MACULAR SCHISIS IN ADVANCED GLAUCOMA.

*Ghadeer Al-Humimat MD *, Ibtisam Marashdeh MD*, Duaa Daradkeh MD *, Karanjit Kooner MD*

ABSTRACT

Background: Macular schisis is typically associated with congenital or high myopia-related abnormalities but has also been observed in glaucomatous eyes. Structural damage to the lamina cribrosa (LC) may permit cerebrospinal fluid (CSF) to track into the retinal layers.

Case Presentation: A 63-year-old woman with severe primary open-angle glaucoma presented with unilateral visual changes and was found to have macular schisis on OCT. Imaging revealed posterior bowing and multiple cracks in the LC, suggesting a communication between the subarachnoid space and retina. Observation was recommended due to preserved visual acuity. At six months, macular schisis had significantly improved with stable IOP and better compliance.

Conclusion: This case supports the hypothesis that glaucomatous LC damage, combined with IOP fluctuations, may facilitate CSF migration into the retina. Early detection and stabilization of IOP are critical in preventing further visual compromise.

Keywords: Macular schisis, glaucoma, lamina cribrosa, cerebrospinal fluid, OCT, optic nerve

JRMS August 2025; 33 (2):10.12816/0062216.

INTRODUCTION

Macular schisis is the splitting of the neurosensory retina and has been described in various ocular conditions, including X-linked retinoschisis, congenital optic disc abnormalities such as optic disc pits and coloboma, and pathological myopia. [1] In addition, several cases of macular schisis secondary to glaucomatous optic neuropathy have been reported. [2-6] Hollander et al. [2] and Kahook et al. [3] have reported the incidence of peripapillary schisis extending to the macula in patients with acute angle closure glaucoma (ACG). They theorized that acute elevation in intraocular pressure (IOP) may have led to the vitreous entering the retina through invisible small breaks (micro holes) in the retinal fiber layers. Others have reported the incidence of macular schisis in various types of glaucoma: primary open angle glaucoma (POAG), normal tension glaucoma (NTG), and juvenile open angle glaucoma (JOAG), with the assumption that vitreous entered the retina through microscopic holes in the retinal nerve fiber layers. However, no evidence was provided. [2-6]

Glaucoma is a progressive optic neuropathy leading to characteristic changes on the optic disc, resulting in visual field defects with or without elevated IOP. [7] The lamina cribrosa (LC) is believed to be the primary site of nerve damage in glaucoma.[8] Progressive glaucoma damages the LC, causing thinning, posterior bowing, focal defects/cracks, and ultimately Schnabel cavernous degeneration. [8,9]

**From the Department Of Surgery*

Correspondence should be addressed to Dr. Omar Vayed Alshwabkeh Shwabkeh,, Te:+962772356644. omar@yahoo.com

The LC also separates two pressurized compartments, namely the intraocular compartment with its own IOP and the intracranial compartment with its own intracranial pressure (ICP).The latter is mainly contributed by the cerebrospinal fluid (CSF) circulating in the subarachnoid space.[10] CSF is produced in the cerebral ventricles and flows into the subarachnoid space of the brain. From the intracranial subarachnoid space, a volume gradient permits CSF to flow to the orbital subarachnoid space. [11] Around the optic nerve and at the level of LC, the orbital subarachnoid space is defined by a unique anatomy in which the CSF reaches a dead end. The mechanism of CSF recycling around the optic nerve is poorly understood. [11]

However, there is histological evidence supporting the presence of lymphatic capillaries in the dura mater around the human optic nerve. [12] Furthermore, histological studies have shown evidence of a glymphatic system inside the optic nerve and the retina, which is believed to be involved in waste clearance of the central nervous system including the eye. [13-15] This glymphatic pathway was originally described in the brain and consists of three elements: a para-arterial CSF influx route, a para-venous interstitial fluid clearance route, and a transparenchymal pathway, which is dependent upon astroglial water transport. [14] We hypothesize that marked thinning and/or crack/defects at the level of the LC in our patient were induced by glaucomatous optic neuropathy and combined with wide fluctuations in IOP forced the diffusion of CSF to the optic nerve and retina.

