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Dissociation of retinal ganglion cell complex and superficial retinal vessel density on optical coherence tomography in a case of pediatric optic neuritis

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ABSTRACT

Purpose: To report the case of a pediatric patient with optic neuritis in whom changes in the retinal ganglion cell complex (GCC) and superficial retinal vessel density were dissociated.
Observations: An 8-year-old girl had an upper respiratory tract infection in early February 2019, after which she began to experience oculomotor pain and vision loss in her left eye. She was diagnosed with optic neuritis of the left eye. Initial examination showed a visual acuity of 20/20 in her right eye and light perception in her left eye. After steroid pulse therapy, her left visual acuity improved to 20/20 in April 2019, with no further symptoms to date. The GCC in the affected eye continued to become thinner until November 2019. However, optical coherence tomography angiography carried out after improvement in her visual function showed no difference in vascular density of the superficial retinal capillary plexus between the right and left eyes.
Conclusions and importance: In glaucoma, GCC thinning and vascular density loss occur almost simultaneously at an early stage. However, the current neuritis case showed changes in GCC but no corresponding changes in vascular density in the same area. This report suggests that optic neuritis and glaucoma involve different mechanisms of GCC thinning.

1. Introduction

Pediatric optic neuritis is a neuro-ophthalmic condition characterized by degeneration of the optic nerves,[1] manifesting clinically with acute or subacute visual loss, frequently accompanied by periorbital pain, dyschromatopsia, and visual field defects.[2,3] The optic nerve inflammation may have multiple etiologies, including idiopathic, autoimmunity, infection, granulomatous diseases, vasculitis, paraneoplastic disorders, and demyelination. Pediatric optic neuritis, involving inflammation of the optic nerve, is often observed after viral infection or vaccination.[1,4,5] It typically starts during the first decade of life, and has an incidence rate of 0.15–0.57 per 100,000 person-years, which is less than that of adult-onset optic neuritis.[4]

Glaucoma is the leading cause of irreversible blindness worldwide. It is a progressive optic neuropathy characterized by optic nerve head damage, retinal ganglion cell death, and progressive visual field loss.[6] The retinal ganglion cell complex (GCC) and retinal nerve fiber layer (RNFL) thicknesses measured by optical coherence tomography (OCT) were shown to be significantly thinner in glaucomatous compared with normal eyes,[7] while the degree of vessel density loss shown by OCT angiography (OCTA) was significantly correlated with glaucoma severity.[8] Optic neuritis also shows the decrease in the thickness of GCC or RNFL.[9] Here, we noted dissociation between GCC thinning and decreased superficial vessel density in a patient with pediatric optic neuritis. We present this case suggesting that the damage mechanism occurring after optic neuritis may differ from the general mechanism in glaucoma.

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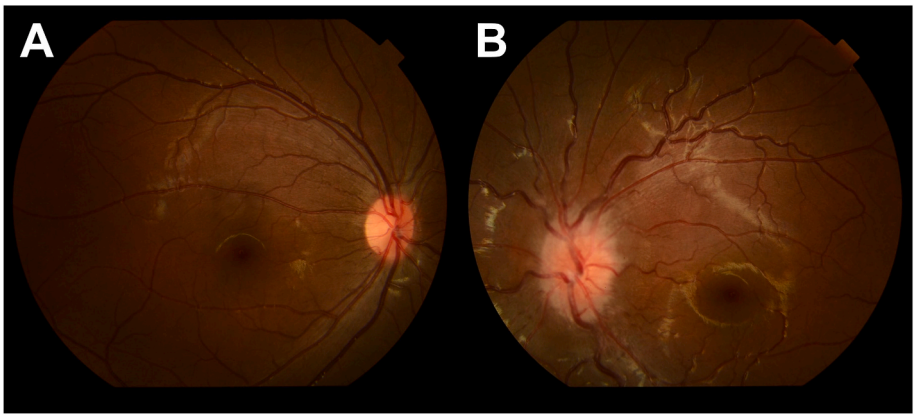


Fig. 1. A: Right eye showing normal disc. B: Left eye showing papillary disc edema.

