Utility of noninvasive imaging modalities in a retina practice

Chaitra Jayadev, Nimesh Jain, Sonia Sachdev, Ashwin Mohan, Naresh Kumar Yadav

Fluorescein angiography (FFA) has been the gold standard to understand, diagnose and treat retinal disorders. However, being an invasive procedure it has several limitations including adverse drug reactions. Hence, noninvasive tests that can be repeated during the course of the disease are the need of the hour. The aim of our study was to compare images of patients with retinal microvasculature pathology taken from three different imaging modalities (invasive vs. noninvasive). Lesions were detected more easily and with a greater resolution of morphology on retinal function imaging (RFI) and optical coherence tomography angiography (angio-OCT). Functional integrity of the vessels was better delineated on FFA. RFI and angio-OCT are noninvasive rapid and efficient methods to image vascular conditions with easy repeatability and negligible adverse effects.

Key words: Angio-optical coherence tomography, fluorescein angiography, invasive, noninvasive, retinal function imaging

Imaging the retinal microvasculature is critical for the diagnosis of retinal pathological conditions. Fluorescein angiography (FFA) has been the gold standard so far to understand, diagnose and treat retinal vascular disorders. Recent advances in technology have revolutionized imaging in ophthalmology. Optical coherence tomography angiography (angio-OCT; Optovue, Heidelberg, Germany) and retinal function imaging (RFI; Optical Imaging, Israel) allow high-resolution imaging akin to *in vivo* histopathology of the retina.[1] Angio-OCT works on the principle of interferometry,[2] while RFI uses the hemoglobin in red blood cells as a contrast agent and green light[3] (540 nm) to study vascular morphology. This gives an advantage of noninvasive mapping and visualization of retinal capillaries.

In this paper, we describe and compare retinal vascular morphology imaged with invasive (FFA; Spectralis, 55°, Heidelberg, Germany) and noninvasive (RFI 50° and angio-OCT 8 mm × 8 mm) modalities.

Case Reports

Case report 1

A 23-year-old with Coats disease had previously received multiple intravitreal anti-vascular endothelial derived growth factor injections and laser photocoagulation in the right eye. On the last examination, his corrected distance visual acuity was 20/120. Fundus examination [Fig. 1a] showed scarring around the fovea temporally with an adjacent vascular frond and laser scars in the superotemporal and inferotemporal area. The morphology of the vascular frond was evaluated with three different imaging modalities. FFA image [Fig. 1b] shows early hyperfluorescence with a subsequent increase in intensity and blurring of margins in the late phase suggestive of leakage from the lesion. RFI [Fig. 1c] and angio-OCT [Fig. 1d] clearly delineate the vascular frond morphology with dot-like protuberances on RFI.

Access this article online	
Quick Response Code:	Website: www.ijo.in
	DOI: 10.4103/0301-4738.198850

Department of Vitreoretina, Narayana Nethralaya, Bengaluru, Karnataka, India

Correspondence to: Dr. Chaitra Jayadev, Narayana Nethralaya, 121/C, Chord Road, 1st "R" Block, Rajaji Nagar, Bengaluru - 560 010, Karnataka, India. E-mail: drchaitra@hotmail.com

Manuscript received: 18.05.16; Revision accepted: 26.11.16

Cite this article as: Jayadev C, Jain N, Sachdev S, Mohan A, Yadav NK. Utility of noninvasive imaging modalities in a retina practice. Indian J Ophthalmol 2016;64:940-3.

