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Case report

Choroidal blood flow impairment demonstrated using laser speckle flowgraphy in a case of commotio retinae

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ABSTRACT

Purpose: To report the time course of choroidal blood flow (CBF) in a commotio retinae case using laser speckle flowgraphy (LSFG).
Observations: A 58-year-old Japanese man with complaints of worsening left visual acuity after blunt eye trauma was diagnosed with commotio retinae. A funduscopic examination showed macular opacity, and LSFG results demonstrated CBF impairment in the affected eye.
Optical coherence tomography also showed disruption of the photoreceptor outer segment. Seven months after the initial visit, CBF was significantly increased, along with improvement in the photoreceptor outer segment.
Conclusion: and importance: We revealed CBF impairment in a case of commotio retinae for the first time. CBF impairment may be involved in the pathogenesis of commotio retinae, and LSFG may be useful for examining CBF in commotio retinae.
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1. Introduction

Commotio retinae has been observed frequently following ocular blunt trauma. Transient whitening of the retina appears as a zone of grey-white opacity in the macula or opposite to the site of impact as a contrecoup injury.[1] Histopathologic studies have clarified that disruption of the photoreceptor outer segment and retinal pigment epithelium (RPE) occur due to severe trauma.[2,3] Optical coherence tomography (OCT) findings also previously demonstrated disruption of the ellipsoid zone and corresponding hyperreflectivity.[4]

However, to our best knowledge, the time course of choroidal blood flow (CBF) in commotio retinae has not yet been investigated. In this paper, we demonstrate that CBF increased along with improvement of the photoreceptor outer segment in a case of commotio retinae associated with ocular blunt trauma 7 months after the injury.

1.1. Case report

A 58-year-old Japanese man presented at the first visit with complaints of worsening visual acuity in his left eye. A day before his first visit, he experienced blunt trauma to his left eye from a tennis ball during a tennis match. He visited the department of ophthalmology at a local hospital because of visual deterioration. The patient's decimal best-corrected visual acuity (BCVA) was 0.02, and a slit-lamp examination showed traumatic hyphema. He was referred to Toho University Sakura Medical Center in Sakura, Japan (referred to hereafter as “our hospital”) on the next day with a main complaint of worsening visual acuity in the left eye.

At the initial visit to our hospital, the patient's decimal BCVA had recovered to 1.2 and intraocular pressure (IOP) was within the normal range in both eyes. A slit-lamp examination of the left eye showed only subconjunctival hemorrhage, but the hyphema had disappeared. A fundus examination of the right eye was normal (Fig. 1A), and that of the left eye demonstrated that commotio retinae involved the macular area in a 1–2 optic nerve head diameter region (Fig. 1B). Subsequently, we measured CBF in the macular area using laser speckle flowgraphy (LSFG-NAVI™, Softcare Co., Ltd., Fukuoka, Japan). The measurement circle was set at the center of the macula in both the right and left eye at the initial visit.

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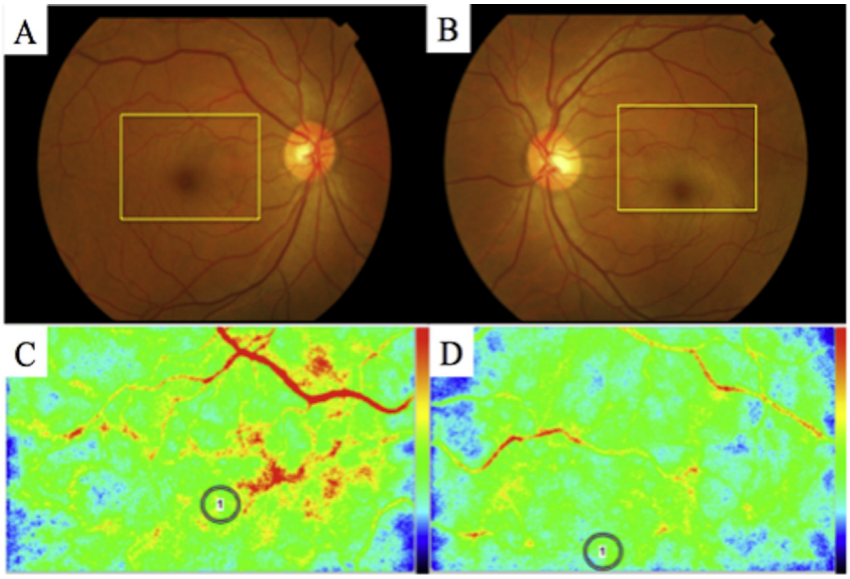

