

OCT ANGIOGRAPHY IN RETINAL AND CHOROIDDAL DISEASES

A case series demonstrates the value of this new imaging modality.

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Angiography is a photographic diagnostic examination tool used to assess conditions of the retinal vasculature. Conventional angiography involves intravenous injection of a dye, either fluorescein or indocyanine

green, into the vascular system. Its perfusion is then captured with a camera. Although conventional angiography is a gold standard imaging modality used to investigate many retinal diseases, it is not without complications and side effects.

Optical coherence tomography (OCT) uses interferometric analysis of short-coherence-length light to provide depth-resolved imaging of ocular tissues such as the retina and choroid. If multiple images are taken of the same area over time, changes in reflectance properties over that area of tissue can be measured. Stationary tissue shows little variation, whereas moving elements—blood flow for instance—show more prominent changes.¹ The variation over time of some of these measurable reflectance parameters (such as amplitude or phase information of the reflected light) forms the basis for a flow imaging technique called OCT angiography (OCTA).

A COMPARISON

The basic concept of OCTA is motion detection. To isolate and image blood flow, we rely on the fact that blood is the only thing in motion in the fundus. OCTA is therefore a functional extension of OCT that can be used to visualize the microvasculature by detecting motion contrast from flowing blood.

Fluorescein angiography (FA) provides 2-D image sets that allow dynamic visualization of blood flow with a wide field of view; patterns of dye leakage, pooling, and staining can be appreciated, and these have been well documented in the literature.² However, FA cannot separately visualize the intraretinal structures of major capillary networks; the images of

superficial and deep capillaries overlap, so two of the three major capillary networks (superficial retinal, deep retinal, and choriocapillaries) do not appear to be imaged well despite the retina's being a nearly transparent structure.³

Other drawbacks that limit the widespread use of FA include its invasive nature, its cost, and the time it takes to perform; therefore, it is not ideal for use on a regular basis in a busy clinical setting. Although considered safe, the dye poses risks ranging from nausea to allergic reactions, including, in rare instances, anaphylaxis. For evaluation of patients requiring frequent follow-up examinations or those who may not tolerate injection of the intravenous dye, a rapid, noninvasive technique to visualize retinal and choroidal vessels would be beneficial.⁴

OCTA, in contrast, is a noninvasive technique that acquires volumetric angiographic information without the use of a dye. The en face images obtained can be scrolled to visualize individual vascular plexuses and to segment the inner retina, outer retina, choriocapillaris, and other areas of interest.⁴



AT A GLANCE

- FA is an important diagnostic tool for evaluating patients with retinal pathologies, but several drawbacks limit its widespread use.
- OCTA is a noninvasive technique that does not require the use of a dye; motion contrast due to blood flow allows users to visualize the eye's microvasculature.
- OCTA is not without its own limitations, and validation of the accuracy and reproducibility of OCTA data is needed.

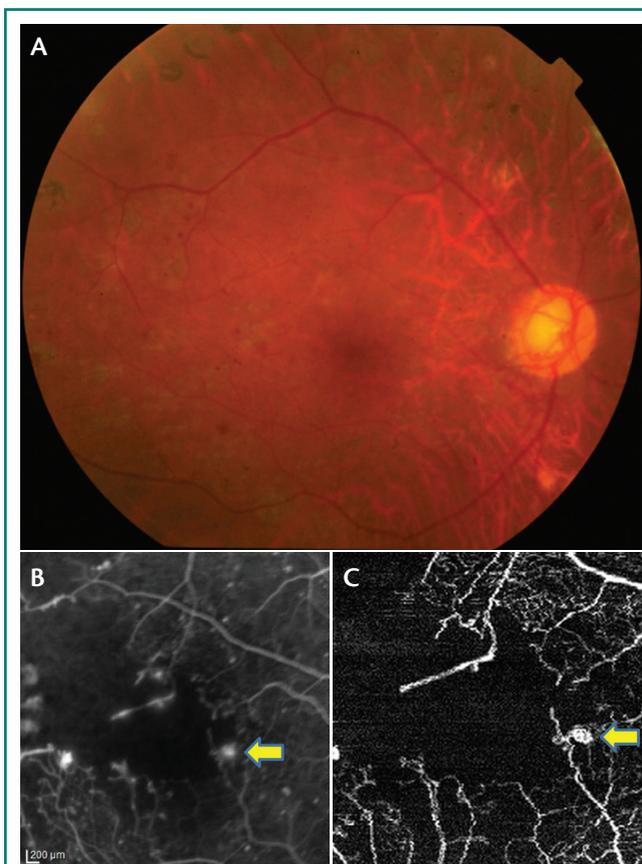


Figure 1. Fundus photograph OD shows lasered PDR (A). FA of OD shows leaking microaneurysms (arrow) at the posterior pole with capillary nonperfusion (CNP) area adjacent to FAZ (B). OCTA of OD shows microaneurysms and CNP area adjacent to FAZ corresponding to FA; note that the microaneurysm formation (arrow) can be clearly delineated and corresponds to leakage seen at same site in FA (C).

