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Case Report

Optical Coherence Tomography Angiography Imaging of Foveal Atrophy Secondary to Commotio Retinae in a Pediatric Patient

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Abstract

Optical coherence tomography-angiography (OCTA) is a fast, reliable, and non-invasive technique for the diagnosis and follow-up of patients with commotio retinae (CR). Severity of the damage to the retinal and choroidal microvasculature in OCTA imaging and the visual prognosis are directly related to the severity of trauma. There are a few published reports on OCTA in CR that shows alterations of the retinal or superficial choroidal vessels and choriocapillary plexus. OCTA imaging seems to be predictive for visual prognosis. Herein, we present a 6-year-old boy, who had blunt trauma to the right eye with a stick during outdoor playing with visual acuity reduction to 0.1 following resolution of the Berlin's edema. In our case, OCTA revealed damage to the outer layers of the retinae and choriocapillaris and resulting in permanent vision loss. OCTA is a non-invasive, rapid, and safe imaging technique that qualitatively and quantitatively analyzes blood flow from the superficial capillary plexus to the choriocapillaris, which can be predictive in the visual prognosis.

Keywords: Berlin's edema, blunt trauma, commotio retinae, microvascular damage, optical coherence angiography-angiography

Introduction

Commotio retinae (CR) is an outer retinal disturbance that follows blunt trauma to the eye and can lead to temporary or permanent loss of vision (1-5). Histopathologic studies have clarified that disruption of the photoreceptor outer segment and retinal pigment epithelium (RPE) occur due to severe trauma (1-3). Pathogenesis of CR has been suggested to be both mechanical and hemodynamic in nature. Direct mechanical forces are thought to damage photoreceptors and blood vessels in the nerve fiber layer (4,5).

Patients with CR have been traditionally examined with optical coherence tomography (OCT) that allows cross-sectional imaging of the retina. OCT-angiography (OCTA) is a recently popular non-invasive imaging technique that provides *en face* visualization of the retinal vascular networks (6,7). Therefore, OCTA is an important tool in the diagnosis and follow-up of patients with outer retinal and choroidal disorders. OCTA imaging is predictive for visual prognosis by demonstrating the damage at microvascular level.

Herein, we present a pediatric case presented with Berlin's edema secondary to blunt trauma, followed up with OCTA for acute and long-term microvascular alterations and ultimately developed foveal atrophy.

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Case Report

A 6-years-old boy who had blunt trauma to the right eye with a stick during outdoor playing had been admitted to the emergency service immediately after the injury. At first admission, best-corrected visual acuity (BCVA) could not be evaluated due to patient non-compliance, severe pain, nausea, and vomiting. Slit lamp examination showed cloudy cornea, intense anterior chamber cells, and hyphema in the right eye. Blood in the anterior chamber precluded examination of deeper intraocular structures including the fundus. Posterior segment seemed to be normal on ocular B-scan ultrasonography. Left eye examination revealed normal findings. The intraocular pressure (IOP) measured using Goldmann applanation tonometry was 35 mmHg, in the right eye. Intravenous 20% mannitol was commenced immediately and he was put on topical prednisolone acetate q3h, timolol-dorzolamide b.i.d., brimonidine b.i.d., cycloplegics t.i.d., and peroral 500 mg acetazolamide tablet b.i.d. The patient was recommended upright lying and drinking water frequently.

Two days after the trauma, his BCVA could be assessed as 0.05 in the right eye with clear cornea, mild to moderate anterior chamber reaction, clear crystalline lens, and normal IOP. However, intense Berlin's edema of the right macula was evident on OCT and OCTA imaging (TOPCON DRI OCT-1 Model Triton 3D OCT, Topcon Corp., Japan). Furthermore, OCT displayed subretinal fluid, increased reflectivity, and disruption of the photoreceptor layer and RPE of the right eye (Fig. 1a). OCTA revealed damage to the outer layers of the retinae and choriocapillary plexus (Fig. 1b). The left eye images revealed normal findings (Fig. 2). Topical nepafenac t.i.d., topical dexamethasone q.i.d., and systemic corticosteroids (24 mg prednisone daily) were started to suppress subfoveal inflammation. About 10 days after injury, BCVA of the right eye improved to 0.1 and subretinal fluid disappeared. OCT demonstrated parafoveal retinal thinning with complete loss of the outer nuclear layer and disorganization of the inner retina. Disorganization of the ellipsoid zone was prominent, which merged with the interdigitation zone and the RPE (Fig. 3a). OCTA revealed that damage to the outer retinal plexus and choriocapillary persisted, and foveal avascular zone (FAZ) was enlarged (Fig. 3b). Peroral prednisolone tablet was tapered off and discontinued. Topical eye drops were discontinued after 2 weeks. Protective spectacles for the fellow eye were prescribed.

