Correlation Between Ischemic Retinal Accidents and Radial Peripapillary Capillaries in the Optic Nerve Using Optical Coherence Tomographic Angiography: Observations in 6 Patients

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ABSTRACT

BACKGROUND: Perfusion of the optic nerve has been widely studied using fluorescein angiography (FAG), which is currently regarded as the criterion standard. However, FAG has adverse effects associated with intravenous contrast administration and is limited in its capacity to characterize and stratify the different vascular layers of the optic nerve and retina. The use of new imaging techniques, such as optical coherence tomographic angiography (Angio-OCT), is therefore important.

AIM: A qualitative description is made of the vascular layers of the optic nerve and of how vascular events affect radial peripapillary capillaries (RPC). Two patients with central retinal artery occlusion (CRAO), 1 with arteritic anterior ischemic optic neuropathy (AAION), and 3 healthy subjects were studied.

RESULTS: The Angio-OCT imaging afforded better visualization of the depth of the RPC and rest of the vascular layers of the retina compared with FAG. Optic nerve surface perfusion was affected in AAION and proved normal in CRAO.

CONCLUSIONS: Our results indicate that perfusion of the papilla and RPC mainly arises from the papillary plexus that depends on the posterior ciliary artery.

KEYWORDS: Angio-OCT, radial peripapillary capillaries (RPC), arteritic anterior ischemic optic neuropathy (AAION), central retinal artery occlusion (CRAO), posterior ciliary artery

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Introduction

Fluorescein angiography (FAG) is an in vivo technique used to study the perfusion of the vascular nerve. Although it is currently regarded as the criterion standard, FAG is unable to adequately visualize 2 of the 3 large capillary networks.[1] The radial peripapillary capillaries (RPC) were characterized by the histological studies of Michaelson[2] and were widely studied by Hayreh, who found the circulation of the optic nerve to depend on the posterior ciliary artery—the retinal circulation arising from the central retinal artery being in charge of perfusion of the surface of the optic nerve.[3] This study uses optical coherence tomographic angiography (Angio-OCT) to perform a qualitative analysis of the perfusion of the optic nerve, focusing on the RPC, in 3 groups of patients: 2 patients with central retinal artery occlusion (CRAO), 1 with arteritic anterior ischemic optic neuropathy (AAION), and 3 healthy subjects.

Optical coherence tomographic angiography offers many advantages, including the possibility of examining the retinal vascularization in vivo without the need for contrast administration and the obtainment of high-resolution images. Improvements in the technique, including better monitoring of flow and the rapid obtainment of images with fewer artifacts, will improve our knowledge of many retinal vascular disorders.

Materials and Methods

A cross-sectional, descriptive observational study was made of the Angio-OCT images corresponding to 2 patients with CRAO, 1 with AAION, and 3 healthy subjects (controls) between April and June 2016. The inclusion criteria were the absence of previous eye disease and the existence of an ophthalmological history, including ocular pressure values within normal limits, a normal anterior segment, and occurrence of the vascular event less than 1 month before Angio-OCT exploration. The presence of myopia, incipient cataract disease, or pseudophakia was regarded as an exclusion criterion.

All the patients and 2 of the controls had cardiovascular risk factors, such as dyslipidemia (controlled with statins) and arterial hypertension (treated with angiotensin-converting enzyme inhibitors). The age ranged from 57 to 70 years. The 2 patients with CRAO and 2 of the controls were men, whereas the patient with AAION and one of the controls were women. They had no other disease conditions.

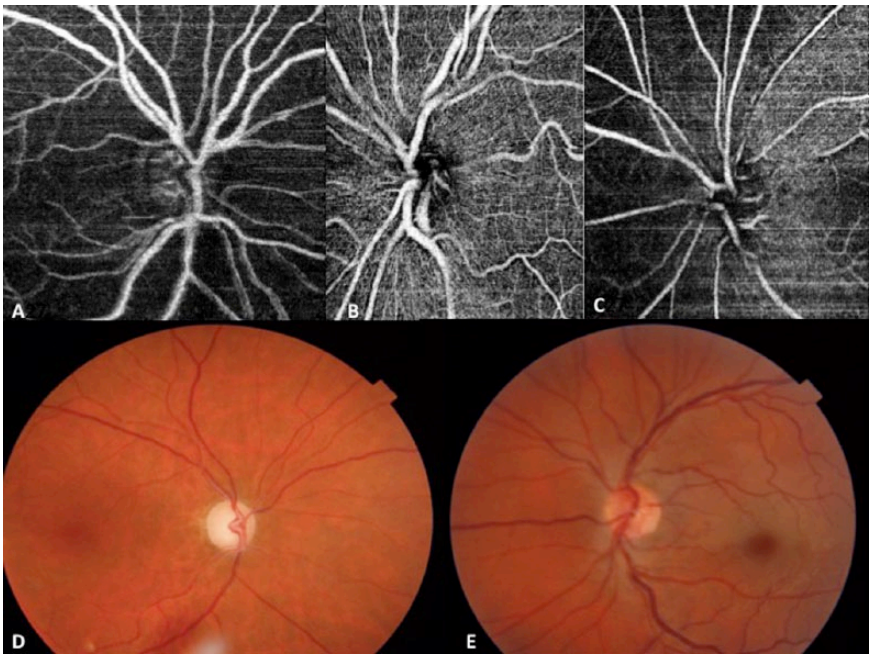

Figure 1. (A) Radial peripapillary capillaries (RPC) in arteritic anterior ischemic optic neuropathy (AAION), (B) RPC in healthy eye, (C) RPC in central retinal artery occlusion (CRAO), (D) posterior pole in AAION, and (E) posterior pole in CRAO.