Furthermore, OCTA data can be viewed in 3-D form, retaining the depth interrelationships of retinal and choroidal tissue.

In this article we share our experience using OCTA to image a range of retinal vascular and choroidal diseases.

CLINICAL CASE SERIES

This observational case series includes patients who presented to our practice. All patients were scanned with the 3 mm x 3 mm scan pattern using Angioscan OCTA software for the RS-3000 Advance OCT system (Nidek).

Case No. 1: Patient With Diabetic Retinopathy and Discussion

A 62-year-old man with diabetes and hypertension presented with diminution of vision in his right eye (OD) lasting 3 years. Ocular history included retinal laser performed on both eyes for diabetic retinopathy (DR) 2 years previously. His best corrected visual acuity (BCVA) was 6/24 OD. Fundus examination

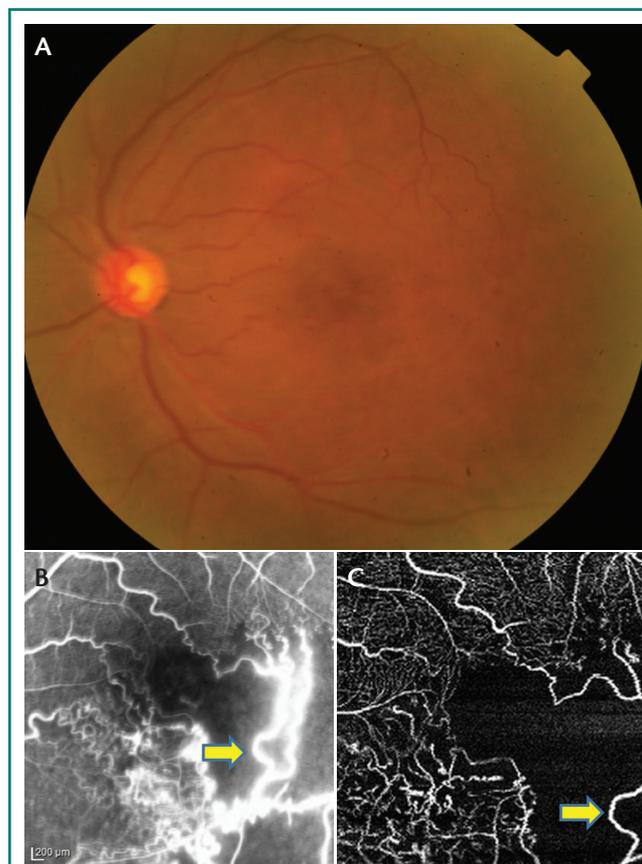


Figure 2. Fundus photograph OS shows ischemia in inferotemporal quadrant (A). FA of OS shows CNP area adjacent to FAZ and inferotemporal to it, surrounded by collateral vessels (arrow) (B). OCTA of OS shows CNP area adjacent to FAZ and inferotemporal to it corresponding to FA; note that the collateral vessel (arrow) can also be delineated corresponding to FA (C).

revealed lasered proliferative diabetic retinopathy (PDR) changes OD (Figure 1A). FA showed leaking microaneurysms OD (Figure 1B). OCTA revealed microaneurysms and capillary nonperfusion (CNP) in the area adjacent to the foveal avascular zone (FAZ) OD (Figure 1C), corresponding with the FA image.

DR is one of the leading causes of blindness worldwide, and OCTA has already shown promise in identifying changes in the disease.⁵ In this case, OCTA clearly visualized microaneurysms, locating their exact intraretinal depth, areas of retinal nonperfusion, and FAZ remodeling. Thus, OCTA was able to image retinal microvascular changes not detected by clinical examination. In cases that involve neovascularization of the disc (NVD) and neovascularization elsewhere (NVE), FA shows the leakage of dye from the neovascularization, whereas OCTA can actually delineate the network of new vessels in NVD and NVE. Therefore OCTA may be clinically useful in evaluating the microvascular status and effectiveness of treatments for DR.