Six months after the injury, BCVA was stable at 0.1, and OCTA showed persisted damage at the outer retinal and choriocapillary levels, as well as enlargement of FAZ (Fig. 4). At the 1st year following trauma, BCVA was 0.15 in the right eye with normal anterior segment findings and intraocular pressure. OCT revealed scar tissue with foveal atrophy. OCT-A findings persisted (Fig. 5).

Discussion

CR also known as Berlin's edema is a condition involving the outer retinal layers following blunt globe trauma, characterized clinically by a transient opacity of the retina in the macula or mid-periphery that can lead to temporary or permanent loss of vision (1-4). It can be observed directly at the posterior pole or opposite the impact zone with contrecoup mechanism. In 1873, Berlin attributed the grayish discoloration of the fundus to the extracellular retinal edema (4,8). However,

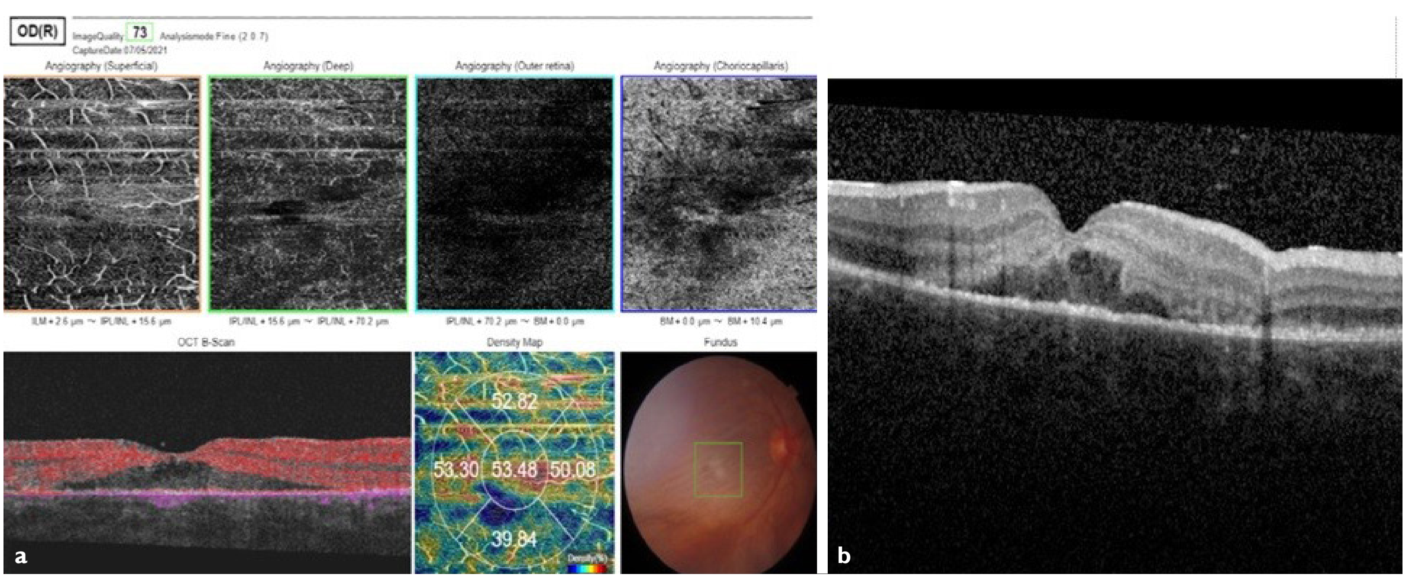

Figure 1. OCT and OCTA imaging at the 1st day after trauma to the right eye. **(a)** OCT showed the subretinal fluid and damage at the RPE level, **(b)** OCTA displayed damage at the level of superficial and deep plexuses and choriocapillaris.

