12 Ocular Perforating Injury

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Abstract

Ocular perforating injuries can cause significant vision loss and have worse prognosis than ocular penetrating injuries. However, it is difficult to distinguish one from another of these two kinds of open globe injuries in daily clinical practice. Comparing with ocular penetrating injuries, ocular perforating injuries are more challenging to manage due to the possible involvement of the whole eye and the inaccessible locations of the exit wound. Proper evaluation of the extent of the injury based on both trauma history taking and examinations and planning a surgical strategy is a key element for management of such patients. This chapter includes five cases with brief descriptions, illustrating figures and personal tips and tricks, aiming to provide a guide about diagnosis and management of ocular perforating injuries.

Keywords

Ocular perforating injury · Vitrectomy
Posterior exit wound · Foreign body

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12.1 Introduction

The ocular perforating injury (OPI) refers to an ocular injury with an entry and exit wound caused by a single object [1, 2]. It was also known as double-penetrating injury which had been replaced by perforating injury because the former term is not adequately specific as it may also be used to describe wounds caused by two foreign bodies that enter but do not exit the globe. The ocular perforating injury is usually caused by high-speed moving objects such as iron, steel, and glasses, and males were predominantly affected in relation to males' hyperactive behavior and work preferences [3, 4]. Comparing to other types of open global injuries, OPI has relatively lower incidence which was 2.45% and 2.93% in the epidemiology studies of open global injuries done in Egypt and Australia, respectively [5, 6]. It has been demonstrated that perforating injuries have significantly worse prognosis than blunt traumas, as any structure of the anterior segment to the posterior segment could be involved [7, 8]. For instance, corneal/scleral laceration, hyphema, traumatic cataract, vitreous hemorrhage, retinal detachment, epiretinal/subretinal hemorrhage, suprachoroidal hemorrhage, endophthalmitis, and proliferative vitreoretinopathy caused by the delayed effects of intraocular cellular proliferation could be found in OPI. The development of pars plana vitrectomy (PPV) has

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become the optimal treatment for such patients and prevented the injured eye being enucleated [9–11]. Proper specialized interventions of the lesions especially the exit wound are crucial to good visual prognosis [12].

12.2 Case #1: The Eye Hit by a Piece of "Steel"

12.2.1 Case Description

A 23-year-old male steelworker presented with a painful eye at the emergency room of Tianjin Medical University General Hospital 18 h after his right eye was hit by a piece of "steel." The right eye had no light perception. A 15-mm-long partial-thickness laceration was noticed on the upper eyelid of the right eye, penetrating through the muscular layer with still functional levator palpebrae superioris muscle. Conjunctiva was hyperemic and swollen. An irregular 8 mm full-thickness laceration was seen from 3 to 7 o'clock in the cornea. Other structure of the injured eye was blocked by dense hyphema. The intraocular pressure was low (T-2). The axial and coronal computed tomography (CT) scans of the orbit revealed a roundish high density foreign body located posterior to the eyeball (Fig. 12.1), which indicated ocular perforation injury. Surgical repair of the cornea and upper eyelid was arranged immediately after all the ocular examinations were done. One day after the surgery, the patient gained light perception vision. Ten days after surgery, the injured eye reached a relatively stable condition with a diagnosis of traumatic cataract, traumatic hyphema, traumatic vitreous hemorrhage, proliferative vitreoretinopathy, and intraorbital foreign body caused by the ocular perforating injury based on slit lamp examination (Fig. 12.2), B ultrasound (Fig. 12.3), and CT (Fig. 12.4). For further treatment of this eye, the