Fig. 1. Color fundus photography and laser speckle flowgraphy findings at initial visit A color fundus photograph of the right eye (A) is normal, and that of the left eye (B) shows retinal opacity in the macular area appearing as a white lesion. A laser speckle flowgraphy (LSFG) image of the right eye is shown in (C), and an LSFG image of the left eye is shown in (D). Based on fundus photography, a circle was created on the LSFG color map at the initial visit. The circle is located on the fovea. A red color represents a high mean blur rate (MBR), which indicates blood flow, and a blue color represents a low MBR. The MBR in (C) is lower than that shown in (D). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

We manually determined the circle's position by comparing fundus photographs and LSFG color map images. LSFG images of the right and left eye are shown in Fig. 1C and D. LSFG results demonstrated that the fundus image of his left eye was represented with cooler colors compared with his right eye. LSFG used the mean blur rate (MBR) as an indicator of blood flow.[5] In the present case, the CBF of the affected and fellow eyes were 11.5 and 13.5. However, the MBR in the macula (i.e., the CBF) obtained by LSFG was not investigated via hydrogen gas clearance measurements of optic nerve head blood flow.[6] Therefore, it is not certain whether the CBF of the left eye was lower than that of the right eye at the initial visit.

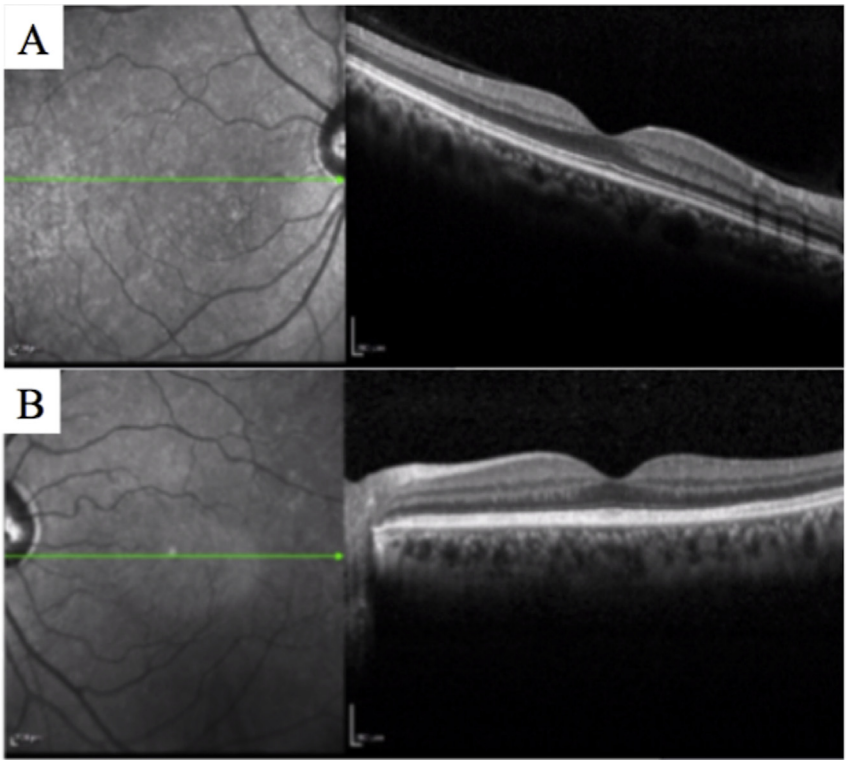

Fig. 2. Optical coherence tomography findings at initial visit. Optical coherence tomography of the right eye (A) shows normal inner and outer retinal segment architecture. The left eye (B) shows increased reflectivity of the ellipsoid and interdigitation zones with disappearance of the thin hyporeflective optical space.

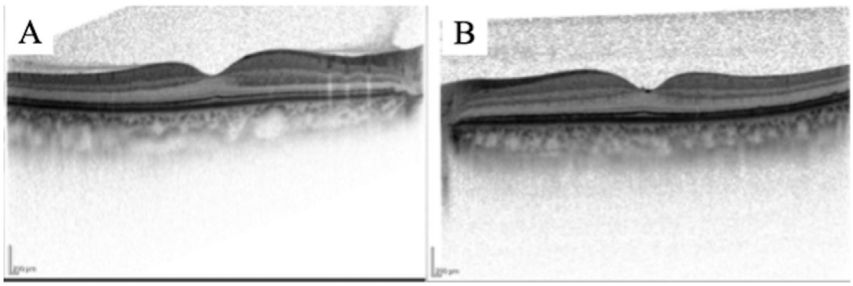

Fig. 3. Enhanced-depth imaging optical coherence tomography findings at initial visit. Enhanced-depth imaging optical coherence tomography of the right eye (A) shows that the central choroidal thickness is 329 μm while that of the left eye (B) is 238 μm.

