Case Report

Retinal evaluation by fundus angiography before and after vitrectomy and foreign body removal in a patient with ocular siderosis: a case report

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Background: Ocular siderosis (OS) is a rare severe complication arising from retained iron-containing intraocular foreign bodies. In the young male patient reported in this paper, the intraretinal diffusion and distribution of siderotic particles before and after the removal of the foreign body were observed via fundus angiography (FA).

Case Description: A 33-year-old decoration worker was diagnosed as the absolute stage of right eye glaucoma in the local hospital and was treated with cataprolol and brinzolamide eye liquid to reduce intraocular pressure. The symptoms did not improve. He came to our hospital for treatment. He was finally diagnosed with "foreign body, siderosis, and secondary glaucoma in the right eye" based on eye examinations. According to the observation via fundus fluorescein angiography (FFA), indocyanine green angiography (ICGA), grade 2–3 vascular occlusion extended in a gradient along the foreign body, there was no retinal perfusion in the temporal retina, the siderotic particles were distributed along the artery, and inflammatory changes occurred in the optic nerve and retinal vein. He underwent pars plana vitrectomy, foreign body removal, retinal laser photocoagulation, silicone oil filling and pressure reducing valve implantation. Silicone oil was removed three months later. The postoperative visual acuity was not improved, the intraocular pressure was well controlled, and there was concurrent cataract, but it did not affect the fundus examination. At 3 and 10 months after operation, the fundus angiography showed that the particles distributed along the artery decreased, the inflammation of optic nerve and retinal vein subsided, and the laser spots in the non perfusion area were clear.

Conclusions: The influence of iron ion on retinal vein and the distribution of iron ion along retinal artery can be seen macroscopically by FA before and after foreign body removal.

Keywords: Ocular siderosis (OS); fundus angiography (FA); case report

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Introduction

Ocular siderosis (OS) refers to a series of degenerative ocular changes such as retinopathy, cataract, and secondary glaucoma induced by the progressive deposition of iron ions and the formation of hydroxyl radicals due to ferrous foreign bodies retained in the eyes (1). In general, such injuries occur during metal hammering or grinding, so males are more susceptible to OS.

Ultrasonography, though a safe and noninvasive imaging tool, should be used with caution when examining open ocular traumas. Intraocular foreign bodies can be diagnosed by pure

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X-ray plain films, while computed tomography (CT) is best at identifying the existence and three-dimensional location of foreign bodies (2). As one of the most common means of detecting ocular pyrite, the electroretinogram can evaluate the overall retinal function, with such characteristic changes as the decline of b waves and the b wave/a wave ratio (3).

Since the optical media of the eye generally become very blurred after injuries, fundus lesions can be hardly observed with the naked eye, and fundus angiography (FA) characteristics have been rarely reported. Shaikh *et al.* (4) performed fluorescein angiography in a patient with OS and found extensive capillary non perfusion. They believe that this manifestation may be related to the retention of intraocular iron foreign bodies. Faure *et al.* (5) observed a patient with OS through fundus fluorescein angiography (FFA) in 2014 and revealed the arterial trend distribution of iron particles. With the passage of time, the number of particles decreased, which they believe may be related to the activity of macrophages. In this paper, one male patient suffered from a ferrous intraocular foreign body incurred during hammering 1 year ago. He did not see a doctor soon given no inflammatory signs, decreased visual acuity, or pain in the eye. As the patient had transparent optical media, which enabled us to conduct preoperative and postoperative follow-up through FA, and macroscopically see the manifestations of siderosis in the retina before and after foreign body removal, including large areas without perfusion, the distribution of iron ions along the artery and the gradual regression of retinal vein inflammation. We present the following case in accordance with the CARE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1114/rc).

Case presentation

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Patient information

A male patient aged 33 years old was a decoration worker. He was subjected to swelling pain in the right eye concurrent with loss of vision for 20 days. He was diagnosed with "glaucoma in the right eye" in a local hospital. The patients were treated with cataprolol and brinzolamide eye liquid to reduce intraocular pressure. The symptoms did not improve, and he was hospitalized in our hospital on February 3, 2021.