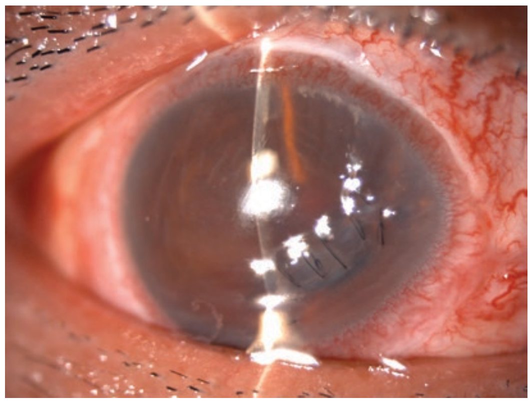

Fig. 12.2 The slit lamp examination of the right eye 10 days after the primary repairing surgery showing conjunctival hyperemia, the suture of the entry wound on the swollen cornea, hyphema, and traumatic cataract

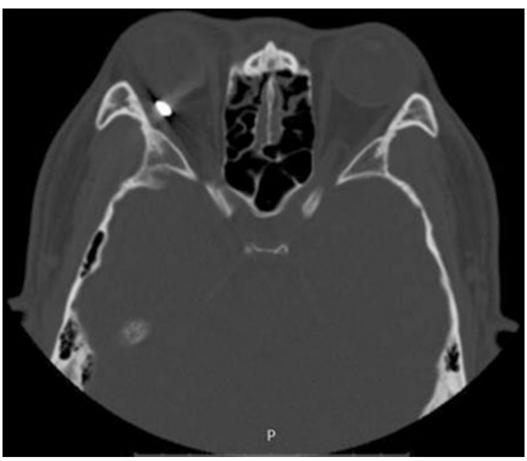

Fig. 12.1 The CT scan acquired 18 h after trauma showing the roundish metal foreign body located just behind the posterior wall of the eye with air surrounded and the irregular shape of the eyeball

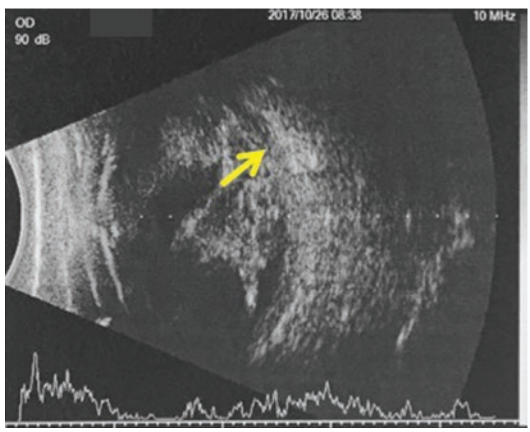

Fig. 12.3 The B-scan ultrasounds of the right eye acquired 10 days after the primary surgery which show incarceration of substance with irregular shape and strong echo around the possible exit wound

lensectomy-vitrectomy combined with silicone oil injection was performed under general anesthesia. During the surgery, the exit wound was observed located next to the fovea superior temporally (Fig. 12.5). One day after the lensectomy-vitrectomy, the patient gained counting finger vision at the temporal visual field of the right eye. With the cornea edema (Fig. 12.6) and epiretinal and subretinal hemorrhage resolving gradually, the fundus and healed wound were visualized 8 days after vitrectomy (Fig. 12.7). Three months after vitrectomy, the patient gained the best corrected visual acuity (BCVA) as 0.1 and intraocular pressure (IOP) as 17 mmHg. The exit wound was healed

Fig. 12.4 The CT scan taken 10 days after the primary surgery showing the metal foreign body still located posteriorly from the eyeball with the resorption of the air around it and no infection sign was observed

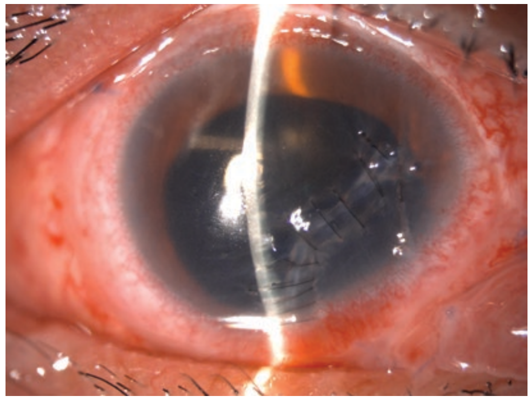

Fig. 12.6 The slit lamp examination of the right eye 8 days after the vitrectomy showing conjunctival hyperemia, the suture of the entry wound on the less swollen cornea, clear anterior chamber with a normal depth, dilated pupil, and aphakia