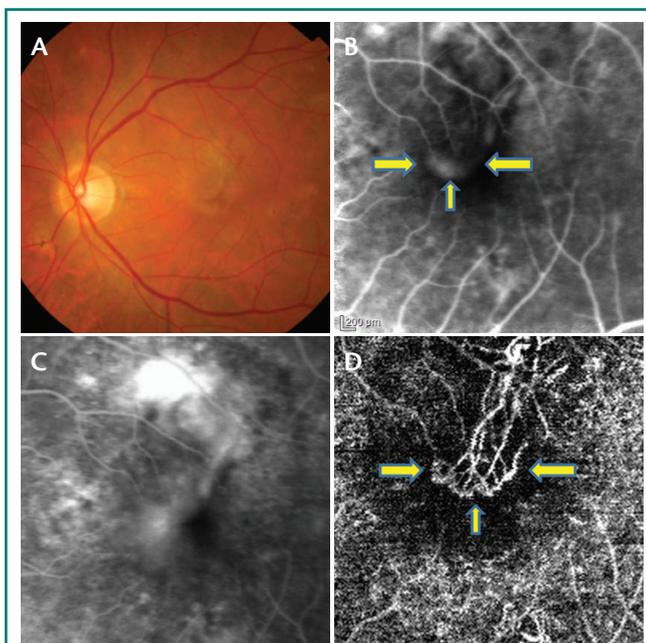


Figure 3. Fundus photograph OS shows greyish elevation of tissue deep to retina at macula suggestive of CNV in AMD (A). FA of OS shows a discrete, well-demarcated focal area of hyperfluorescence at macula (arrow) in early phase frame (B), with hyperfluorescence increasing in intensity in later phase frame (C) and extending beyond boundaries of hyperfluorescence identified in early phase, suggestive of classic CNV. The actual network of new vessels (arrow) can be very clearly delineated in OCTA, and its size corresponds to the extent of leakage from CNV seen in FA (D).

Case No. 2: Patient With Retinal Vein Occlusion and Discussion

A 65-year-old woman with known hypertension presented for follow-up of resolving vitreous hemorrhage secondary to a branch retinal vein occlusion (BRVO) OD. She was asymptomatic in her left eye (OS). Her BCVA was 6/9 OD and 6/6 OS. Fundus examination revealed ischemia in the inferotemporal quadrant OS (Figure 2A), suggestive of inferotemporal BRVO. An area of CNP adjacent to and inferotemporal to the FAZ OS was shown on FA (Figure 2B). OCTA agreed with FA (Figure 2C).

In this case, OCTA findings were consistent with clinical, anatomic, and FA findings, including areas of impaired vascular perfusion, vascular dilation, shunt vessels (collaterals), and intraretinal edema. Hence, OCTA, in conjunction with spectral-domain OCT, could be at least equally effective as FA for evaluating and managing macular complications in patients with RVO.

Case No. 3: Patient With Choroidal Neovascularization and Discussion

A 72-year-old man, pseudophakic in both eyes (OU), presented with diminution of vision OS lasting 2 to 3 months. His

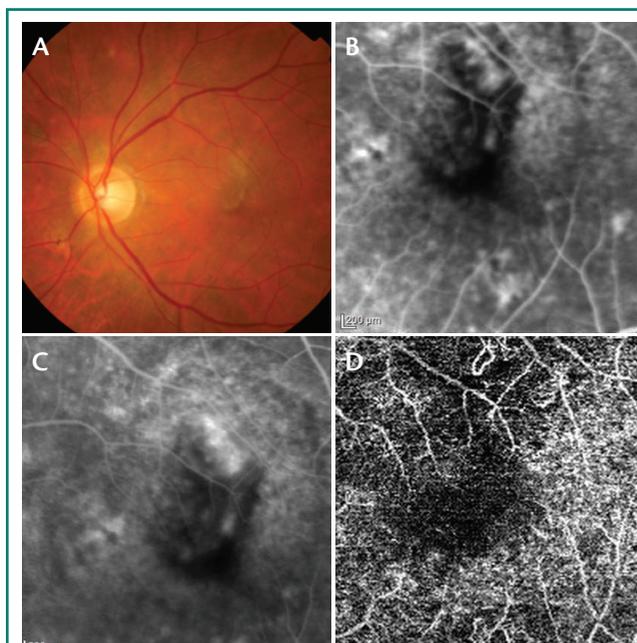


Figure 4. Same patient as in Figure 3, 6 weeks after intravitreal injection of ranibizumab OS. Fundus photograph OS shows resolving CNV (A). FA of OS in early (B) and late (C) phases shows an absence of the leakage from the CNV tissue compared with the pretreatment FA as seen in Figure 3 (B and C). The actual network of new vessels seen in Figure 3D appears to have disappeared in OCTA after intravitreal injection of ranibizumab (D).