CASE PRESENTATION

We report a case of a 63-year-old female with a diagnosis of severe POAG [nerve fiber layer thickness 66 µ right eye (OD) and 58 µ left eye (OS)] who was noncompliant with her medications and follow-ups. She presented with a recent onset of blurred vision in OD. Her past ocular history was positive for a family history of glaucoma and besides topical antihypertensive medications, she had undergone selective laser trabeculoplasty (SLT) in both (OU) eyes. Visual acuity was 20/20 OU and the IOP measured 14 mmHg OU however, the IOP had fluctuated between 12 and 21 mmHg OU over the past year. Biomicroscopic slit lamp examination of the anterior segment was normal except for early nuclear cataract OU. A dilated fundus examination OD revealed a cup-to- disc ratio of 0.9 and supero-temporal sub retinal fluid (**Figure 1A**). The left eye (OS) also had a cup-to-disc ratio of 0.9 with no evidence of retinal fluid as shown by optical coherence tomography (OCT) of optic nerve and macula using AngioVue® [Avanti RTVue XR, Optovue Inc. Fermont, CA, USA software version 2018.00.14) (**Figure 1B**)]. OCT OD using a Spectralis® (Heidelberg Engineering GmbH, Heidelberg, Germany) in the extended depth imaging (EDI) mode demonstrated the presence of macular schisis extending from the depth of the optic disc toward the macula (**Figure 1C**). The LC was thin and bowed posteriorly with multiple linear cracks and a communication between the subarachnoid space and the retinal layers (**Figure 1C**). The macular schisis mainly involved the outer plexiform layer with sparse

entanglement of the retinal nerve fiber layer (RNFL), and the surface appeared intact (**Figure 1D**). Fundus fluorescein angiography showed a superotemporal hypofluorescent area involving the macula with no evidence of dye leakage (**Figure 1E**).

We consulted a retina specialist who recommended observation only for this patient because of her excellent vision. The patient was counseled regarding her condition and we stressed the importance of compliance with medications. Six months later, the vision and IOP were stable and OCT showed appreciable improvement in the macular schisis (**Figure 2A,2B**).

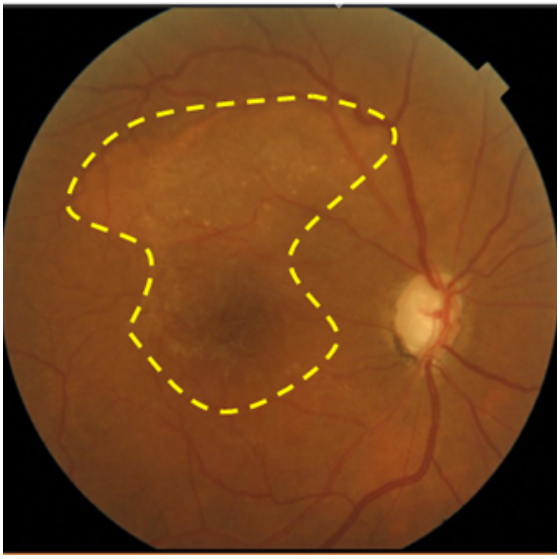

Figure 1A: Fundus photograph of the right eye showing glaucomatous optic disc cupping with cup to disc ratio of 0.9 and supero temporal sub retinal fluid involving the macula (dashed line).

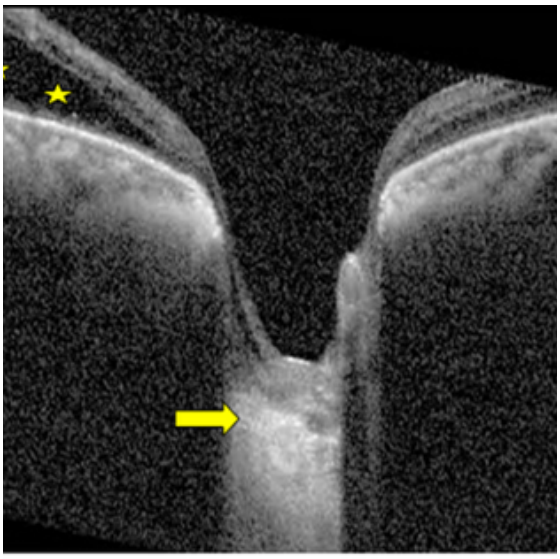

Figure 1B: Optical coherence tomography of the optic disc (top) and the macula (bottom) of the left eye. The optic disc has deep cupping with no peri-papillary schisis and the macula is normal.