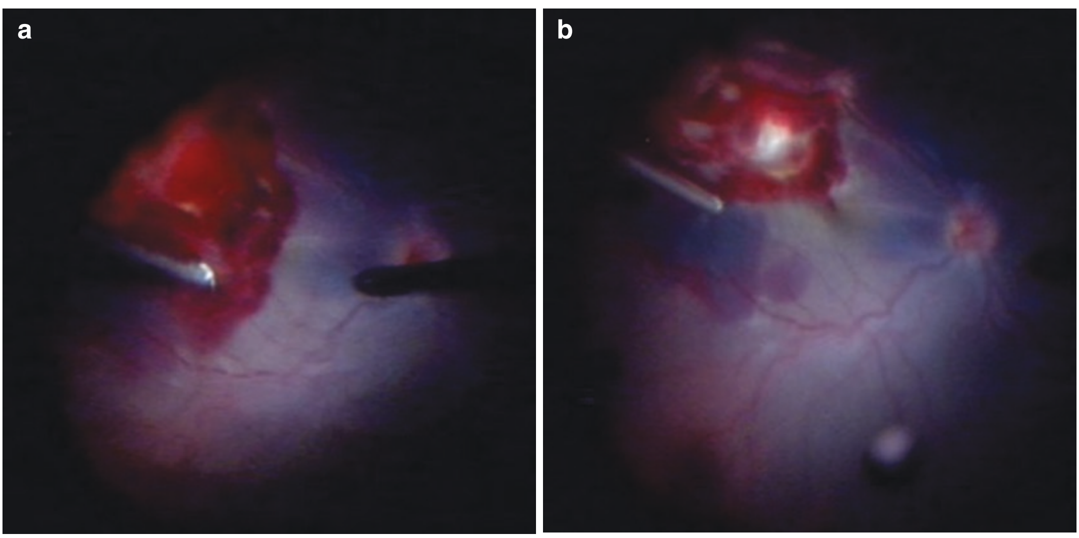

Fig. 12.5 The screenshot of the right eye's fundus during vitrectomy. (**a**) The exit wound involved the superior temporal part of the macula and was covered by hemorrhage. (**b**) After removing part of the blood around the wound, it was found that the wound hardly spared the fovea, and the subretinal hemorrhage can be noted inferior to the wound. The wound was like a volcano: the base was the healed scleral exit by fibrosis tissue, and crater was damaged retina and choroid tissue with coagulated blood

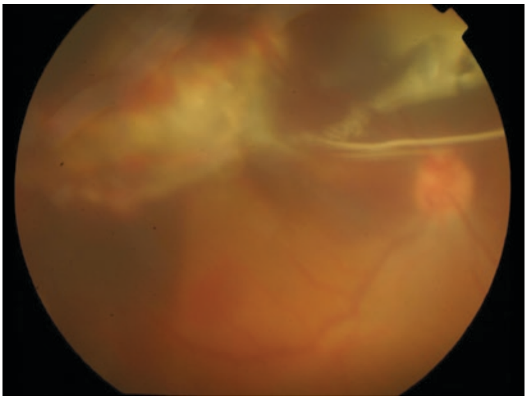

Fig. 12.7 The color fundus image of the right eye 8 days after vitrectomy showing the fibrosis tissue surrounding the wound and subretinal hemorrhage