Mydriasis was induced with 1% tropicamide eye drops. Ophthalmological exploration included best-corrected visual acuity (BCVA), slit lamp exploration of the anterior segment, tonometry, and funduscopy.

The Angio-OCT imaging was performed with swept source, Angio-OCT Tritón (Topcon, Tokio, Japón), involving 3 × 3 and 6 × 6 mm scans of the papilla and macula. This instrument affords 100 000 scans per second at a wavelength of 1050 nm. Optical coherence tomographic angiography was also performed from macula to disc (12 mm scan).

Optical coherence tomographic angiography image segmentation was carried out by the Angio-OCT Tritón system software. The RPC were obtained centering the 3 × 3 and 6 × 6 mm scanner at the head of the optic nerve, with inclusion of the nerve fibers in this segmentation (section measuring approximately 50 µm). The internal limiting membrane was used as reference plane. The superficial vascular plexus was selected, including the ganglionic cell layer from the macula (60-70 µm), and the deep vascular plexus was similarly selected with inclusion of the thickness of the internal nuclear layer (20-30 µm). The system software also showed the choriocapillary vascular network.

The fluorescein images were selected from the earliest frames that showed venous filling and afforded the sharpest view of the retinal capillaries.

Results

The 2 patients with CRAO presented BCVA <20/120. Optical coherence tomographic angiography was performed between 2 and 4 weeks after the episode in both cases. The RPC were not diminished and exhibited a normal distribution (Figure 1C and E)

The patient with AAION presented BCVA 20/30. The images obtained showed a clear decrease in RPC density (Figure 1A and D).

Finally, the healthy subjects presented BCVA 20/20, and the distribution of the layers was similar in all 3 cases, with a normal RPC density (Figure 1B).

Discussion

Vascularization of the head of the optic nerve is divided into 4 parts: the radial peripapillary capillaries (with centrifugal perfusion from the arterioles of the central retinal artery) are located anteriorly and are followed by the prelaminar network (composed of peripapillary choroid vessels arising from the short posterior ciliary arteries). Behind this network lies the laminar vascularization composed of short posterior ciliary arteries (giving rise to the circle of Zinn-Haller at intrascleral level). Finally, the retrolaminar vascularization layer (composed of anastomoses of the short posterior ciliary arteries and vessels of the pia mater) is located in the most posterior position.[2-6]

According to this anatomical classification, alterations of the RPC would be observed in the event of central retinal artery occlusion during the acute phase of ischemia. In our 2 patients with CRAO, although imaging was performed between 2 and 4 weeks after the episode, without associated improvement of visual acuity, the RPC were apparently normal—exhibiting a slightly lesser network density than in the healthy subjects, although this decrease was not as important as in the patient with anterior ischemic optic neuropathy. These observations show that the network contains numerous anastomoses between the arterioles of the central retinal artery and the short posterior ciliary arteries, thereby maintaining perfusion of the head of the optic nerve.

Limitations

Although these findings require confirmation based on a larger number of patients, they may represent an important step forward in our knowledge of retinal vascular diseases and other eye disorders. However, as demonstrated by the recent and thorough descriptions of the RPC,[1] the technique can be used to study unknown aspects related to diseases such as glaucoma or diabetic retinopathy, which have remained elusive to date because of difficulties in characterizing the RPC from the images afforded by FAG.

Conclusions

Optical coherence tomographic angiography affords improved knowledge of the radial peripapillary capillaries. The short posterior ciliary arteries make a crucial contribution also to vascularization of the most superficial layer of the RPC (Figure 1C).

According to Hayreh,[3] these vessels are inaccessible; the precise anatomy of the vascularization controlling perfusion of the head of the optic nerve is therefore unclear. However, despite the lack of histological studies, our results suggest the key role played by the short posterior ciliary arteries.

The above is also reflected in our patient with AAION, where we not only observed a decrease in vessels of the prelaminar, laminar and retrolaminar layers but also recorded a marked decrease in the RPC.

Author Contributions

Authors make substantial contributions to conception and design, and adquisition of data and analysis and intepretation of data. Authors participate in drafting the article or revising it critically for important intellectual content and we give final approval of the version to be submitted and any revised version.

REFERENCES

1. Sapide F, Klancnik JM Jr, Cooney MJ. Retinal vascular layers imaged by fluorescein angiography and optical coherence tomography angiography. *JAMA Ophthalmol*. 2015;133:45–50.
2. Michaelson I. *Retinal circulation in man and animals*. Springfield, IL: Charles C Thomas; 1954.
3. Hayreh SS. Blood supply of the optic nerve head. *Ophthalmologica*. 1996;210:285–295.
4. Alterman M, Henkind P. Radial peripapillary capillaries of the retina. II: possible role in Bjerrum scotoma. *Br J Ophthalmol*. 1968;52:26–31.
5. Henkind P. Radial peripapillary capillaries of the retina. I: anatomy: human and comparative. *Br J Ophthalmol*. 1967;51:115–123.
6. Henkind P. Symposium on glaucoma: joint meeting with the National Society for the prevention of blindness: new observations on the radial peripapillary capillaries. *Invest Ophthalmol*. 1967;6:103–108.