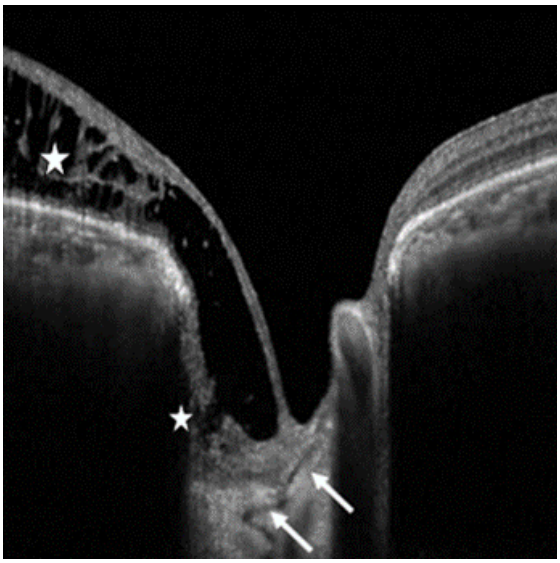

Figure 1C: Optical coherence tomography of the optic disc, right eye, showing the sub retinal fluid (stars) extending from the depth of the optic disc cup toward the retinal layers. The lamina cribrosa appears thinned, displaced posteriorly with multiple cracks (arrows). The subarachnoid space is connected to the retinal layers (star).

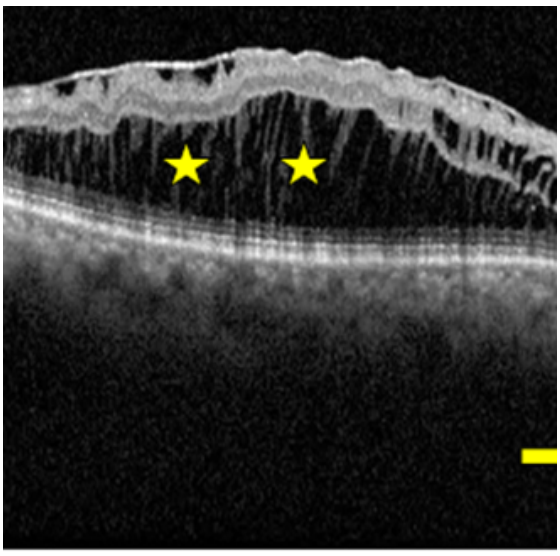

Figure 1D: Optical coherence tomography of the macula, right eye, revealing splitting of the retinal layers (stars) and connecting to the optic disc (arrow).

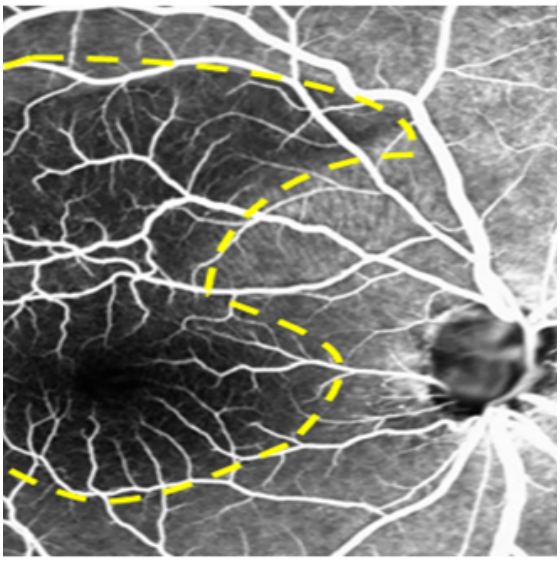

Figure 1E: Retinal fluorescein angiography, right eye, demonstrates hypo fluorescent area in the macula and the supero temporal retina without leakage (dashed line).

