond by using widefield scans. WF SS-OCTA montages are able to image the entire posterior pole in just a few minutes,[29] though montages were not performed in this case. Current limitations of SS-OCTA include the cost of current instruments and inability to obtain commercial reimbursement that is commensurate with the amount of physician interpretation time that can be required, as demonstrated by this case.

In summary, SS-OCTA imaging was sufficient, in the absence of dye-based angiography, for the diagnosis and longitudinal evaluation of multifocal retinal and choroidal embolic occlusions. The repeatability of SS-OCTA allowed us to observe the dynamic course of the disease as demonstrated in this patient over time. The imaging and interpretation strategies demonstrated here can be applied more generally to occlusive retinal and choroidal vascular disease of various etiologies.

3.1. Patient consent

Written consent to publish this case has not been obtained. This report does not contain any personal identifying information.

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Authorship

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

Declaration of competing interest

Philip Rosenfeld and Giovanni Gregori received research support from Carl Zeiss Meditec, Inc. and the University of Miami co-owns a patent that is licensed to Carl Zeiss Meditec, Inc.

Philip Rosenfeld is a consultant for Apellis, Boehringer-Ingelheim, Carl Zeiss Meditec, Chengdu Kanghong Biotech, Ocunexus Therapeutics, Hemera Biosciences, F. Hoffmann-La Roche Ltd., Isarna Pharmaceuticals, Ocunexus, Ocudyne, and Unity Biotechnology.

Philip Rosenfeld has equity interest in Apellis, Verana Health, and Ocudyne.

Jayanth Sridhar reports personal fees from Alcon, Alimera, and Oxurion.

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None.

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