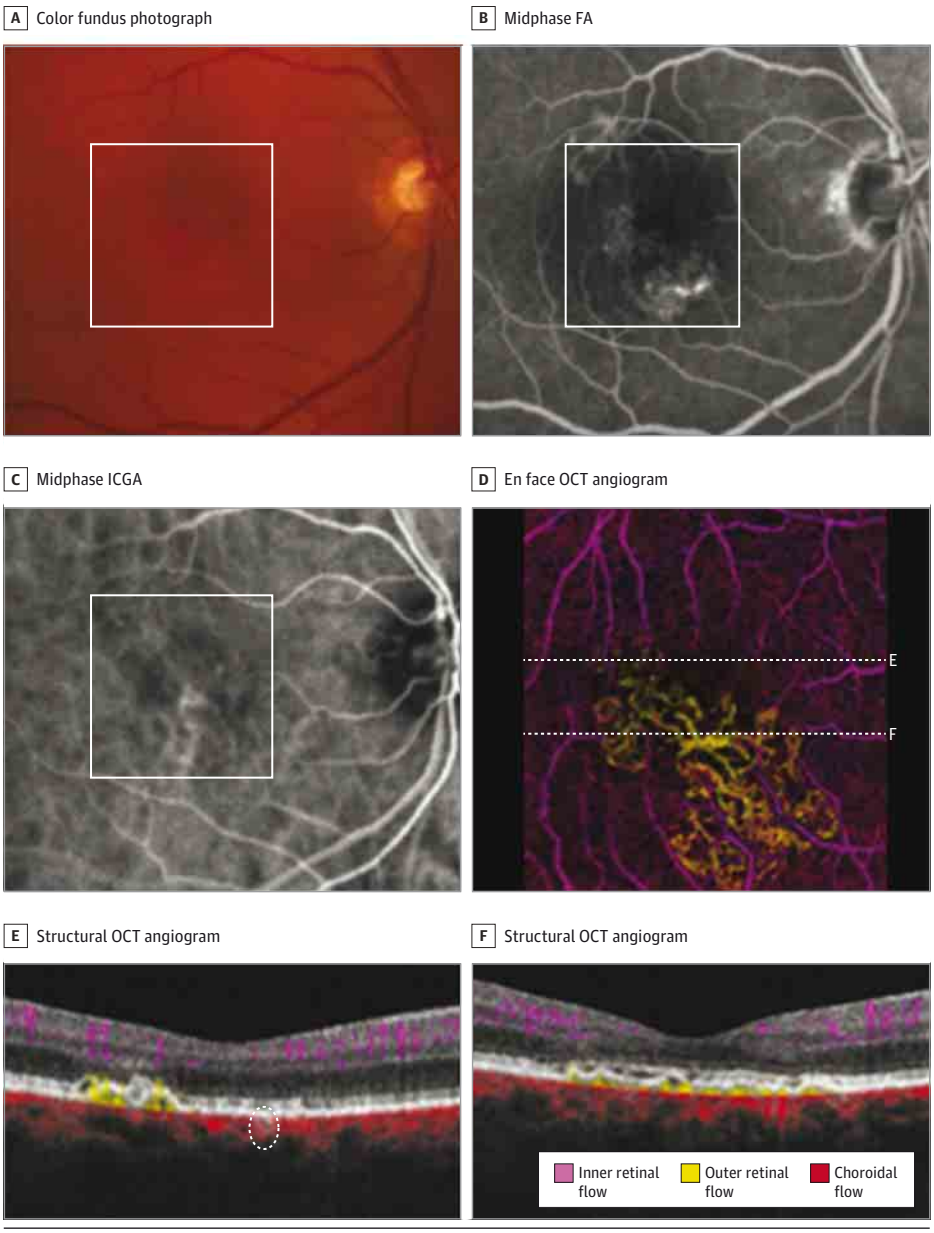
Letters

RESEARCH LETTER

Optical Coherence Tomographic Angiography of Choroidal Neovascularization Associated With Central Serous Chorioretinopathy