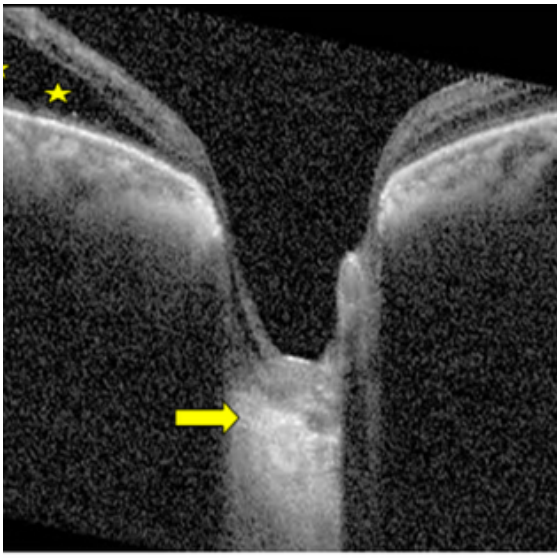

Figure 2A: Optical coherence tomography of the optic disc, right eye, taken 6 months later showing regression of the sub retinal fluids (stars)and no evidence of the cracks (arrow).

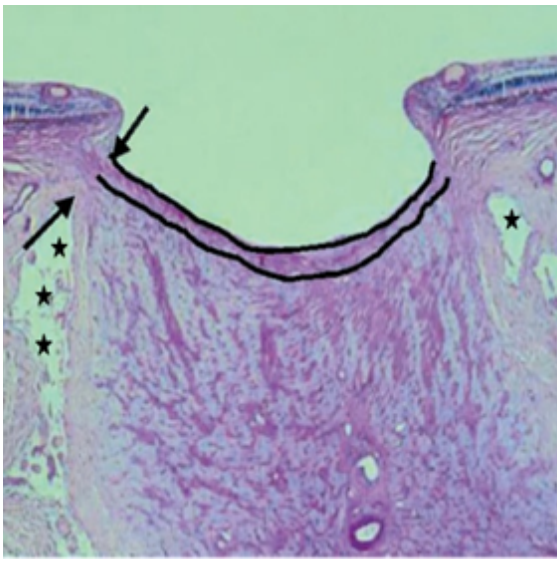

Figure 3A: Histological section of the optic nerve in a glaucomatous eye showing the thinned and posteriorly displaced lamina cribrosa (black lines). The arrows show the close relationship between the cerebrospinal fluid in the subarachnoid space (stars) and the lamina cribrosa. [Jonas et al. (8) reproduced with permission from ARVO (Association for Research in Vision and Ophthalmology), MD,USA]

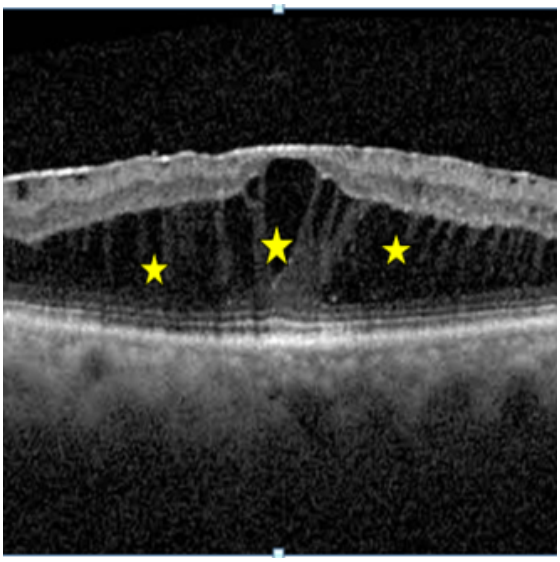

Figure 2B: Optical coherence tomography of the macula, right eye, obtained 6 months later showing decrease in the sub retinal fluids (stars).

