Superficial and Deep Foveal Capillary Plexus Hypoperfusion on Optical Coherence Tomography Angiography in Unilateral Epiretinal Membrane

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Abstract

Purpose: To document and evaluate the presence of hypoperfusion of the foveal superficial and deep capillary plexus in a patient with unilateral epiretinal membrane (ERM) as seen on optical coherence tomography angiography (OCTA).

Methods: A 73-year-old male presented for a comprehensive exam with a history of an ERM OD. Best corrected acuities (BVA) were 20/20 OD and OS. Optical coherence tomography (OCT) and OCTA was performed OU. Results: OCTA revealed tortuosity of the superficial foveal vasculature, reduced vascular density, areas of outer retina, superficial and deep capillary plexus hypoperfusion and a smaller foveal avascular zone OD. Isolated areas separating the inner from outer retina was observed on OCT OD. Isolated pigment epithelial detachments were also present OS. Conclusion: Distortions of macular integrity by an epiretinal membrane affects the retinal circulation leading to hypoperfusion of the foveal superficial and deep capillary plexus. In addition to structural alterations caused by an epiretinal membrane, concurrent hypoperfusion may contribute to the development of structural breaks within the inner retina.

Keywords: Optical coherence tomography, optical coherence tomography angiography, epiretinal membrane, retinal capillary plexus hypoperfusion

Introduction

The wrinkling of the macular structure in addition to contributing to decreased vision and metamorphopsia has been documented to cause dilation and tortuosity of vessels, exudative leakage, inner retinal separation and the development of lamellar and macular holes.1,6 Fluorescein angiography (FA) in conjunction with confocal laser ophthalmoscopy, has also demonstrated decreased perifoveal blood perfusion of the superficial capillary plexus (SCP).4,7 Foveal deep capillary plexus (DCP) hypo-perfusion has recently been documented in patients with an epiretinal membrane (ERM) using optical coherence tomography angiography (OCTA).1,5,9 This observation is significant considering the DCP is anatomically located at the inner nuclear layer (INL) and this layer is initially affected by fibro-cellular proliferation from the ERM.5,10 Consequently, a lack of perfusion may contribute and exacerbate the damage in this area as well as other areas affected by the ERM.1,4,5,9,10

We present a case of a unilateral ERM OD imaged with OCTA. Our findings support prior documentation of vessel tortuosity and hypo-perfusion of foveal superficial, deep capillary plexus and outer retina secondary to an ERM. Other results include the presence of a smaller foveal avascular zone (FAZ) OD compared to that of the left eye and an isolated area of inner-outer retina layer separation OD. We evaluated these findings in the context of the likelihood that hypo-perfusion may also have a contributing role in the ensuing pathophysiology associated with an ERM.

Methods

A 73-year-old male presented for a comprehensive exam. He was previously diagnosed with an ERM OD by a retinal specialist recommending observation. The patient complained of blurry vision and visual distortion, however, best corrected acuities (BVA) were 20/20 OD and OS. Preliminary findings were all unremarkable. Slit lamp examination revealed mild nuclear sclerosis and cortical cataract but otherwise was similarly unremarkable. Intraocular pressure readings were 17 mm Hg OD and OS. Dilated fundus exam indicated healthy optic nerves with cup/disc ratios of 0.3/0.3 OU. An ERM was present OD but not OS. Isolated pigment epithelial detachments (PEDs) were present OS. The peripheral retina was unremarkable OU. Optical coherence tomography (OCT) and optical coherence tomography angiography (OCTA) were performed.

Results

OCT confirmed the presence of an ERM, increased central foveal thickness (CFT) and isolated inner-outer areas of retinal separation OD (figure 1 a-b). Isolated PEDs OS were also visible on OCT. OCTA showed tortuous foveal vessels with darkening of the DCP lumen indicative of hypo-perfusion OD. The superficial plexus vascular density (VD) was reduced OD. Similarly, areas of hypo-perfusion were observed for the outer retina OD. OCTA of the left eye was unremarkable. In addition, the INL was thicker and the FAZ was smaller OD than OS (figure 2 a-d). Continued observation was recommended, and the patient was instructed to return to clinic if increased distortions on Amsler grid or decreased vision were noticed.
Discussion