BCVA was 6/24 OS. Fundus examination OS revealed grayish elevation of tissue deep to the retina at the macula, suggestive of choroidal neovascularization (CNV) in age-related macular degeneration (AMD) (Figure 3A). On FA, a discrete, well-demarcated focal area of hyperfluorescence at the macula was evident (Figure 3B), with hyperfluorescence increasing in intensity and extending beyond boundaries identified in early phase frames, suggesting classic CNV (Figure 3C). OCTA distinctly showed the actual network of new CNV vessels (Figure 3D). The patient was given one intravitreal injection of ranibizumab 0.5 mg (Lucentis, Genentech) OS.

He presented 6 weeks later with an improvement in BCVA to 6/12 OS. Fundus examination revealed resolving CNV at the macula OS (Figure 4A). FA of the same eye in early (Figure 4B) and late (Figure 4C) phases showed an absence of leakage from the CNV tissue compared with the pretreatment FA (Figures 3B and 3C). The network of new vessels shown in Figure 3D was no longer visible on postinjection OCTA (Figure 4D).

AMD is a leading cause of irreversible vision loss in those 65 years of age and older. AMD is broadly classified into wet and dry forms. Wet AMD is heralded by the formation of CNV; it accounts for approximately 15% of AMD cases and makes up the majority of cases with vision loss.⁶