Clinical findings

Ophthalmic examination: The left vision was 1.0, without abnormality in the anterior or posterior segment. There was no light perception in the right eye, mild conjunctival congestion, and growth of corneoscleral conjunctival scar at the nasal side into the cornea by 1 mm (*Figure 1A*). In addition, mild corneal edema, normal anterior chamber depth, Tyndall's sign (+), pupil diameter of 4.5 mm, light reflection (–), and a perforation on the peripheral iris corresponding to the conjunctival scar at 3 o'clock were observed (*Figure 1B*). In addition, clear lens, vitreous opacities, and pale fundus optic nerves [cup-to-disc ratio (C/D) =0.9] were detected, which indicated typical optic nerve changes in advanced glaucoma. An organized wrappage with a size of approximately 1 optic disc was seen at the supratemporal vascular arcade, vascular occlusion was observed on the retina where the wrappage was located, and many particles were deposited on the retinal surface (*Figure 2*).

Diagnostic assessment

Gonioscopy showed that the bilateral anterior chamber angles were open, and pigment granules were deposited in the trabecular meshwork of the right eye. B-mode ultrasound revealed vitreous opacity and the shadow of a metal foreign body at the posterior pole of the right eye (*Figure 3*). According to ultrasonic biomicroscopy (UBM), the bilateral anterior chamber angles were open, and a perforation on the peripheral iris was observed at 3 o'clock in the right eye (*Figure 4*). In the CT image, a metal foreign body existed in the right eyeball (*Figure 5*). As seen by optical coherence tomography (OCT) (*Figure 6*), the foreign body was wrapped by tissues, accompanied by edema of peripheral retina and dot-like high reflection in the deep and shallow retinal tissues. The patient had already lost vision in that eye when diagnosed, and no waveform was found in the electroretinogram examination. According to the eye and imaging examinations, a definite diagnosis was made as follows: foreign body, siderosis and secondary glaucoma in the right eye. During our inquiry about his history of ocular trauma, the patient complained that a

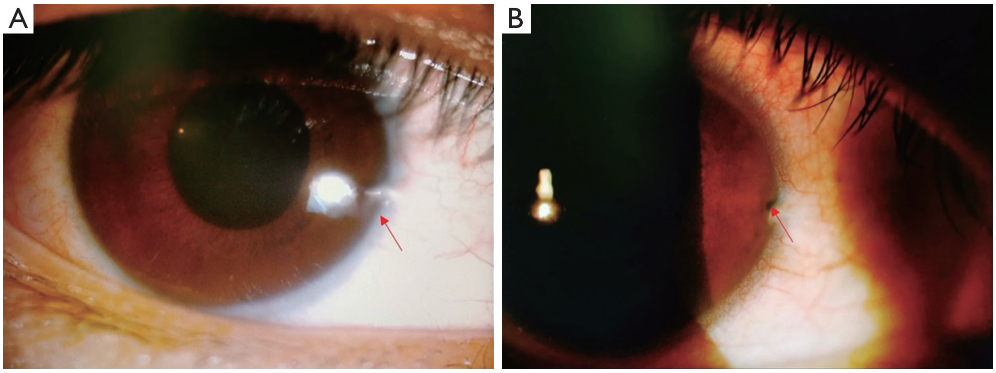

Figure 1 The anterior segment of the patient's right eye was photographed. (A) A corneal limbal conjunctival scar (arrow) at 3 o'clock at the nasal side together with mydriasis in the anterior segment image. (B) A perforation on the peripheral iris (arrow) at 3 o'clock.