In general, CBF is affected by fluctuations in ocular perfusion pressure (OPP).[7] To examine potential alterations in the time course of OPP, we measured the patient's IOP, and systolic and diastolic blood pressure (SBP and DBP, respectively) for the calculation of mean blood pressure (MBP) and OPP. MBP was calculated from SBP and DBP measurements using the following equation: MBP = 1/3·(SBP - DBP) + DBP. Subsequently, OPP was defined as the weighted difference between MBP and IOP, and was calculated using the following equation: OPP = 2/3·MBP - IOP. The difference in OPP (mmHg) between the affected eye (44.0) and fellow eye (43.5) at the initial visit was not significant.

An OCT examination (Spectralis OCTR; Heidelberg Engineering Inc., Heidelberg, Germany) showed that the ellipsoid and interdigitation zones were obscured in the area of retinal opacity corresponding to commotio retinae, and central retinal thickness (CRT) was not significantly different between the left eye (222 μm) and the right eye (224 μm) (Fig. 2). Enhanced-depth imaging OCT showed that the central choroidal thickness (CCT) of the left eye (238 μm) was significantly thinner than that of the right eye (329 μm) (Fig. 3). A previous report suggested that CCT was affected by axial length[8]; therefore, we measured axial length using the IOL Master® (Carl Zeiss Meditec, Jena, Germany). The axial length of the left (23.56 mm) and right eye (23.65 mm) was approximately the same. Whereas LSFG findings of the left eye showed a decrease in CBF, fluorescein angiography results indicated that there was no acute fluorescein leakage and blockade at the level of the pigment epithelium in the fovea. We diagnosed commotio retinae by these clinical findings and started clinical follow up without medication.

Fig. 4 shows the time course of macular opacity and LSFG images of the macular area.

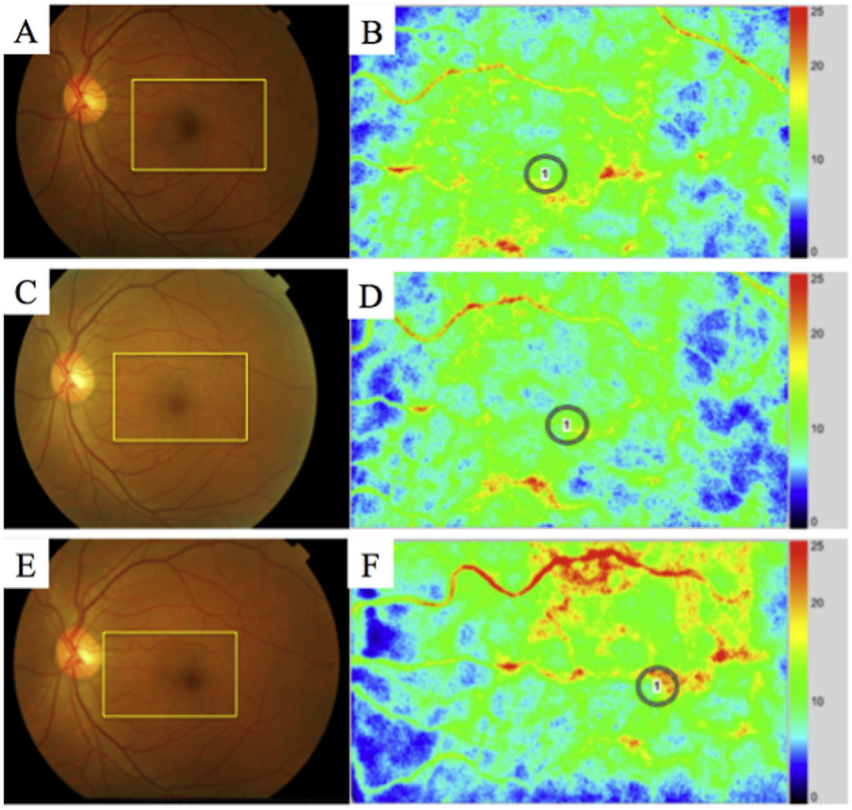

Fig. 4. Time course of color fundus photography and laser speckle flowgraphy findings. Fundus photography and laser speckle flowgraphy (LSFG) images of the left eye at 1, 4, and 7 months after the initial visit are shown in (4A) and (4B), (4C) and (4D), and (4E) and (4F), respectively. The macular opacity disappeared 1 month after the initial visit and there was no reappearance. LSFG images show that warm colors increased over time. The mean blur rates of the macula in (4B), (4D), and (4F) are 13.2, 13.8, and 19.9, respectively. Taken together, the macular opacity disappeared along with the choroidal blood flow increase.