Case report 2

A 62-year-old male diabetic patient on a regular follow-up had worsened from nonproliferative to proliferative diabetic retinopathy in the left eye [Fig. 2a]. FFA [Fig. 2b] shows early hyperfluorescence with a subsequent increase in intensity and blurring of margins in the late phase

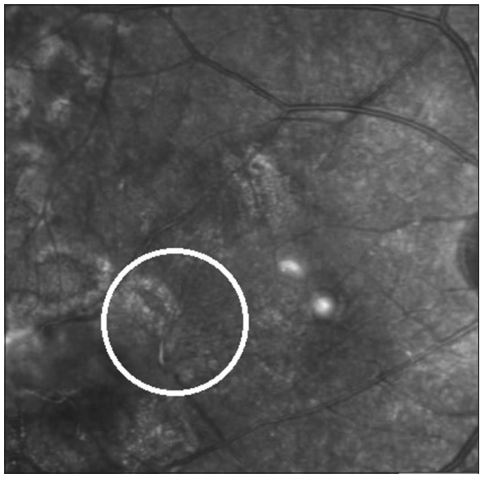

Figure 1a: Red-free fundus image of the right eye showing lasers scars in the temporal periphery with a vascular frond temporal to the fovea

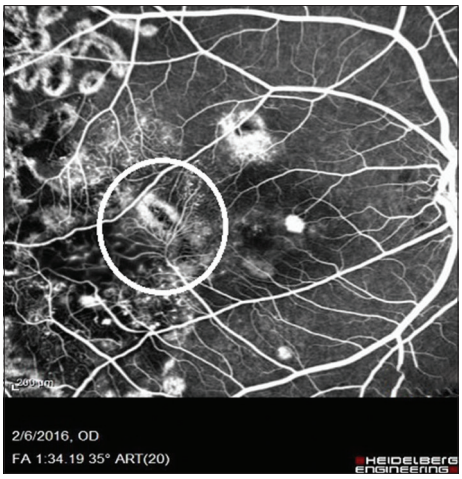

Figure 1b: Fluorescein angiography image shows early hyperfluorescence with late leakage from the vascular frond

Figure 1c: Retinal function imaging of the same vascular frond with dot-like protuberances

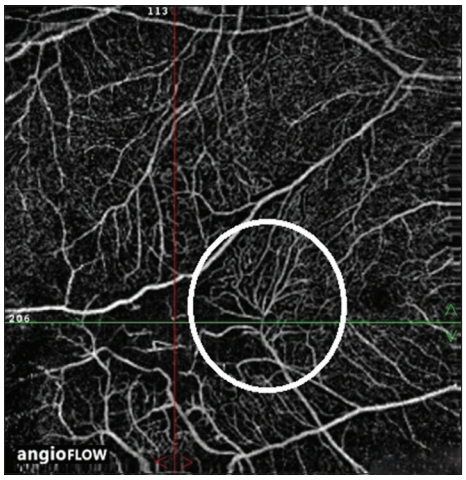

Figure 1d: The vascular frond imaged with optical coherence tomography angiography

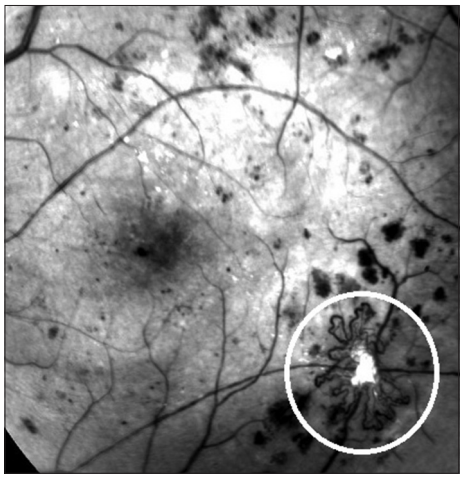

Figure 2a: Red-free fundus image of the left eye showing new vessels along the inferior temporal arcade