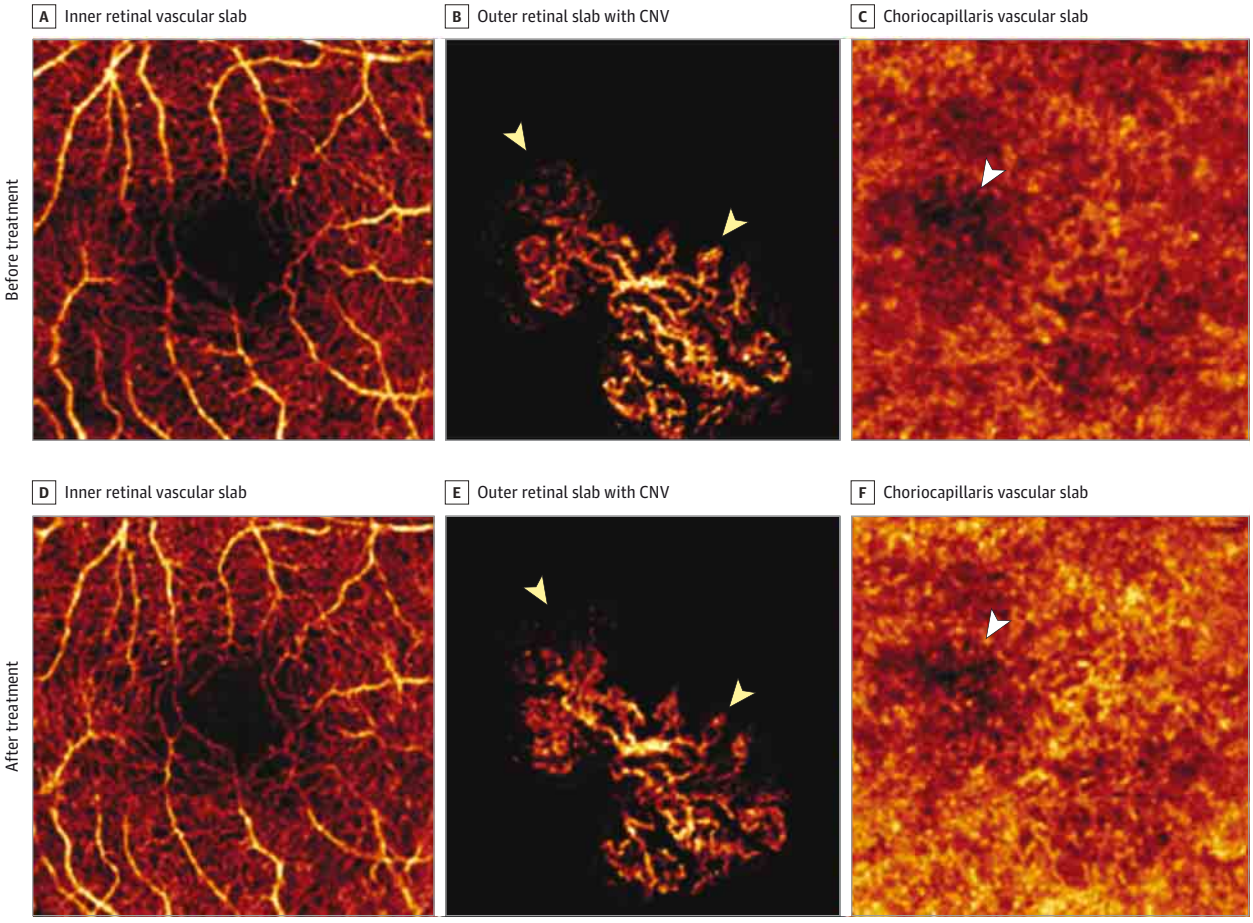
Choroidal neovascularization (CNV) can complicate chronic central serous chorioretinopathy (CSC) and may be difficult to diagnose because CSC itself can be associated with pigment epithelial detachment, subretinal fluid, and ill-defined patterns of hyperfluorescence on fluorescein angiography (FA).[1,2] Structural optical coherence tomographic (OCT) techniques such as en face OCT have been used to identify CNV but the vascular contrast is low, limiting image detail.[3] This case report describes OCT angiography of CNV in chronic CSC.

Figure 1. Detection of Choroidal Neovascularization Associated With Chronic Central Serous Chorioretinopathy by Optical Coherence Tomographic (OCT) Angiography



A-C, Color fundus photograph (A), midphase fluorescein angiogram (FA) (B), and midphase indocyanine green angiogram (ICGA) (C) of central serous chorioretinopathy (box). D-F, Optical coherence tomographic angiograms of retinal vessels (purple) and choroidal neovascularization (yellow) presented en face (D) and with structural OCT at sections noted in panel D (E and F). E, Circle indicates the focal choriocapillaris defect.