One month after the initial visit, the left decimal BCVA remained at 1.2 and complaints of worsening visual acuity were slightly improved. The macular opacification had disappeared (Fig. 4A) and LSFG findings indicated that warm colors were slightly increased compared with the findings from the initial visit (Fig. 4B).

Four months after the initial visit, the macular opacity had disappeared completely (Fig. 4C). Visual complaints were improved, and LSFG results demonstrated that CBF had increased from 11.5 to 13.8 (Fig. 4D). Seven months after the initial visit (the last visit), the left decimal BCVA was 1.2, there was no macular opacity (Fig. 4E), and LSFG results demonstrated that warm colors were more prevalent on imaging compared with the initial visit (i.e., CBF was increased substantially) (Fig. 4F). OPP remained unaltered during the time course, with values of 44.4, 45.3, and 44.7 at 1, 4, and 7 months after the initial visit, respectively. Fig. 5 shows the time course of the OCT findings. Compared with the OCT findings from the initial visit, the three layers comprising the junction of the ellipsoid zone, interdigitation zone, and RPE gradually became easily differentiable 1, 4, and 7 months after the initial visit (Fig. 5A, B, and 5C). Taken together, the OCT findings showed that the photoreceptor outer segment slightly recovered with an improvement in CBF in the macular area. However, the CRT of the left eye did not demonstrate significant changes between the initial visit (222 μm) and last visit (214 μm). Furthermore, the CCT of the left eye also was not significantly different between the initial visit (238 μm) and last visit (255 μm). The CCT of the left eye remained less than that of the right eye (288 μm) at the last visit.

2. Discussion

To the best of our knowledge, no reports have investigated CBF in a case of commotio retinae using LSFG. In the current case, we revealed the dynamics of choroidal circulation in commotio retinae for the first time. At the initial visit, the CBF of the left eye was decreased at the lesion with macular opacity. However, the CBF of the macular lesions gradually increased, and the hyperreflectivity of the outer segment layer decreased along with the macular opacity discoloration as time proceeded. Considering these clinical findings, the ellipsoid and interdigitation zones might be disrupted from CBF impairment associated with blunt eye trauma.

Several studies previously used OCT to examine the morphologic features of macular commotio retinae.[9,10] It has been reported that the photoreceptor outer segment and RPE were most vulnerable to damage.[4,10] The clinical findings in the present case are consistent with previous reports, which demonstrated that patients had especially disrupted ellipsoid and interdigitation zones.