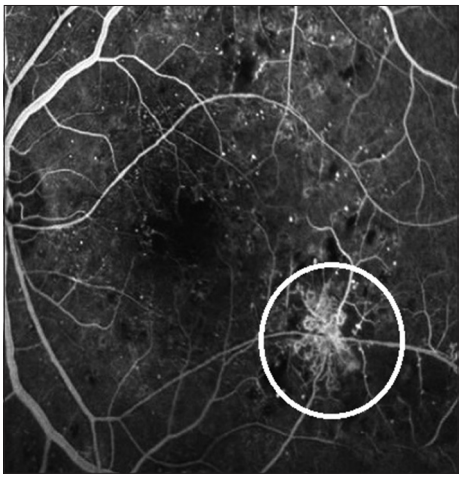

Figure 2b: Fluorescein angiography shows early hyperflourescence with late leakage suggestive of new vessels

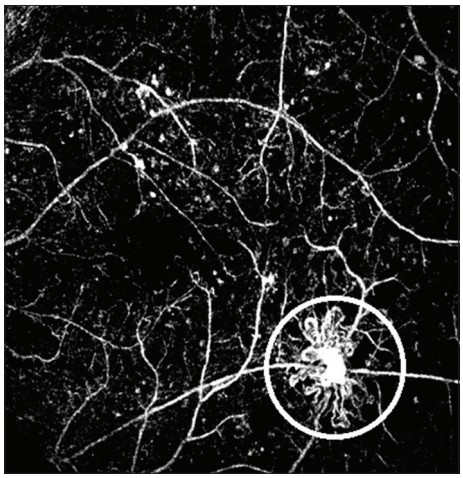

Figure 2c: Retinal function imaging clearly delineating the neovascularization elsewhere

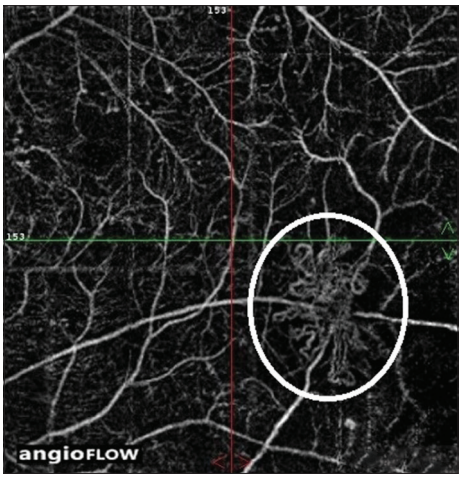

Figure 2d: Optical coherence tomography angiography image showing new vessel morphology

Figure 3a: Red-free fundus image of the right eye shows sclerosed vessels along superotemporal arcade with collateral channels suggestive of old branch retinal vein occlusion

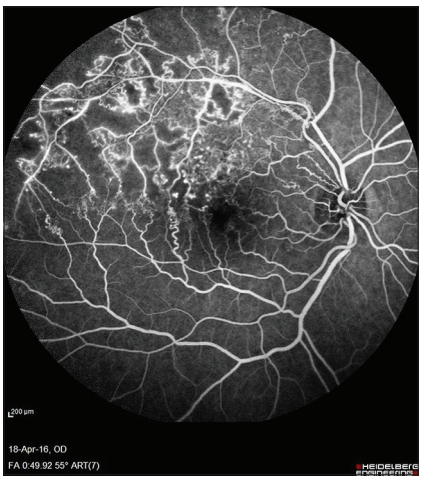

Figure 3b: Fluorescein angiography shows widespread areas of hypofluorescence along superotemporal area suggestive of capillary nonperfusion with late staining of vessels in temporal area

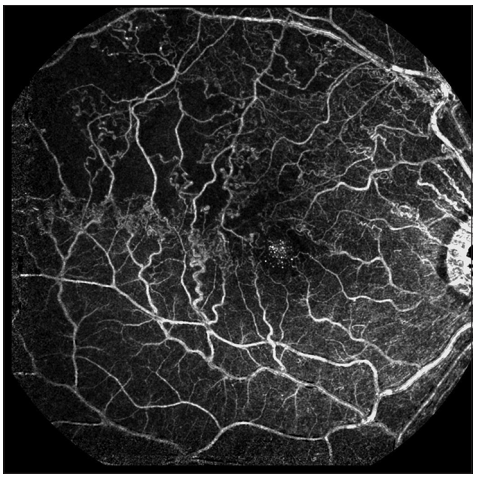

Figure 3c: Retinal function imaging the corresponding areas with capillary nonperfusion