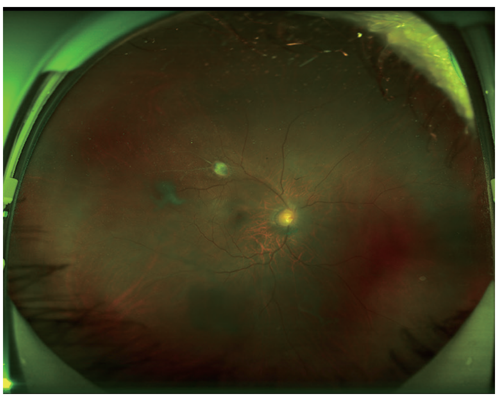

Figure 2 Wrapped intraocular foreign body concurrent with vascular occlusion on the fundus image.

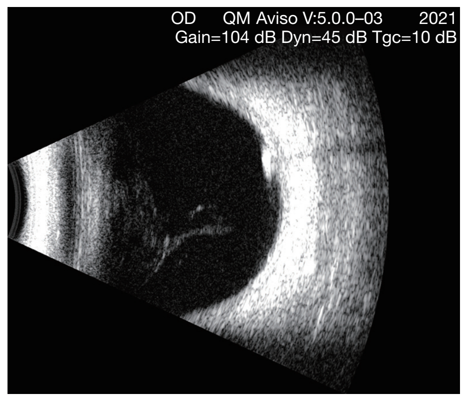

Figure 3 Vitreous opacities and intraocular foreign body found on B-mode ultrasonic examination.

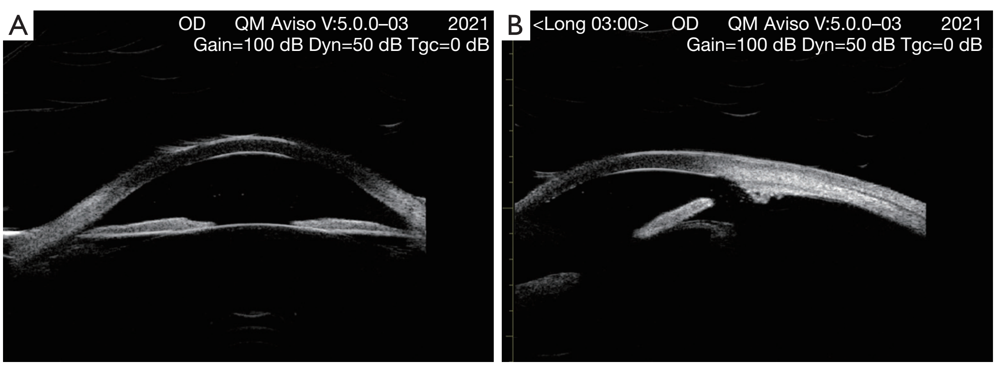

Figure 4 Ultrasound biomicroscopic image of the right eye: the open right atrial angle (A) and the peripheral iris perforation at 3 o'clock (B).

foreign body splashed into his right eye when knocking a metal object while working as a decorator 1 year earlier. He felt slightly uncomfortable at that time, which was relieved after rest, without eye pain or decreased visual acuity, so he did not go to a doctor. Considering the transparent optical media in his right eye, we performed FFA on February 4, 2021 (*Figure 7*). The FFA of the right eye showed that at the supratemporal vascular arcade, grade 2–3 vascular occlusion extended in a gradient along the foreign body, with a large nonperfusion region. Massive dot-like blocked fluorescence on the retinal surface, blurred optic disc boundary in the advanced stage, stained veins, fluorescein leakage, and inflammatory manifestations of the optic nerves and veins were observed. Indocyanine green angiography (ICGA) suggested that the foreign body persisted till the advanced blocked fluorescence, during which a large amount of dot-like weak fluorescence was distributed along the retinal artery.