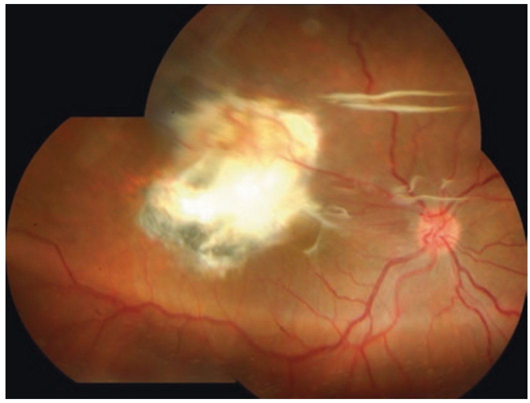

Fig. 12.9 The color fundus image of the right eye 5 months after vitrectomy showing scar at the posterior wound with pigment changes and attached retina surrounding the wound

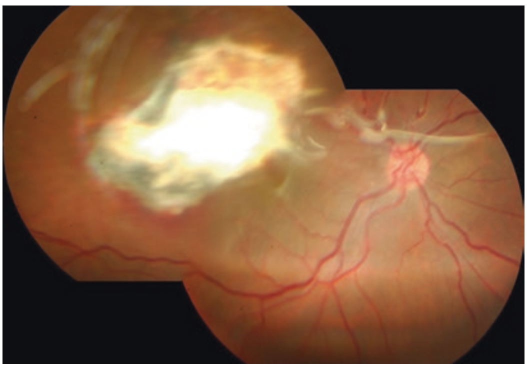

Fig. 12.8 The color fundus image of the right eye 3 months after vitrectomy showing the resolved subretinal hemorrhage and scar forming at the posterior wound with pigment changes and attached retina surrounded

well with the scar tissue, and no retinal detachment was noticed (Fig. 12.8). Five months after vitrectomy, the eye still remained stable with the BCVA as 0.1, IOP as 16 mmHg, and retina surrounding the exit wound well attached (Fig. 12.9).

12.2.2 Tips and Pearls

The eye was hit by a piece of metal when the patient was peening the steel. According to eye examinations and CT scans, the metal penetrated the eye through the cornea and located in the orbit, which indicated the metal was with a certain amount of hardness and high speed. The streak artifacts of the metal on CT scans suggested its magnetic property. As the streak artifacts of the foreign body blocking part of the posterior wall, there should be a suspicion that the foreign body may insert the wall. Comprehensive preparation needs to be done before the surgery for moving the foreign body.

The posterior exit wound is usually difficult to be located and sutured. PPV should be performed within 2 weeks to remove vitreous hemorrhage and release the traction caused by fibrosis proliferation on the retina, especially the retina around the exit wound, as well as locate and check up the exit wound. Laser photocoagulation should be done to seal the tear of the retina if the tear occured away from the macula. If the wound is in the macula and there is no retinal detachment around the wound, laser photocoagulation is not recommended.

The exit wound healing not only includes the healing of the retina and choroid but also involves the healing of the sclera by fibrosis formation. Generally speaking, the exit wound is often found to be closed up a few days after primary surgery, and managing the retinal damage becomes the major issue. In this case, the posterior exit of the eye ball had already been sealed by scar tissue at the time of vitrectomy. So the surgeon decided to treat the wound without further laser treatment after vitrectomy as there was no retinal detachment noted around the exit wound. If the posterior wound wasn't closed, filling the open one with a same size Tenon's capsule or absorbable gelatin sponge should be an option. Regarding the removal of the intraorbital foreign body, posteriorly located inorganic intraorbital foreign body should be left alone, unless they are causing significant orbital complications such as neurological compromise, mechanical restriction of ocular movements, acute or chronic inflammation, or infection [13]. The objects causing ocular perforating injury are usually metal with high hardness and relatively low magnetism, which are usually well-tolerated and seldom lead to orbital siderosis [14]. However, long-term regular electroretinography evaluation is recommended for monitoring possible retinal toxicity from the foreign bodies [15]. It's known that the oxidative damage of iron on the surrounding tissue can be enhanced by ascorbic acid through increasing the production of hydroxyl radicals and lipid alkoxyl radicals [16, 17], the fact of orbital tissue is lack of ascorbic acid which leads to less possibility of such damage. What's more, the foreign bodies would be covered by fibrosis tissue gradually and be less active as time passes by. And there is no evidence of the foreign body causing infection, affecting eye movement or migrating toward critical orbital structure in this case. So the foreign body wasn't removed during the surgery, and close follow-up was indicated to the patient.