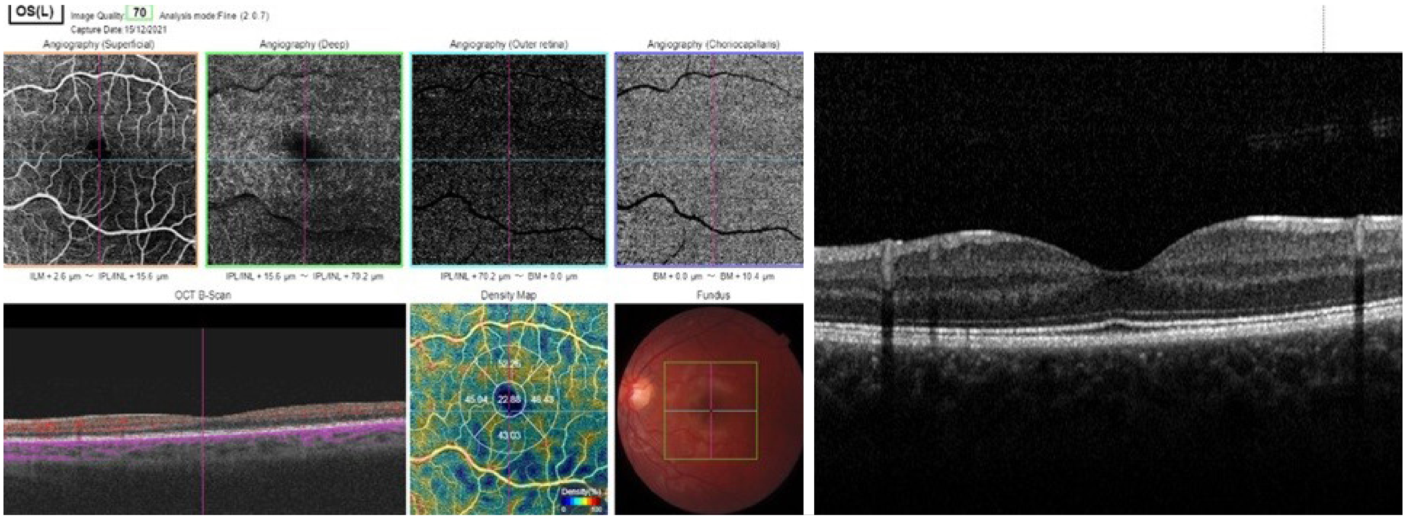

Figure 2. Left eye revealed normal findings.