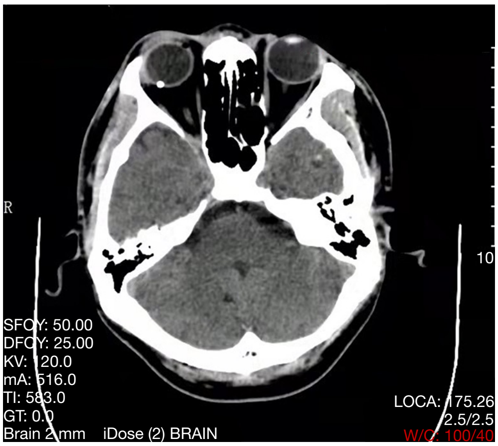

Figure 5 CT tip: metal foreign body in the right eyeball. R, right; CT, computed tomography.

Therapeutic intervention

On February 4, 2021, the patient underwent FFA and ICGA for the first time;

On February 5, 2021, pars plana vitrectomy (PPV), removal of the foreign body, retinal photocoagulation, silicon oil injection, and glaucoma valve implantation were performed.

Silicon oil removal was done on the right eye on May 12, 2021.

Fundus angiography was rechecked twice on June 15, 2021 and December 14, 2021.

Timeline of FFA, ICGA examination and surgical treatment (*Figure 8*).

Figure 6 OCT: foreign body was wrapped by tissues, accompanied by edema of the peripheral retina (A) and dot-like high reflection in the deep and shallow retinal tissues (B). OCT, optical coherence tomography.

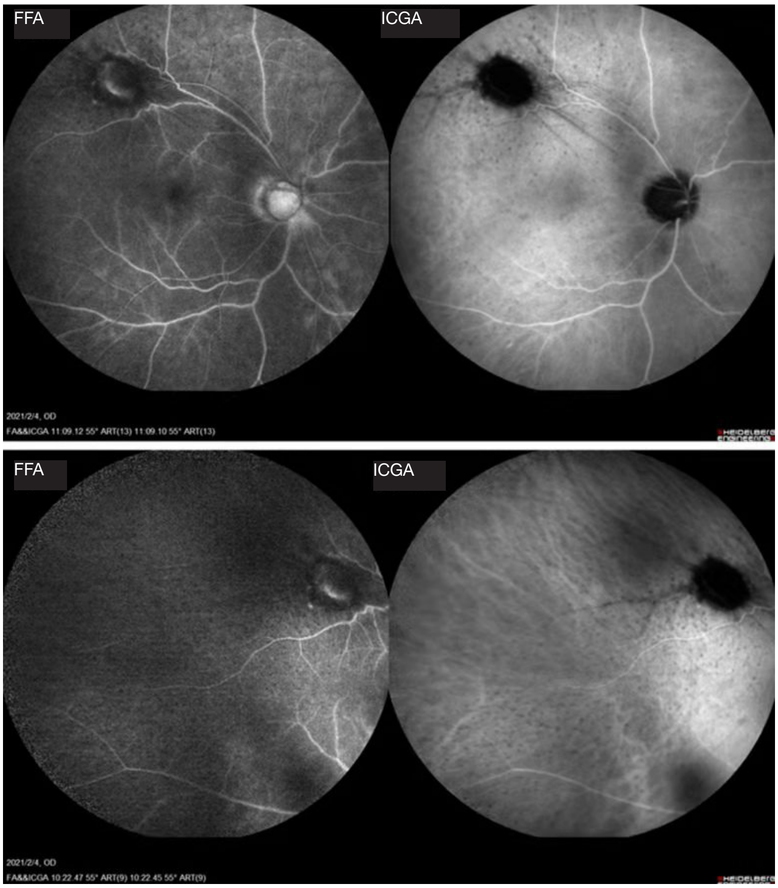

Figure 7 Before PPV, right-eye FFA: grade 2-3 vascular occlusion at the supratemporal vascular arcade extending in a gradient along the foreign body, a large nonperfusion region, massive dot-like blocked fluorescence on the retinal surface, blurred optic disc boundary in the advanced stage, stained veins, and fluorescein leakage; right-eye ICGA: foreign body persisting till the advanced blocked fluorescence, and massive dot-like weak fluorescence distributed along the retinal artery. PPV, pars plana vitrectomy; FFA, fundus fluorescein angiography; ICGA, indocyanine green angiography.