12.3 Case #2: The Eye Hit by an "Iron" Nail

12.3.1 Case Description

A 39-year-old man presented at the emergency room with the right eye hit by an "iron" nail 8 h ago. The visual acuity of this eye was hand motion (HM)/30 cm which couldn't be corrected. The intraocular pressure (IOP) was 9.4 mmHg. The slit lamp examination revealed a central full-thickness edematous corneal laceration, relatively shallow anterior chamber, cloudy aqueous humor, round pupil with the diameter of 3 mm, and opacified lens cortex with a partial outflow of it through the ruptured anterior capsule (Fig. 12.10). Orbital computerized tomography (CT) showed perforating global injury of the right eye with uncompleted lens structure and hyperreflective intraocular foreign body (IOFB) penetrating through the posterior global wall (Fig. 12.11). B-scan ultrasonography showed a high echo in the vitreous body which was suspected to be the IOFB (Fig. 12.12). A combined surgery was performed immediately including debridement and suture of the cornea, cataract extraction, pars plana vitrectomy, IOFB extraction, fluid-air exchange, intraocular laser photocoagulation, and C2F6 gas tamponade. It turned out that the IOFB was a "steel" nail with about 16 mm long (Fig. 12.13). The IOP was low for 5 days after surgery which was probably caused by the loss of C2F6 gas through the unclosed posterior wound. The OCT was acquired for a better understanding of the exit wound and demonstrated a full thickness of the retina and choroid hole at the site of the wound as well as deficiency of outer nuclear layer and irregularity of IS/OS (ellipsoid zone) under the fovea (Fig. 12.14a, b). Another surgery of fluid-air exchange was performed for raising the IOP at the 6th day after the primary surgery. Four days after the

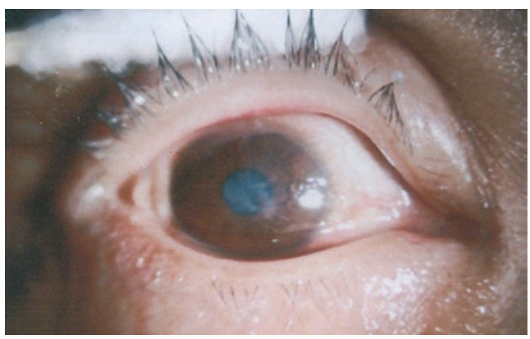

Fig. 12.10 The slit lamp image showing a full-thickness edematous laceration at the center of the cornea, shallow anterior chamber, cloudy aqueous humor, round pupil with the diameter of 3 mm, and opacified lens cortex with a partial outflow of it through the ruptured anterior capsule