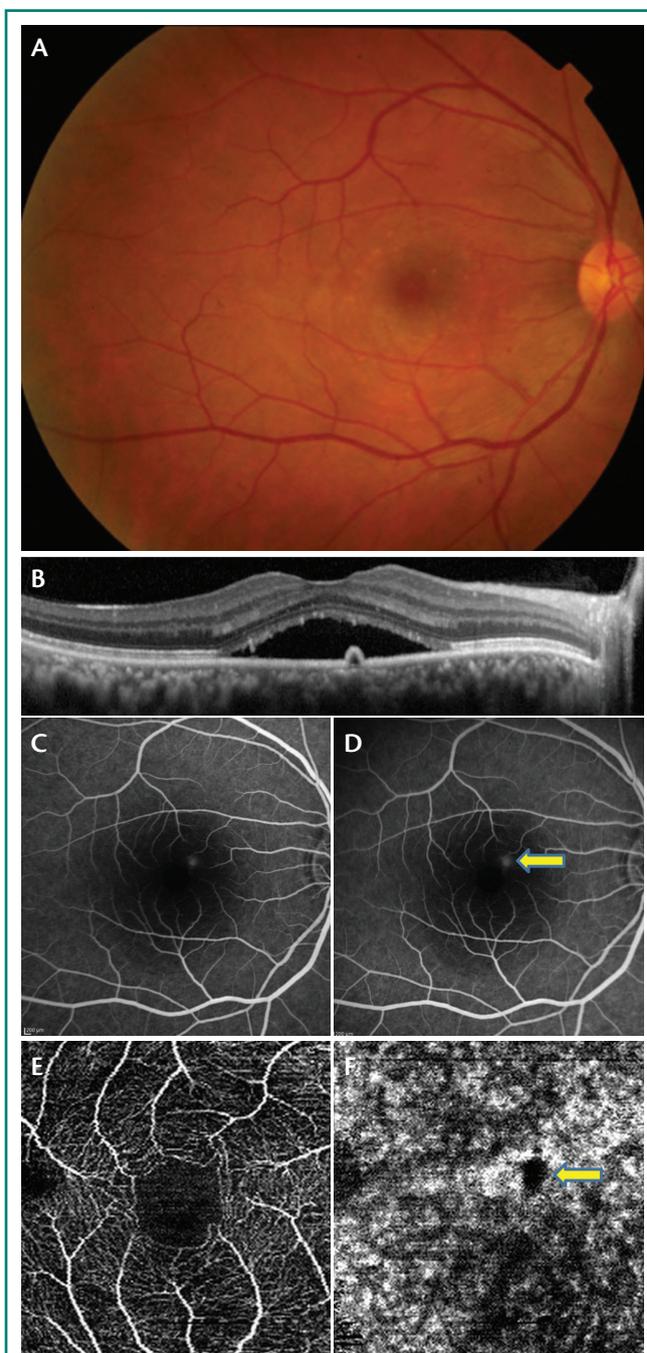


Figure 5. Fundus photograph OD shows a well-demarcated oval-shaped area of neurosensory retinal detachment in the posterior pole with yellow dots seen over the posterior pole suggestive of CSCR (A). OCT scan OD shows fluid collection under the neurosensory retina at the fovea with a small PED (B). FA of OD shows inkblot pattern of leakage superonasal to fovea (arrow) suggestive of CSCR (C and D). OCTA with segmentation around the ILM shows normal inner retinal vasculature (E). OCTA with segmentation around the RPE shows fluid tract (arrow) corresponding to the site of inkblot leakage in FA and to the PED on OCT (F).

El Ameen et al characterized CNV using OCTA.⁷ In their cohort of 14 patients, all demonstrated a hyperflow vascular lesion in the outer retina with a glomerulus (4 of 14 patients) or medusa head shape (10 of 14 patients), surrounded by a dark halo, demonstrating that OCTA is highly sensitive in detecting CNV.

Case No. 4: Patient with Central Serous Chorioretinopathy and Discussion

A 39-year-old man presented with diminution of vision OD for the past 3 to 4 years. His BCVA was 6/9 OD. Fundus examination revealed a well-demarcated oval-shaped area of neurosensory retinal detachment in the posterior pole with yellow dots over the posterior pole, suggestive of central serous chorioretinopathy (CSCR) (Figure 5A). An OCT scan OD showed subneurosensory retinal fluid collection at the fovea with a small retinal pigment epithelial detachment (PED) (Figure 5B). FA showed an inkblot pattern of leakage superonasal to the fovea, suggestive of CSCR (Figures 5C and 5D). With segmentation around the internal limiting membrane (ILM), OCTA showed normal inner retinal vasculature (Figure 5E), whereas OCTA with segmentation around the retinal pigment epithelium (RPE) showed a fluid tract (Figure 5F), corresponding to the site of the inkblot leakage seen in FA and to the PED noted on OCT.

CSCR typically affects the young and middle-aged populations. Patients usually develop one small area or sometimes several small areas of serous detachment of the RPE in the macular or paramacular area, generally associated with serous detachment of the overlying and surrounding retina. Demonstration of CSCR is based on typical angiographic dye leakage from the choroid into the subretinal space, associated with appearance of defects in the RPE and sometimes pooling of dye in the sub-RPE space.

We report the OCTA feature of a probable fluid tract visible at the level of the outer retina corresponding to the site of typical inkblot leakage on FA. Our case also had a small PED at the same site as the fluid tract on OCTA; therefore, it cannot be ascertained whether the leakage or the PED led to the appearance of the fluid tract on OCTA. Hence, OCTA images of the superficial and deep retinal plexus, outer retina, and choriocapillaris did not reveal any characteristic pattern directly associated with the leakage point in acute CSCR.

OCTA: LIMITATIONS AND FUTURE APPLICATIONS

As indicated by the cases described above, OCTA has major implications for understanding tissue perfusion, and this imaging modality could help detect retinal blood flow compromise before the appearance of clinically meaningful changes. OCTA can show both structural and blood flow information, and it provides a detailed view of the retinal

(Continued on page 64)

(Continued from page 60)

vasculature, making it possible to accurately delineate microvascular abnormalities in patients with diabetic eye disease and vascular occlusions. Additionally, OCTA helps quantify vascular compromise based on the severity of DR and can elucidate the presence of CNV in wet AMD.⁴

Although OCTA overcomes some of the limitations of conventional angiography (eg invasiveness, allergic risk, and cost), the technique is in its infancy, with plenty of room for improvement, so it has great potential. Unlike FA, OCTA is a static image. It has a smaller field of view and lower resolution than FA.

Spaide et al described various artifacts seen in OCTA images,⁸ noting that these artifacts can occur due to OCT image acquisition, intrinsic characteristics of the eye, eye motion, image processing, and display strategies. Another limitation is OCTA's suboptimal correction of these artifacts. Because OCTA uses the principle that movement in the back of the eye represents blood flow, it is prone to motion artifact.

Our expectations for OCTA must be tempered, given our limited experience with the technology. As with any new technique, validation of the accuracy and reproducibility of the data is needed. Further studies in larger cohorts are required to establish an association between retinal flow compromise and retinal pathologies. Additionally, future innovations in both hardware and software technologies are expected to help in obtaining larger fields of view with higher resolution and decreased motion artifacts. It seems likely that we are going to continue to hear about OCTA for a long time. ■

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