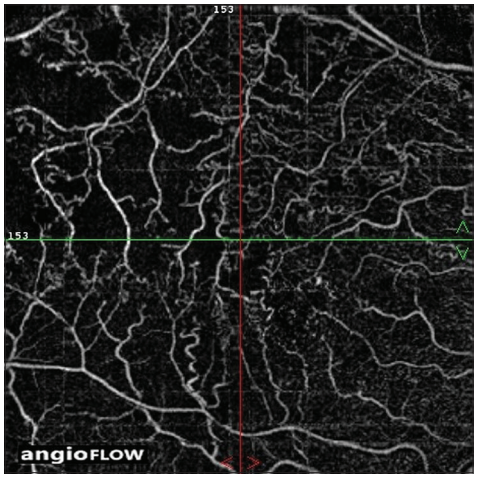

Figure 3d: Optical coherence tomography angiography delineating areas of capillary nonperfusion

suggestive of neovascularization elsewhere (NVE) along the inferior temporal arcade. On imaging the same area with RFI [Fig. 2c] and angio-OCT [Fig. 2d], the NVE was more clearly delineated.

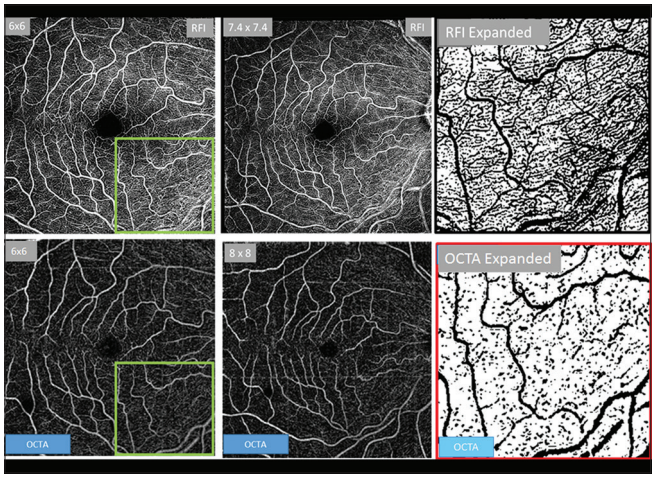

Figure 4: Retinal function imaging and optical coherence tomography angiography image of a normal patient which clearly depicts that resolution of retinal function imaging is better than optical coherence tomography angiography when larger areas are imaged

Case report 3

A 57-year-old male presented to us with complaints of diminution of vision in the right eye since a year. He is a known hypertensive since the past 10 years. Fundus examination [Fig. 3a] showed a superotemporal branch retinal vein occlusion with collaterals in the temporal area of the right eye. FFA [Fig. 3b] of the right eye shows areas of hypofluorescence along the superotemporal area suggestive of areas of capillary nonperfusion (CNP) with collaterals in the temporal area, which were easily picked up with the RFI and angio-OCT [Fig. 3c and d].

Discussion

Fundus FFA is a sensitive tool to investigate patients with retinal vascular morphologies. However, it necessitates intravenous injection of a contrast dye and entails adverse reactions of varying severity, including anaphylaxis.[4] It is also relatively contraindicated in various clinical conditions such as renal failure, ischemic heart disease, and pregnancy.[5] To overcome these limitations, noninvasive modalities can be used to study vascular morphology. Angio-OCT is a relatively new technology based on two technologies split spectrum amplitude-decorrelation angiography and motion correction technology.[6] It works by collating the decorrelation signals (differences in backscattered OCT signal intensity or amplitude) between sequential OCT B-scans taken at the same cross-section to build a map of blood flow. RFI is equipped with a standard fundus camera, a customized stroboscopic flash lamp system and a fast digital camera.[7] A 60 Hz and 1024 × 1024 pixels digital imaging system captures images of the fundus at high rates to reduce retinal motion in between subsequent frames and follow erythrocytes moving at up to 20 mm/s.[7] A single click acquires a "series" of eight monochrome standard fundus camera images. This sequence of eight frames can be presented in the form of a movie. The RFI system has the capability of distinguishing the direction of blood flow within the retinal blood vessel and thereby distinguishes between a retinal artery and vein.