Follow-up

The postoperative visual acuity was not improved, the intraocular pressure was well controlled, and there was concurrent cataract, but it did not affect the fundus examination. Fundus angiography was reviewed on June 15, 2021 and December 14, 2021 (*Figure 9A,9B*). FFA exhibited supratemporal vascular occlusion in the right eye, and the laser was distinct on the retinal surface. In addition, the optic disc boundary was clear, and there was no fluorescein staining or leakage in the retinal vein, implying the inflammation had resolved. ICGA showed that dot-like weak fluorescence was still distributed along the artery, but there was less of it than before operation. FFA displayed visible patchy fluorescein staining beside the optic disc and in the macular region. ICGA presented patchy blocked fluorescence at the corresponding part during FFA, representing the intraoperative injury of retinal tissues (arrows in *Figure 9A,9B*).

Discussion

This paper reports a male patient who had a history of hammering iron foreign bodies one year ago. At that time, there were no inflammatory signs in the eyes, no symptoms such as vision loss and pain, and did not seek medical treatment in time. One year later, he became blind in the right eye and was diagnosed as “foreign body in the right eye, rust disease in the right eye and secondary glaucoma in the right eye”. Fundus angiography was followed up before

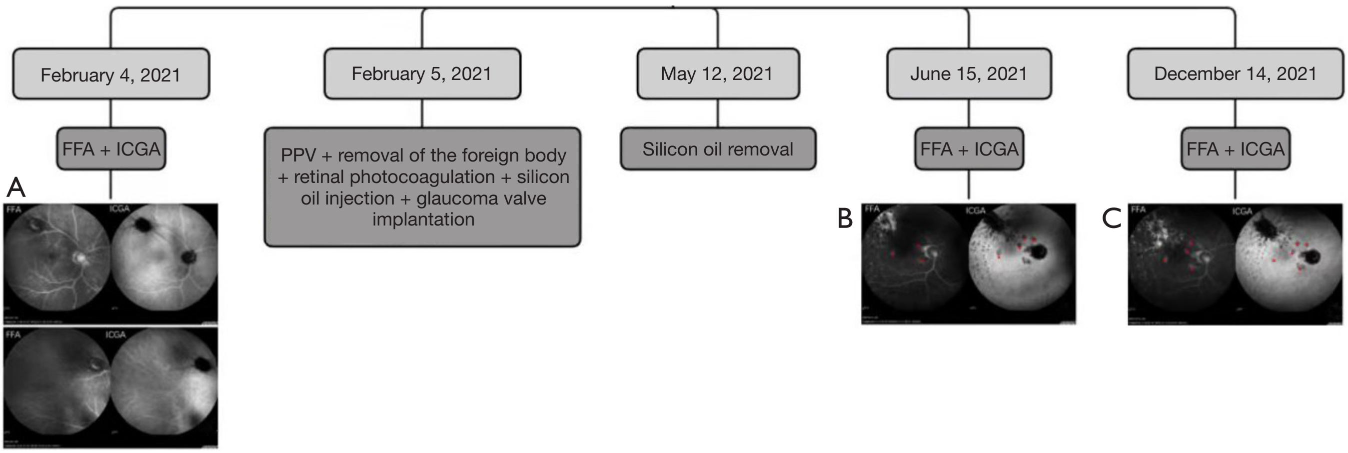

Figure 8 Timeline of FFA, ICGA examination and surgical treatment. (A) Before PPV, right-eye FFA and ICGA. (B) Three months after PPV, right-eye FFA and ICGA. (C) Ten months after PPV, right-eye FFA and ICGA. PPV: pars plana vitrectomy; FFA, fundus fluorescein angiography; ICGA, indocyanine green angiography.