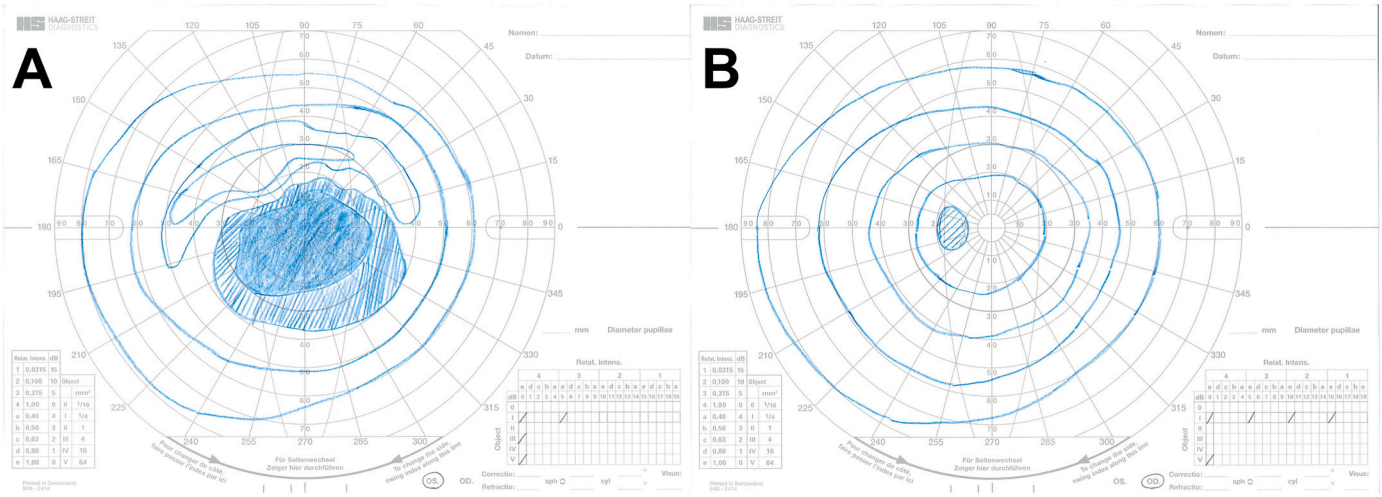
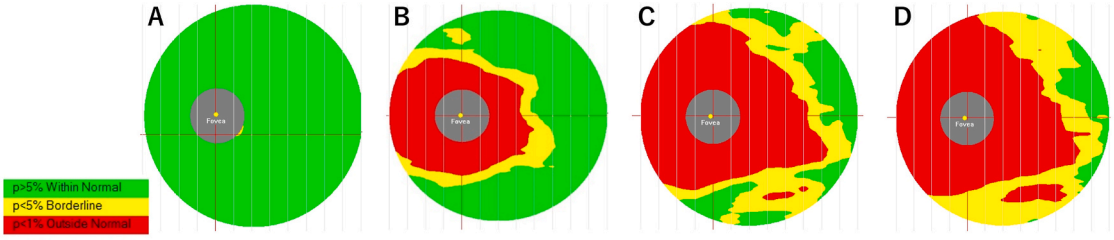


Fig. 2. Goldmann visual field test in left eye. A: Central scotoma. Isopter V-4-e, III-4-e, I-4-e, and I-3-e from the outside. B: Disappearance of central scotoma and no visual field defect. Isopter V-4-e, I-4-e, I-3-e, I-2-e, and I-1-e from the outside.

2. Case report

An 8-year-old girl developed an upper respiratory tract influenza type A infection in early February 2019. She was treated conservatively to relieve her fever. However, in mid-February, she began to experience oculomotor pain and vision loss in her left eye. Ocular examination at a local clinic showed a visual acuity of 20/80 in her left eye. Later in February, she lost left photosensation, and was referred to the Department of Ophthalmology at Hiroshima University Hospital for a medical examination and treatment. She had no relevant past history or family history and was not receiving any medication.

Initial examination showed a best corrected visual acuity in her right eye of 20/16 and light perception in her left eye. Intraocular pressure (IOP) measured with a non-contact tonometer was 17 mmHg in her right



Average GCC (μm)	100	77	68	65
Superior GCC (μm)	102	77	67	65
Inferior GCC (μm)	98	76	68	65

Fig. 3. Transition of ganglion cell complex (GCC) thickness on optical coherence tomography. A: February 2019 (first visit), B: March 2019, C: April 2019, D: November 2019. The numbers at the bottom of the figure show the changes in Average GCC (μm), Superior GCC (μm) and Inferior GCC (μm) at points A to D.

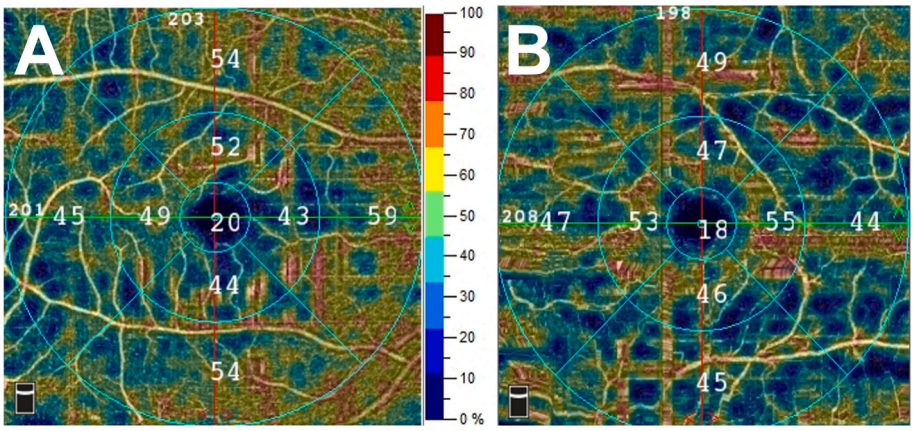


Fig. 4. Superficial vessel density of retina on optical coherence tomography angiography. The average vascular density was 46.7 % in the right eye (A) and 44.9 % in the left eye (B). There was no significant difference in vascular density between the right and left eyes ($p = 0.68$, paired t-test).

eye and 14 mmHg in her left eye. Light reflection in the right eye was prompt and sufficient, but and poor and insufficient in her left eye. There were no notable anterior ocular findings. Fundus examination showed a choked disk in the left eye (Fig. 1). She had an absolute central scotoma in her left eye spanning 20° upward, 30° downward, and 40° horizontally, but her right eye was normal, according to the Goldmann visual field test (Fig. 2A).