These noninvasive modalities have their advantages and limitations. Salient ones include rapidity of performing the imaging, repeatability and an absence of any adverse effects. Morphological patterns as well as CNP areas[8] can be very well delineated with the RFI and angio-OCT. Leaks on FFA can obscure these details. Only angio-OCT allows segmentation; hence, abnormalities in different retinal layers can be detected. A higher resolution and field of view is obtained with the RFI when compared to angio-OCT [Fig. 4]. Measurement of blood velocity and flow, oximetry and metabolic mapping are other features of the RFI.

Disadvantages of the noninvasive modalities include a smaller field of view, a maximum of 50° compared to 200° in ultra wide field FFA.[9] This limits the indication to macular disease currently. In addition, the angio-OCT and RFI requires that the patient to fixate for several seconds, whereas a single FFA frame can be obtained in seconds. Interpretation and image processing is time consuming and at times, a difficult aspect of the newer modalities. Vascular leakage, which is of diagnostic importance in several retinal diseases, is not seen in the noninvasive modalities. Cost of instrumentations and further upgrades is a deterrent with these devices when compared to the simpler FFA.

Despite some limitations, we see in the above three case that vascular frond morphology of neovascularization and delineation of areas of CNP is satisfactorily achieved with the noninvasive imaging modalities. We have seen that the outcomes are comparable between the RFI and angio-OCT. The added advantage over FFA of being noninvasive and repeatable make them excellent tools for macular imaging.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Chhablani J, Jayadev C. Future in retinal imaging for clinicians. Indian J Ophthalmol 2015;63:370-2.
2. Matsunaga D, Yi J, Puliafito CA, Kashani AH. OCT angiography in healthy human subjects. Ophthalmic Surg Lasers Imaging Retina 2014;45:510-5.
3. Grinvald A, Bonhoeffer T, Vanzetta I, Pollack A, Aloni E, Ofri R, *et al.* High-resolution functional optical imaging: From the neocortex to the eye. Ophthalmol Clin North Am 2004;17:53-67.
4. Yannuzzi LA, Rohrer KT, Tindel LJ, Sobel RS, Costanza MA, Shields W, *et al.* Fluorescein angiography complication survey. Ophthalmology 1986;93:611-7.
5. Chawla S, Chaudhary T, Aggarwal S, Maiti GD, Jaiswal K, Yadav J. Ophthalmic considerations in pregnancy. Med J Armed Forces India 2013;69:278-84.
6. Puliafito CA. OCT angiography: The next era of OCT technology emerges. Ophthalmic Surg Lasers Imaging Retina 2014;45:360.
7. Izhaky D, Nelson DA, Burgansky-Eliash Z, Grinvald A. Functional imaging using the retinal function imager: Direct imaging of blood velocity, achieving fluorescein angiography-like images without any contrast agent, qualitative oximetry, and functional metabolic signals. Jpn J Ophthalmol 2009;53:345-51.
8. Merin S, Ber I, Ivry M. Retinal ischemia (capillary nonperfusion) and retinal neovascularization in patients with diabetic retinopathy. Ophthalmologica 1978;177:140-5.
9. Manivannan A, Plskova J, Farrow A, McKay S, Sharp PF, Forrester JV. Ultra-wide-field fluorescein angiography of the ocular fundus. Am J Ophthalmol 2005;140:525-7.