Figure 2. Segmented En Face Optical Coherence Tomographic Angiograms Before and After Treatment With Intravitreous Bevacizumab



A-F, Optical coherence tomographic angiograms before (A-C) and after (D-F) intravitreous bevacizumab treatment. A and D, Normal inner retinal vascular slabs. B and E, Outer retinal slabs with choroidal neovascularization (CNV). Arrowheads indicate CNV branch disappearance. C and F, Choriocapillaris vascular slabs. Arrowheads indicate reduced flow.

Methods | Macular angiograms (3 × 3 mm) were obtained using spectral-domain OCT (70 kHz; RTVue XR; Optovue). The split-spectrum amplitude-decorrelation angiography algorithm was used to distinguish blood flow from static tissue, and angiograms were segmented into 3 vascular slabs: inner retinal, outer retinal, and choriocapillaris as described in detail previously.[4] Choroidal neovascularization was defined as flow in the outer retinal slab between the Bruch membrane and outer plexiform layer. Choriocapillaris angiograms were based on flow signal within 10 µm below the Bruch membrane. The parafoveal retinal vessel density and CNV area were calculated as previously described.[4,5] The Oregon Health and Science University Institutional Review Board approved the study protocol, and written informed consent was provided.

Results | A man in his late 60s with chronic CSC returned for follow-up examination. Visual acuity was 20/25 OD and 20/400 OS. In the right eye, chronic juxtafoveal subretinal fluid persisted for 2 years without treatment. Findings consistent with CSC included choroidal hyperpermeability with indocyanine green angiography (ICGA) as well as absence of drusen and polyps. The left eye had poor vision due to CNV complicating CSC, raising concern for the right eye. However, there was no hemorrhage or exudate in the right eye, and findings on FA and ICGA were nondiagnostic for CNV (**Figure 1**A-C).

En face OCT angiography of the right eye revealed an outer retinal vascular network corresponding to the area of staining on FA (Figure 1B and D). Cross-sectional OCT angiograms demonstrated type 1 CNV (Figure 1E and F). Focal areas of reduced choriocapillaris flow were evident on cross-sectional OCT angiograms (Figure 1E) and en face OCT angiograms (**Figure 2**C and F) that partially correlated with regions of hypofluorescence on ICGA (Figure 1C).

The retinal circulation appeared normal (Figure 2A and D). Three weeks after treatment with intravitreous bevacizumab, retinal vessel density increased by 5.5% from the pretreatment value, a difference of similar magnitude to previously published intervisit reproducibility of 3.55% standard deviation.[5] The initial CNV area calculated from OCT angiographic scans measured 1.44 mm^2; 3 weeks after the patient received intravitreous bevacizumab, the area was reduced to 1.21 mm^2 (a 16% reduction). Subretinal fluid on structural OCT

also improved. Comparing pretreatment vs posttreatment en face angiograms, several peripheral vascular loops in the CNV faded (Figure 2B and E). The choriocapillaris defect appeared smaller after treatment (Figure 2C and F).

Discussion | Optical coherence tomographic angiography provides a novel way to potentially detect CNV.[4] In this case, OCT angiography identified CNV associated with CSC, while findings on structural OCT, FA, and ICGA were nondiagnostic. Because OCT angiography detects CNV by depth (flow in outer retina), it is not dependent on specific dye leakage patterns. Future studies with OCT angiography may reveal higher rates of CNV associated with chronic CSC than previously suspected.

The OCT angiograms showed reduced CNV flow area and CNV vessel loss following treatment. Because retinal vessel density did not decrease, reduced areas of CNV flow likely represent therapeutic effect.

Optical coherence tomographic angiography can also be used to evaluate blood flow of the choriocapillaris. In healthy eyes, the choriocapillaris appears confluent on OCT angiograms.[4] In this case, areas of reduced choriocapillaris flow were noted. Choroidal ischemia has been proposed as a precursor to CNV.[6] Further study is needed to determine whether reduced choriocapillaris flow is associated with chronic CSC and whether it may increase risk of CNV development.

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Study concept and design: McClintic, Huang, Bailey.
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Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Jia reported having financial interest in Optovue, which provided equipment used in the study, and having a patent pending for quantification of vascular abnormality with OCT angiography (US provisional patent application 62/138,196). Dr Huang reported having stock options with Optovue; receiving research equipment and a research grant from Optovue; receiving patent royalties from Optovue and Carl Zeiss Meditec; and having a patent pending for quantification of vascular abnormality with OCT angiography (US provisional patent application 62/138,196). Dr Bailey reported receiving study equipment from Optovue. No other disclosures were reported.

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