Her general condition was good, except for her eye problems. Anti-aquaporin-4 antibody was negative. Based on a diagnosis of left optic neuritis, she received two sessions of steroid pulse therapy (methylprednisolone 625 mg, 30 mg/kg/day) for 3 days. Following steroid pulse therapy, her left visual acuity improved to 20/20 in April 2019, with no further symptoms to date. Four months later, post-treatment visual acuity in the right eye was 20/16 and in the left eye was 20/20. The central scotoma measured by Goldmann perimetry disappeared 2 months after steroid treatment (Fig. 2B). OCT showed that the GCC in the affected eye continued to be thinner until November 2019 (Fig. 3).

OCTA carried out in November 2019, after the improvement in visual function, showed no significant difference in the superficial retinal capillary plexus between the right and left eyes (Fig. 4). The mean vascular density was 46.7 % in the right eye and 44.9 % in the left eye. The vascular density value for the nasal side of the optic papilla was 10 % lower in the left compared with the right eye. However, a paired t-test (JMP software version 16; SAS Inc., Cary, NC, USA) showed no significant difference in vascular density between the left and 、 right eyes ($p = 0.675$).

There was no further GCC thinning after November 2019, and the patient's final visit was in July 2020.

3. Discussion

We observed a patient who initially developed an upper respiratory tract infection, followed by visual disturbance in her left eye a few days later. Most children with optic neuritis benefit from steroid and immunomodulatory treatment, as described previously.[9] However, several studies have reported apoptosis of retinal ganglion cells after an episode of acute optic neuropathy[10–12]. This programmed cell death would lead to thinning of the layer of nerve fibers in the retina due to progressive disappearance of axons, resulting in macroscopic sectoral or total atrophy of the optic nerve at the fundus. This may be the reason why we observed continuous GCC thinning after recovering the visual acuity. Jiang et al. reported not only the GCC and RNFL thickness, but also retinal vessel density decreases after optic neuritis caused by multiple sclerosis and neuromyelitis optica spectrum disorder.[13] The multiple sclerosis patients without ocular complaints also have the retinal vessel density decrease. Our case showed the similar superficial retinal vessel density after recovery from unilateral optic neuritis The right eye had normal GCC thickness and the GCC in the left eye was badly damaged. There is little possibility that the retinal vessel density in both eyes might decreased similarly. Optic neuropathy is a childhood problem with various possible causes.[10,11,14–19] Optic neurites in our case might be caused by other than multiple sclerosis or neuromyelitis optical spectrum disorder.

The GCC and RNFL thicknesses are significantly thinner in glaucoma compared to normal eyes, and the thicknesses were shown to decrease as the severity of perimetric glaucoma increased.[7] OCTA can detect decreased capillary vessel density within the peripapillary nerve fiber layer and macula in patients with suspected glaucoma, preperimetric glaucoma, and perimetric glaucoma,[8] and the degree of vessel density loss correlates significantly with glaucoma severity. The main risk factors for glaucoma are high IOP and non-IOP-related risk factors, such as ischemia, inflammation, and autoimmunity, and astrocyte and glial molecular biology are influenced by or interact with the effects of IOP. Growing evidence suggests that vascular factors may play a role in glaucoma pathogenesis, and both systemic (hypertension, diabetes) and ocular vascular factors (ocular blood flow, ocular perfusion pressure) have been assessed for associations with glaucoma. However, direct and convincing evidence for the primary mechanisms of glaucoma is still lacking.[20]Decreased vascular density along with the progression of glaucoma might indicate the importance of the ocular circulation in glaucomatous ganglion cell damage.

However, ocular circulation appeared to have little effect on ganglion cell loss in the current case of optic neuropathy, suggesting that the blood circulation might have less effect on ganglion cell damage in our optic neuropathy than in glaucoma.

4. Conclusions

We report on a pediatric patient with optic neuritis in whom the GCC findings on OCT and perimacular vessel density on OCTA were dissociated. In glaucoma, blood vessel density is synchronized with changes in GCC thinning. However, the current case suggests that glaucoma and optic neuritis in our case may cause damage to the ganglion cells by different mechanisms.

Patient consent

The patient and patient's legal guardian consented to publication of the case orally.

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Authorship

All authors attest that they meet the current ICMJE criteria for authorship.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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