Tortuosity of the foveal SCP and hypoperfusion associated with an ERM has been documented with FA. However, since imaging with this technique is limited to inner retinal layers, analysis of the effect of the ERM on deeper retinal layers was only recently documented with OCTA. Lin et al. described tortuosity, hypoperfusion of superficial vessels and areas of non-perfusion of the foveal DCP. OCTA studies following ERM peeling have also revealed decreased outer retina flow area velocity and changes in VD in the superficial, deep and outer retinal capillary plexus. Decreased blood flow velocity and VD have been documented even at the choroidal capillary plexus corresponding to the fovea of eyes with an ERM, compared to that of the un-affected contralateral eye. Lin et al. indicated that areas of low signal on OCTA for the SCP, correspond to hypo-fluorescence indicative of hypo-perfusion on FA and reduced flow velocity on scanning FA on eyes with an ERM. They mentioned that while normal capillary flow rate varies between 0.4mm/s to 3.0 mm/s and OCTA hypothetically can detect flow rates between 0.2-0.3 mm/sec, the low signal on the foveal SCP and DCP plexus indicates that the flow velocity must be under 0.2 mm/sec. OCTA could not sense these low flow rate levels and thus indicates hypo-perfusion is present. They also documented eyes that develop a lamellar hole secondary to an ERM, the peripheral fovea did not have low flow signals and suggested that while relief of the traction may produce inner structural defects and absent vascularity, the DCP may be spared.

Kim et al. documented that eyes with greater differences in the FAZ and para-foveal VD had significantly worse post-surgical BVA and suggested that OCTA imaging of the macular capillary plexus had value in determining prognostic surgical outcomes. The investigators observed that eyes with a greater pre-surgical and post-surgical CFT, had a reduced FAZ and para-foveal VD post-surgically. No correlation existed for any of the outer retina pre-surgical parameters. They implied that, ERM traction on the INL may affect the SCP and may lead to a deficiency in the DCP as well. They considered that the vascular deficiency of the DCP may lead to impaired removal of excess retinal fluid leading to increased INL thickness, smaller FAZ and consequent reduction of vision. The para-foveal ganglion cell complex (GCC) thickness was also described to correlate with a reduced FAZ and para-foveal VD. Due to this observation they reflected on the possibility that reduced VD also may give rise to neuronal damage. A thinner post-surgical GCC may indicate that the loss of ganglion cells and the integrity of neural tissue may be a consequence of a lower para-foveal VD. They suggested that the increase in INL thickness and resulting mechanical distortion of the INL components by the ERM may cause cellular and synaptic distress leading also to a reduction in vision.

Since inner and outer retinal hypoperfusion may affect the ganglion cells and neuronal function, it is likely that it may also cause dysfunction and damage to other structural retinal elements such as the Muller cells. One of the functions of the Muller cells is to mitigate the effect of traction and provide structural sustenance to the retina. Muller cell impairment has been suggested to be involved in the pathogenesis of X-linked juvenile retinoschisis and peripapillary retinoschisis associated with glaucoma. In our patient the SCP tortuosity, reduced VD as well as the SCP and DCP low signal was present in the eye with the ERM. The reduced VD and low signal at the SCP and DCP accordingly suggest that hypoperfusion is present in these areas. We propose that the inner outer retinal breaks present in our patient, as well as the development of lamellar and macular holes in cases of ERM, not only may be related to traction of the ERM but dysfunctional damage to the Muller cells due to reduced blood perfusion.
The patient also had a smaller FAZ, thicker INL and CFT in the eye with the ERM. Although rearrangement of the foveal contour may occur after ERM surgery, the OCTA findings present in our patient are associated with poor post-surgical visual prognosis. In addition, while recovery of the FAZ size may occur after ERM peeling, it does not widen in all cases. These observations as well as a BVA of 20/20 and minimal symptoms of metamorphosia reported by the patient, did not indicate surgical intervention.

**Conclusion**

We report inner and outer retina hypoperfusion, a smaller FAZ and the presence of an inner outer retinal breaks in a patient with a unilateral ERM. These findings add to other recent reports of patients with an ERM. These observations may be valuable for determining any surgical recommendation and the prognosis in patients with an ERM. We propose that restraint of blood perfusion secondary to the ERM may also affect the integrity and function of the Muller cells. In addition to shear and traction, damage to the Muller cells may contribute to the development and formation of lamellar holes secondary to an ERM.

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**References**