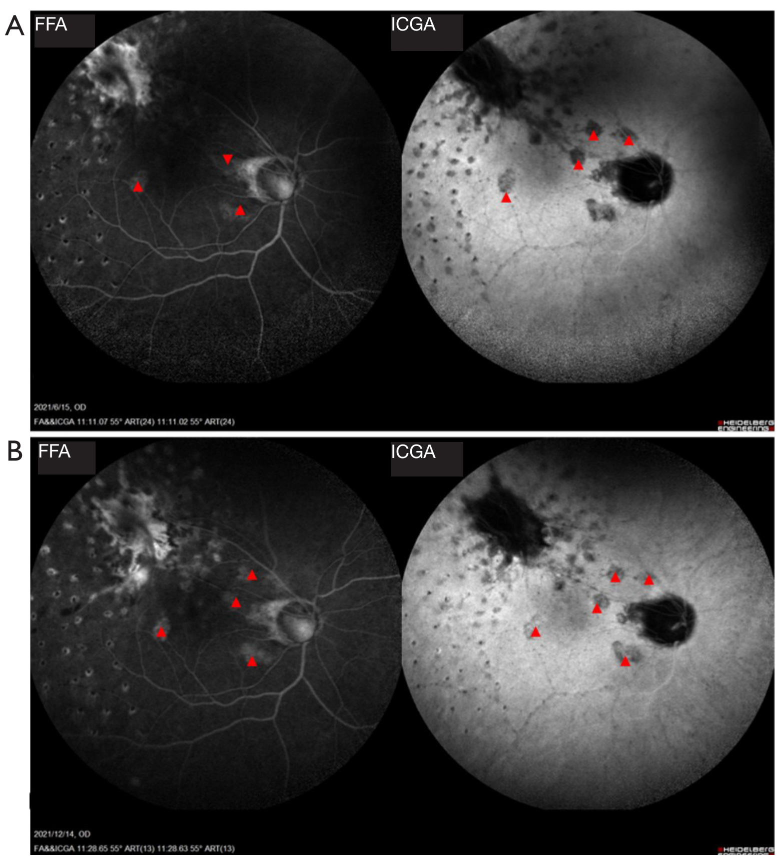

Figure 9 Three (A) and 10 (B) months after PPV, right-eye FFA: supratemporal vascular occlusion, distinct laser on the retinal surface, clear optic disc boundary, and no fluorescein staining or leakage in the retinal vein; right-eye ICGA: distribution of dot-like weak fluorescence along the artery blood vessel, but less than that before the operation; FFA: visible patchy fluorescein staining beside the optic disc and in the macular region; ICGA: patchy blocked fluorescence at the corresponding part during FFA, representing the intraoperative injury of retinal tissues(shown by the red triangle). PPV, pars plana vitrectomy; FFA, fundus fluorescein angiography; ICGA, indocyanine green angiography.

and after operation. It was found that there were large non perfusion areas in the retina, as well as the distribution of iron ions along the artery and the gradual regression of retinal vein inflammation after operation.

In a review published in 2020, Casini *et al.* (1) divided the action mechanism of siderosis upon intraocular tissues into two types: "direct siderosis" close to intraocular foreign bodies and "indirect siderosis" distant from foreign bodies. In the former case, free iron ions promote the formation of oxygen free radicals through redox reaction. In turn, such free radicals damage the intraocular tissues by inactivating enzymes and repressing rhodopsin regeneration. Indirect siderosis, also called vascular hemosiderosis, is characterized by retinal vascular damage, which can induce toxic ocular microangiopathy and uncontrolled macrophage activity. If initiated, the two action mechanisms will lead to serious ocular complications such as heterochromia iridis, cataract, glaucoma, optic neuropathy, retinal chromatosis, and proliferative vitreoretinopathy.

Thanks to advanced imaging technologies, well-developed vitreous surgical instruments, and increasingly mature surgical techniques, intraocular foreign bodies can be diagnosed in the early stage of a trauma and removed quickly, so siderosis induced by the retention of foreign bodies has become rarer (6,7).

Fundus retinal siderosis is hardly observable due to the opacities of optical media after a trauma. This patient was not subjected to corneal injury or lenticular opacities. Although the vitreous body was opaque, it did not influence the retinal observation, and FFA could be performed to observe the exact distribution of iron particles on the retina.