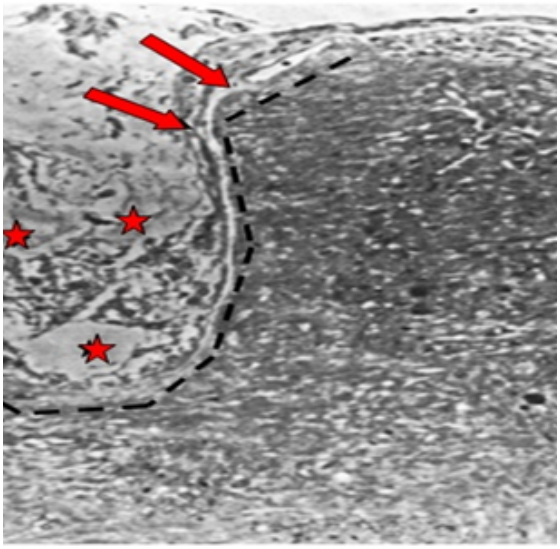

Figure 3B: Electron microscopic view showing pit like change (dash line) in the optic nerve head of a patient with glaucoma. There is a defect in the collagenous struts of lamina cribrosa combined with nerve bundle loss. The wall of the pseudopit is lined by astrocytes (arrows) and loose collagen (stars). [Quigley (16), reproduced with permission from ELSEVIER, AMS, Holland]

DISCUSSION

We report a case of macular schisis secondary to leakage of CSF from the subarachnoid space toward the retinal layers in the presence of advanced glaucomatous optic nerve cupping. A careful fundus examination including OCT and retinal fluorescein angiography revealed no other etiologies.

The glaucoma induced changes of the LC (extreme thinning, posterior displacement, defects or cracks) combined with marked fluctuations of IOP may have provided a route for the CSF diffusion from the subarachnoid space into the retinal layers. Jonas et al. [8] have studied the histological changes of the optic nerve secondary to glaucoma and found marked proximity between the thinned LC and pia matter/subarachnoid space (Figure 3A).

Our patient also showed linear cracks in the LC. These anatomical changes may alter the function of LC as a barrier between the intraocular space and the orbital space and allow the CSF with or without the aid of the glymphatic system to diffuse into the retina. A histological study of human glaucoma optic nerve cupping showed evidence of defects in the LC, which simulated optic disc pits (Figure 3B). [16] In 1969, Gass [17] suggested that CSF might be the source of fluid in cases of congenital optic disc pit. Mathieu et al. [13] reported evidence of glymphatic pathways in the optic nerve while Wang et al. [15] demonstrated the presence of the glymphatic pathways in the retina.

We believe that in our patient, wide fluctuations in IOP may have induced "hammering effect" causing mechanical damage to the thinned LC and resulting in defects or cracks. [18] These cracks could allow the leakage of CSF from the subarachnoid space aided by the glymphatic pathway toward the retina. In addition, the pumping mechanism generated by the IOP variations may further push the CSF into the retinal layers. With observation and enhanced compliance, the patient's condition improved. In contrast to our results, Zhao et al. [6] reported that there was no improvement in the macular schisis in their patient with NTG.

Other treatment approaches, based on the clinical presentation, have been tried such as laser peripheral iridotomy, [2,3] treating elevated IOP with ocular hypotensive medications, [2,3] filtering surgery, [4] pars plana vitrectomy, [4] and barrier laser photocoagulation. [19] The outcomes of treatment have varied from incomplete resolution to persistence of the schisis. [2-6]

CONCLUSION

Macular schisis secondary to CSF diffusion is a rare occurrence in glaucoma but provides excellent clues to the intricate relationship between the optic nerve and the hydrodynamics of the CSF. Stabilization of IOP is of paramount importance in these patients. In addition, co-management with a retina specialist is crucial to establish an accurate diagnosis and follow up care.

AKNOWLEDGEMENT

Supported in part by the Research to Prevent Blindness, New York, NY; Visual Sciences Core Grant P30EY030413.

REFERENCES

1. Lee JH, Park HL, Lee WK. Alterations of the lamina cribrosa are associated with peripapillary retinoschisis in glaucoma and pachychoroid spectrum disease. Ophthalmology. 2016; 123: 2066-2076.

2. Hollander DA, Barricks ME, Duncan JL, Irvine AR. Macular schisis detachment with angel closure glaucoma. Arch opthalmol. 2005; 123: 270-272.

Ishikawa H, Wollstein G, Kageman L, Wojtkowski M, et al. Peripapillary schisis in glaucoma patients with narrow angles and increased intraocular pressure. Am J ophthalmol. 2007; 143(4): 697-699.