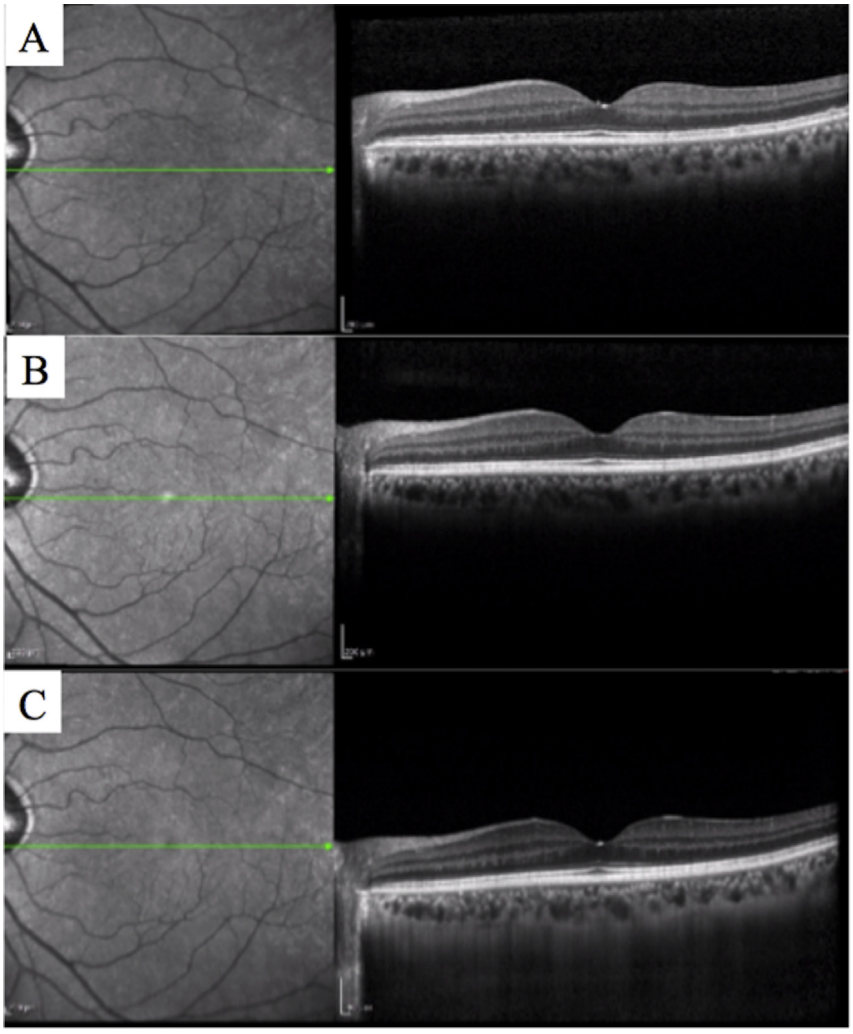

Fig. 5. Time course of optical coherence tomography findings in the left eye. Optical coherence tomography findings in the left eye at 1, 4, and 7 months after the initial visit are shown in (5A), (5B), and (5C), respectively. The interdigitation zone and retinal pigment epithelium gradually become easily differentiated along with improvement of the macular opacity.

Recently, Ahn et al. reported that macular commotio retinae could be subdivided according to the level of photoreceptor damage on the basis of spectral-domain OCT imaging.[11] In the classification scheme, the OCT findings in this case were classified as Grade 1, which showed increased reflectivity in the ellipsoid zone with disappearance of the thin hyporeflective optical space. A previous report indicated that there was a significant association between final BCVA and OCT grades by linear regression analysis.[11] Considering that the final decimal BCVA was 1.2 in the current case, it is consistent with the classification of commotio retinae by OCT imaging.

However, the details of how CBF is involved in disruption of the photoreceptor outer segment have been unclear. Previously, Ohno reported that CBF in experimental commotio retinae in animals transiently increased in the early phase (30–140 min after blunt eye trauma) using the hydrogen gas clearance method.[12] In contrast, CBF decreased to the same levels as in the controls in the middle phase (a few days later), and again increased in the late phase (several weeks later). The previous result was almost consistent with our findings. Considering these clinical findings, it is reasonable to suppose that decrements and fluctuations in CBF are involved in the pathogenesis of the photoreceptor outer segment in commotio retinae, and increments in CBF might be implicated in the recovery of the photoreceptor outer segment.

In the present case, the CCT of the left eye was lower than that of the right eye during follow up, and was slightly increased compared with that at the initial visit. A previous report demonstrated that choriocapillaris damage occurs in cases of commotio retinae.[13] Furthermore, based on indocyanine green angiography, it has been suggested that in severe cases, delayed filling of the choroidal arteries and changes in choroidal vasculature may occur, in addition to choriocapillaris disruption.[13] Considering these clinical findings, we speculate that the thinning of the CCT and impairment of the left eye CBF might be caused by morphologic and functional vascular changes due to blunt trauma.

Furthermore, the CCT of the left eye slightly and gradually increased during follow up compared with that at the initial visit. Previously, no significant correlation between CCT and CBF has been reported in healthy subjects.[14] Therefore, it is unclear whether the increase in CBF influenced the time course of the left eye CCT in this case. A limitation of the current case was the potential effect of macular opacity on MBR values according to altered absorption or laser beam reflex. Considering that CBF gradually increased after macular opacity disappeared, it is reasonable to suggest that macular opacity has a small influence on MBR. However, further studies with more cases are needed to evaluate whether macular opacity affects MBR.

3. Conclusions

In conclusion, this is the first report to demonstrate an increase in CBF along with recovery of the photoreceptor outer segment. Commotio retinae might be involved in CBF impairment and a decrease in choroidal thickness. LSFG is a non-invasive method that may be useful to evaluate the time course of CBF in commotio retinae.

3.1. Patient consent

Informed consent was obtained in writing from the patient for the use of their information and external photograph for the purpose of this report.

Authors' contributions

All authors contributed significantly to the creation of this manuscript; each fulfilled the criteria established by the ICMJE.

Conflicts of interest

None.

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