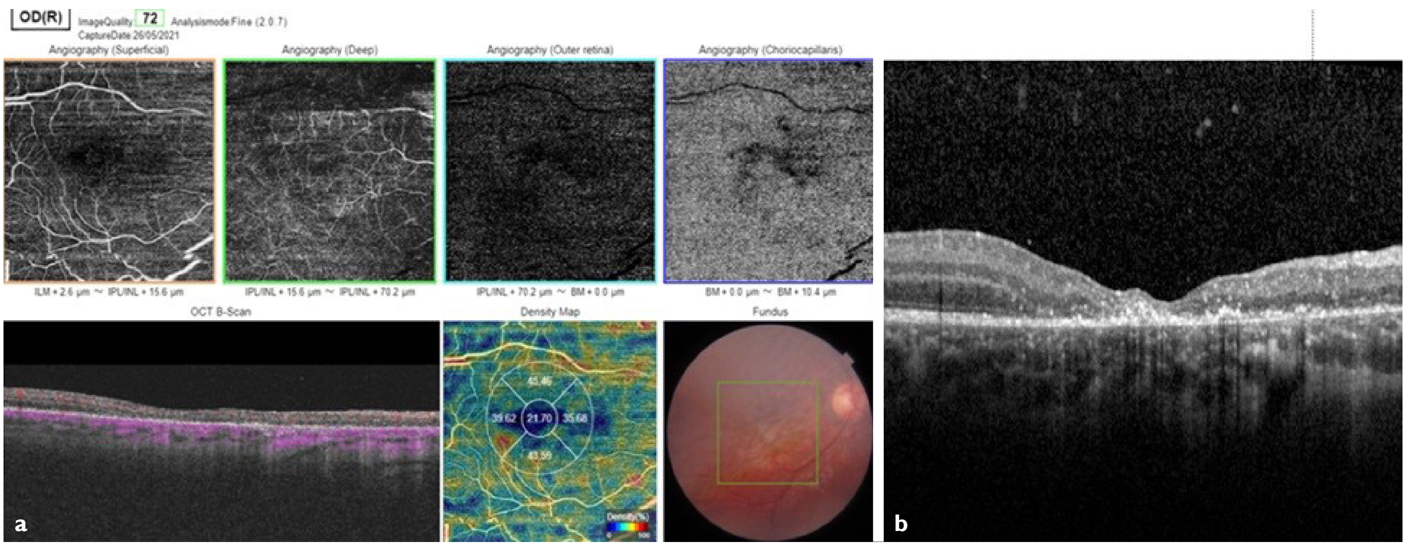

Figure 3. OCT and OCTA imaging at the 10th day after trauma to the right eye. **(a)** Foveal atrophy characterized by loss of outer retinal layers, interdigitating and ellipsoid zone disorganization, increased hyper-reflectivity; **(b)** Damaged choriocapillaris, enlargement of FAZ, and decrease in macular vessel density.

histologic investigations in animals and a human eye demonstrated that CR represents not only extracellular edema but also damage to the photoreceptors and RPE cells (3,4).

The pathogenesis of CR has been suggested to be both mechanical and hemodynamic in nature. Our findings support this hypothesis, revealing mechanical injury at the outer retinal layers by OCT and microvascular impact of the trauma at choriocapillaris by OCTA. The interface between the outer photoreceptor and RPE is a sensitive junction that is most susceptible to disruption from minor or severe blunt trauma. Direct mechanical forces can stretch the neurosensory retina at the junction of the photoreceptor outer segments which are vulnerable to blunt trauma leading to outer retinal disruption. These mechanical forces, especially after severe trauma, are transmitted to the retinal vascular plexus and choroid, triggering hemodynamic mechanisms and may cause damage at the microvascular level (4,5,8,9,10). In addition, Sipperley et al. (1) reported active phagocytosis of the fragmented outer segment 24 h after trauma. Intraretinal hyper-reflexive aggregates visible in spectral domain OCT of severely affected areas may represent clusters of these RPE cells. Later, total loss of the outer segment photoreceptors was observed in those areas, seen as thinning of the outer plexiform and outer nuclear layers (1,10,11).

OCT is an important diagnostic tool to demonstrate anatomical and morphological alterations in CR (2,4,10,11). Ahn et al. (10) divided CR severity into four grades useful also in predicting visual outcomes: Increase in inner segment-outer segment (IS-OS) junction reflectivity with disappearance of the thin hyporeflective optical space (grade 1), defects

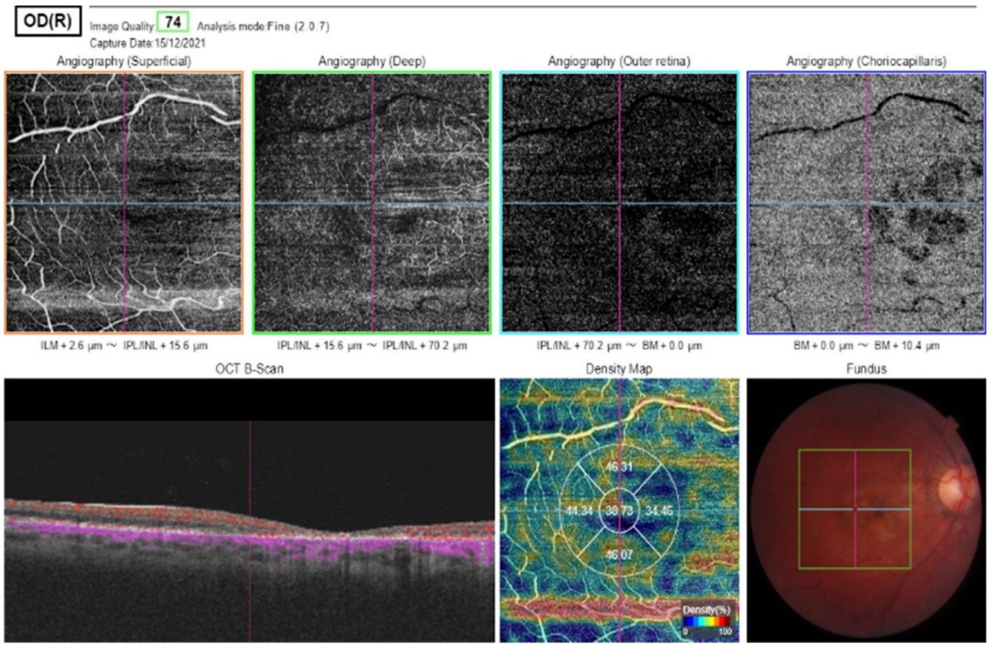

Figure 4. OCT and OCTA imaging at the 6th month after trauma to the right eye. Damage to the superficial and deep plexuses and choriocapillaris persisted.