4. Zumbro DS, Jampol LM, Folk JC, Oliver MM, Anderson-Nelson S. Macular schisis and detachment associated with presumed acquired enlarged optic nerve head cups. Am J Ophthalmol. 2007; 144: 70-74.

5. Hubschman JP, Reddy S, Kaines A, Law S. Nasal retinoschisis associated with glaucoma. Ophtalmic Surg. Lasers and Imaging. 2010 Feb 15: 1-4. DOI: 10.3928/15428877-20100215-60.

6. Zhao M, Li X. Macular retinoshisis associated with normal tension glaucoma. Graefes Arch Clin Exp Ophthalmol. 2011; 249: 1255-1258. DOI:10.1007/s00417-011-1668-y.

7. Foster PJ, Buhrmann R, Quigley HA, Johnson GJ. The definition and classification
of glaucoma in prevalence surveys. Br J Ophthalmol. 2002; 86:238-243.

8. Jonas JB, Berenshtein E, Holbach L. Anatomic relationship between lamina cribrosa,intraocular space, and cerebrospinal fluid space. Invest Ophthalmol Vis Sci. 2003. Figure 3, Histologic section through the optic disc of an eye with secondary angle-closure glaucoma, p5191. Reproduced with permission from ARVO (Association for Research in Vision and Ophthalmology).

9. Giarelli L, Falconieri G, Cameron D, Pheley AM. Schnabel cavernous degeneration. Arch Pathol Lab Med. 2003; 127:1314-1319.

10. Wostyn P, Groot VD, Dam DV, Audenaert K, Killer HE, De Deyn PP. The glymphatic hypothesis of glaucoma: a unifying concept incorporating vascular, biomechanical, and biochemical aspects of the disease. Biomed Res. Int. 2017; 1-7.

11. Lee JH, Park HL, Lee WK. Alterations of the lamina cribrosa are associated with peripapillary retinoschisis in glaucoma and pachychoroid spectrum disease. Ophthalmology. 2016; 123: 2066-2076.

12. Hollander DA, Barricks ME, Duncan JL, Irvine AR. Macular schisis detachment with angel closure glaucoma. Arch opthalmol. 2005; 123: 270-272.

13.Ishikawa H, Wollstein G, Kageman L, Wojtkowski M, et al. Peripapillary schisis in glaucoma patients with narrow angles and increased intraocular pressure. Am J ophthalmol. 2007; 143(4): 697-699.

14. Zumbro DS, Jampol LM, Folk JC, Oliver MM, Anderson-Nelson S. Macular schisis and detachment associated with presumed acquired enlarged optic nerve head cups. Am J Ophthalmol. 2007; 144: 70-74.

14. Iliff JJ, Wang M, Liao Y, Plogg BA, Peng W, Gundersen GA, et al.A paravascular pathway facilitates CSF flow through the brain paranchyma and the clearance of interstitial
Solutes, Including Amyloid b. Sci. Transl. Med. 2012; 4 (147): 147-111. DOI:10.1126/scitranslmed.3003748.

15. Wang X, Lou N, Eberhardt A, Yang Y, Kusk P, Xu Q, et al. An ocular glymphatic clearance system removes ß-amyloid from the rodent eye. Sci. Transl. Med. 2020; 12: 1-14. DOI: 10.1126/scitranslmed.aaw3210.

16. Quigley HA, Green WR. The histology of human glaucoma cupping and optic nerve: clinicopathologic correlation in 21 eyes. Ophthalmology. 1979. Figure 15, pit like change in the optic nerve head of H 159 OD, p1820. With permission from ELSEVIER.

17. Gass JDM. Serous detachment of the macula secondary to congenital pit of the optic nerve head. Am J Ophthalmol. 1969; 67: 821-841.

18. You JY, Park SC, Su D, Teng CC, Liebmann JM, Ritch R. Focal lamina cribrosa defects associated with glaucomatous rim thinning and acquired pits. JAMA Ophthalmol. 2013;131(3):314-20. doi: 10.1001/jamaophthalmol.2013.1926.

19. Prinzi RA, Desai A, Gao H. Laser treatment of macular retinoschisis due to acquired optic nerve pit from glaucoma. BMJ Case Rep. 2015;2015: bcr2015211036. doi:10.1136/bcr-2015-211036.