Retinal ischemia occurs most obviously at the location of the foreign body itself (8). In this case, FFA showed grade 2–3 vascular occlusion extending in a gradient along the foreign body and a large nonperfused region in the bitemporal retina. Cibis *et al.* (9) proposed that the siderosis-induced retinal vascular occlusion may be explained by two hypotheses: First, iron ions bind to perivascular siderophilic substances (acid mucopolysaccharides). Second, ocular cytological changes result from iron absorption by the cytoplasm of endothelial and epithelial cells. Saad *et al.* (4) also observed retinal vascular occlusion without perfusion in a siderosis case, and they thought that such an ischemia manifestation may correspond to the toxicity diffusion gradient of ferrous foreign bodies.

According to previous research findings (1,10), iron has affinity for acid mucopolysaccharides, which are one of the main components of vascular adventitia. Iron particles are mostly deposited along the blood vessels. Hope-Ross *et al.* (11) also argued that toxic microangiopathy may be caused by perivascular deposits. In this case, however, we definitely observed via FFA that iron particles presented a deposition trend along the artery, without any inflammatory response. In contrast, fluorescein staining and leakage in veins occurred in the late stage of FFA. After the foreign body was removed, fewer iron particles were distributed along the artery, accompanied by the evident mitigation of inflammation in the optic disc and vein, which was confusing: Why does venous inflammation occur when particles are mostly gathered beside the artery? There is considerable evidence that (10,12) little or even no iron accumulates in the most seriously damaged tissues, while the undamaged tissues may be susceptible to massive iron accumulation. A possible reason is that Prussian blue only stains ferric ions, but the damage of tissues seems to arise from ferrous ions. As a kind of reducing agent, ferrous ions can permeate into surrounding tissues, interact with important enzymes, damage cellular structures, and further lead to anatomical and functional disorders (13). Iron ion-induced oxidative damage is the primary pathogenetic mechanism of OS. The Haber-Weiss reaction details the transformation process of ferric ions and molecular oxygen free radicals into hydroxyl radicals, as strong oxidants (8):

$$Fe^{3}+O_2^{-} \rightarrow Fe^{2+}+O_2 \quad [1]$$

$$Fe^{2+}+H_2O_2 \rightarrow Fe^{3+}+OH+OH^{-} \quad [2]$$

Such a reaction can be promoted indefinitely only by a small quantity of ferric ions serving as the catalyst. In this study, the particles deposited on the retinal surface were wrapped by a monolayer film, as observed under a high-power lens (14). It was speculated that many ferric ions existed in the particles deposited adjacent to the artery, which were stable since they were wrapped by the film. Ferrous ions with bioactivity led to inflammatory responses in the vein and optic nerve. Moreover, iron ions were violently released in a large quantity due to the intraocular foreign body. When the foreign body was removed, the ferric ions serving as the catalyst were absent, and the Haber-Weiss reaction was no longer promoted infinitely, so the intraocular inflammatory response was relieved.

During the 10 months of follow-up after operation, FFA showed far fewer weak fluorescent spots distributed along the artery, which was correlated with the phagotrophic activity of retinal pigment epithelium (RPE) and macrophages (5,15).

Conclusions

A rare OS was recorded by FA in this case. The inflammation of the retinal vessel and optic nerve were relieved after operation, and the intraretinal diffusion and distribution of iron particles were especially captured. This patient missed the optimal window for treatment and lost vision in his right eye in the end, warning us that clinicians should take each suspicious case seriously. Ocular trauma should be carefully examined to eliminate intraocular foreign bodies (IOFBs). IOFBs may be retained or misdiagnosed for a long time when patients do not pay attention to or receive medical treatment, but most patients will have visual impairment. As an ophthalmologist, in this case, careful examination and timely treatment are needed. Timely removal of foreign bodies is the fundamental to save the patient's visual function.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-1114/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1114/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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