only at the cone OS tips (grade 2), defects at cone OS tips and IS-OS junction (grade 3), and defects at cone OS tips, IS-OS junction, and external limiting membrane (grade 4). Eyes with higher grades at baseline had significantly worse visual and anatomic outcomes. Loss of the IS-OS junction with photoreceptor mitochondrial atrophy is an important milestone for permanent loss of vision (8,10).

OCTA is a fast, safe, and non-invasive diagnostic technique that provides images based on variable backscattering of light from vascular and neurosensory tissue in the retina. It provides detailed and three-dimensional (3D) imaging of superficial and deep capillary plexus, outer retinal circulation, and choriocapillaris layer by obtaining and processing the motion contrast of the erythrocytes in the vessel with successive OCT scans. OCTA allows construction of 3D microcirculation vascular maps of the retina and choroid without the use of exogenous stains. This tool allows for detailed analysis of the retinal perfusion damage in macular and papillary regions that may appear even in the absence of retinal structural loss (5-9).

Both OCT and OCTA played an important role in the diagnosis and follow-up of our case after blunt trauma. In the acute phase, subretinal fluid is observed on OCT, while severe disorganization in the outer retinal layers in the following visits: OCT showed increased hyper-reflectivity, foveal atrophy, disruption of the photoreceptor layer, and RPE.

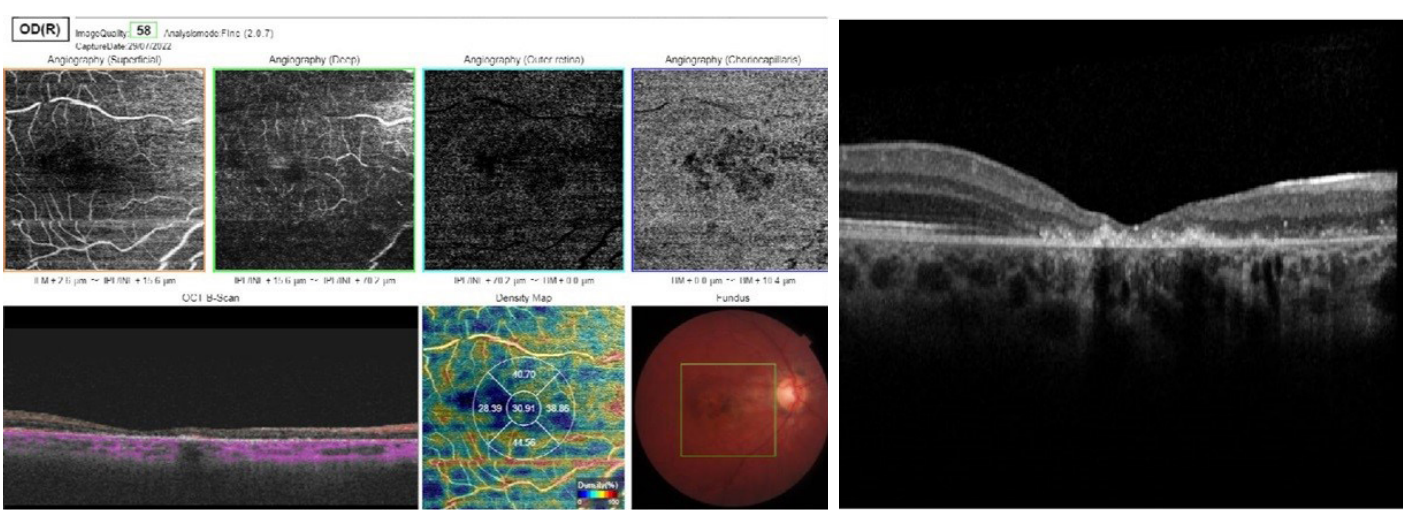

Figure 5. OCT and OCTA imaging at the 1st year after trauma to the right eye. OCT revealed scar tissue with foveal atrophy, OCTA findings persisted.

In addition to mechanical damage, there was also involvement at the level of microvascular capillary plexus (5,8,9). OCTA demonstrated enlargement of FAZ and damage at the level of choriocapillaris, including superficial and deep plexi at acute and long term. Density of vessels in the macula and the size of FAZ are known to be important determinants of visual acuity.

In our case, Berlin's edema developed due to blunt trauma in the early period, as well as hyphema and anterior chamber reaction. These anterior segment findings also had an effect on the early visual acuity reduction. Anterior segment findings regressed with medical treatment. We observed that the visual acuity was 0.1 at 6^{th} month and 0.15 at 1^{st} year following trauma, and the microvascular damage detected by OCT-A stabilized with permanent deterioration in OCT parameters. At the 1^{st} year examination, OCT revealed scar tissue with foveal atrophy and OCTA findings persisted. Development of foveal atrophy with scar tissue and damage at microvascular plexus can be considered as the main factors in long-term poor visual prognosis in our case. Topical, systemic, and even intravitreal steroids may fall short in reversing the pathological process and preserving functional vision.

Visual prognosis is related to the severity and location of retinal damage. At the same time, a variety of posterior and anterior segment pathologies and secondary complications have been reported to result from blunt ocular trauma and have negative impact on visual and anatomical prognosis (12-14). Anterior segment lesions including corneal erosion, microhyphema (blood cell Tyndall) or hyphema, and iris sphincter rupture may accompany CR. Angle recession and IOP elevation are common findings in eyes with blunt traumatic injury. Monitoring IOP should be continued long after the initial episode to detect post-traumatic glaucoma (13-15). Prognosis is generally good with recovery of vision within 3–4 weeks. However, poor visual prognosis and permanent loss of vision can be observed in severe cases resulting in foveal atrophy accompanied by microvascular damage, as in our case. It has been hypothesized that in severe cases, concussive force is transmitted to the retinal vascular plexi and the choroid, inducing a vasogenic response, which possibly causes arterial spasm and reduced blood flow. Depending on trauma severity, these microvascular alterations may lead to enlargement of FAZ and reduced vessel density. In addition, as the outer retina and FAZ also depend on diffusion from choroidal circulation, its compromise may contribute to additional ischemic damage in the vulnerable ellipsoid and interdigitation zones and permanent visual acuity loss (5-7,16).

Retinal vascular damage may accompany Berlin's edema, especially in pediatric cases. OCTA demonstrates retinal vascular changes such as FAZ enlargement and decreased vessel density and damage to choriocapillary plexus; the extent of those microvascular alterations is possibly related to trauma severity (5). Mansour and Shields et al. (8) showed no microvascular alterations in superficial capillary density and FAZ by OCTA, in a case after tennis ball injury, probably due to the fact that the examination was performed 24 h after trauma and it lacked the phase of vascular spasm choroidal vascularization. Wangsathaporn and Tsui (17) revealed no retinal perfusion defects on OCTA in two patients affected by CR following rubber band injuries, despite OCT was performed after 1 year of persistent defects of the outer retinal layer. Papageorgiou et al. (5) revealed that pediatric CR may be associated with retinal vascular changes. Two cases of CR in pediatric patients showed an enlargement of FAZ, 12 h after injury and, in severe cases, also a reduction of the superficial foveal capillary density after 11 months. Montorio et al. (9) used OCTA to demonstrate that the impairment of the retinal microvasculature and its progressive changes over time occurred even in the absence of compromised visual acuity. Yeter et al. (18) evaluated retinal vascular changes and FAZ after blunt trauma in 50 patients with OCTA and found a significant decrease in vascular density in deep capillary plexus in eyes (10%) with CR after blunt trauma, even without significant fundus and OCT findings.

Conclusion

In our case, OCT revealed permanent damage to the outer retinal layers and RPE level and foveal atrophy, while OCTA showed damage at the choriocapillaris level, decrease in vascular density, and enlarged superficial FAZ. Our findings support that pediatric CR may be associated with retinal and choroidal microvascular alterations. The extend of these alterations seems to be correlated to trauma severity and is a good indicator of visual prognosis. OCTA seems to be an important tool in the diagnosis and determination of the severity of the injury.

Disclosures

Informed consent: Written, informed consent was obtained from the patient's family for the publication of thís case report and the accompanying images.

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Conflict of Interest: None declared.

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