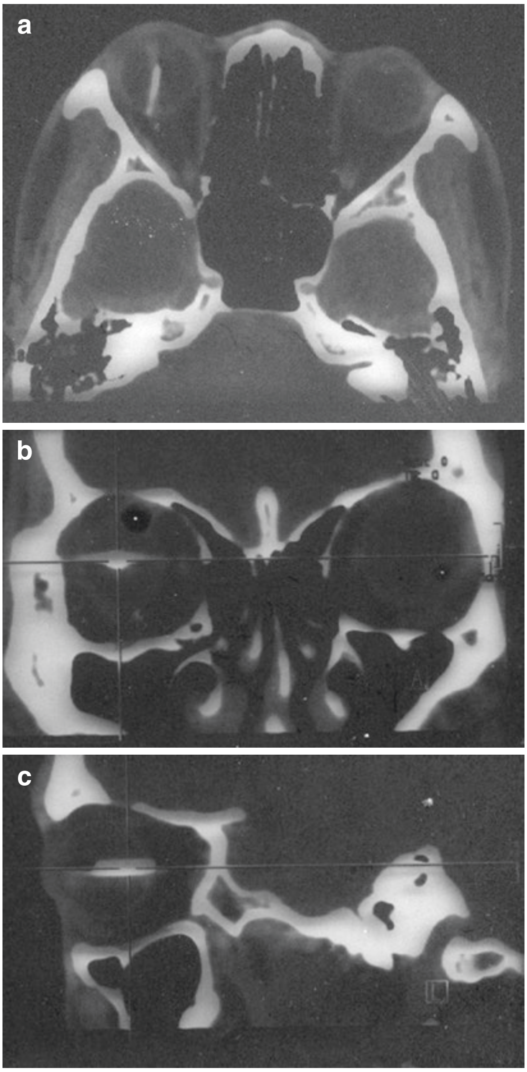

Fig. 12.11 Orbital CT scans of the patient before surgery showing the intraocular foreign body (IOFB) from different angle of the view. (**a**) The axial CT scan showing destroyed lens and hyperreflective IOFB in the vitreous body and penetrating through the posterior global wall. (**b**) The coronal CT scan showing the cross section of the foreign body. (**c**) The sagittal CT scan showing the IOFB embedded in the posterior global wall

secondary surgery, the IOP rose to 19.8 mmHg, but the visual acuity was still HM/30 cm partially due to the gas/fluid interference. The eye examination revealed congestion of the bulbar conjunctiva, well-healed cornea wound, aqueous flare (+), unabsorbed air bubble in the anterior chamber, irregular dilated pupil (7 mm in

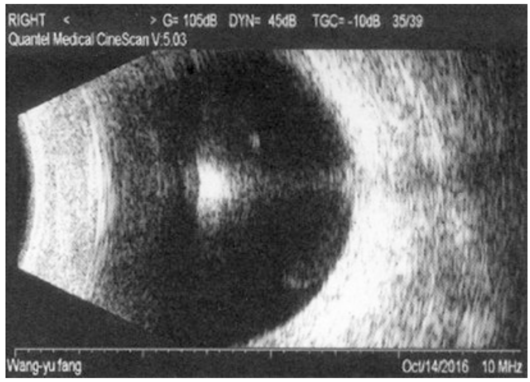

Fig. 12.12 Ultrasonography of the injured eye demonstrating chaotic vitreous body and a high echo substance which was suspected to be the intraocular foreign body

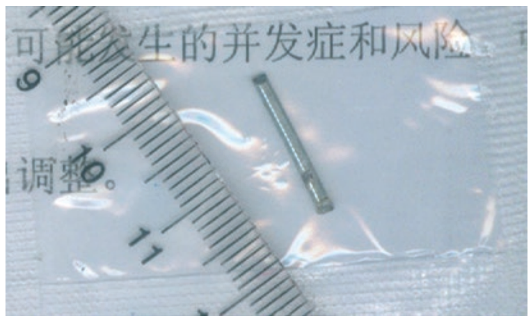

Fig. 12.13 The removed intraocular foreign body during the primary combined vitrectomy surgery was a "steel" nail with length about 16 mm

diameter), lack of the lens (Fig. 12.15), clear vitreous cavity with gas filling 4/5 of the space, and attached retina. Three months after the secondary surgery, the best corrected visual acuity (BCVA) was 0.02, and IOP was 9.6 mmHg. Mildly congested conjunctiva, corneal scar, normal depth anterior chamber, clear aqueous fluid, irregular pupil with the diameter of 7 mm, and aphakia were noted during the slit lamp examination (Fig. 12.16). The retina remained flat with laser spots (Fig. 12.17).

12.3.2 Tips and Pearls

Compared with high magnetic IOFB, the IOFB in this case was easier to locate as there were no radical streak artifacts on the orbital CT images.

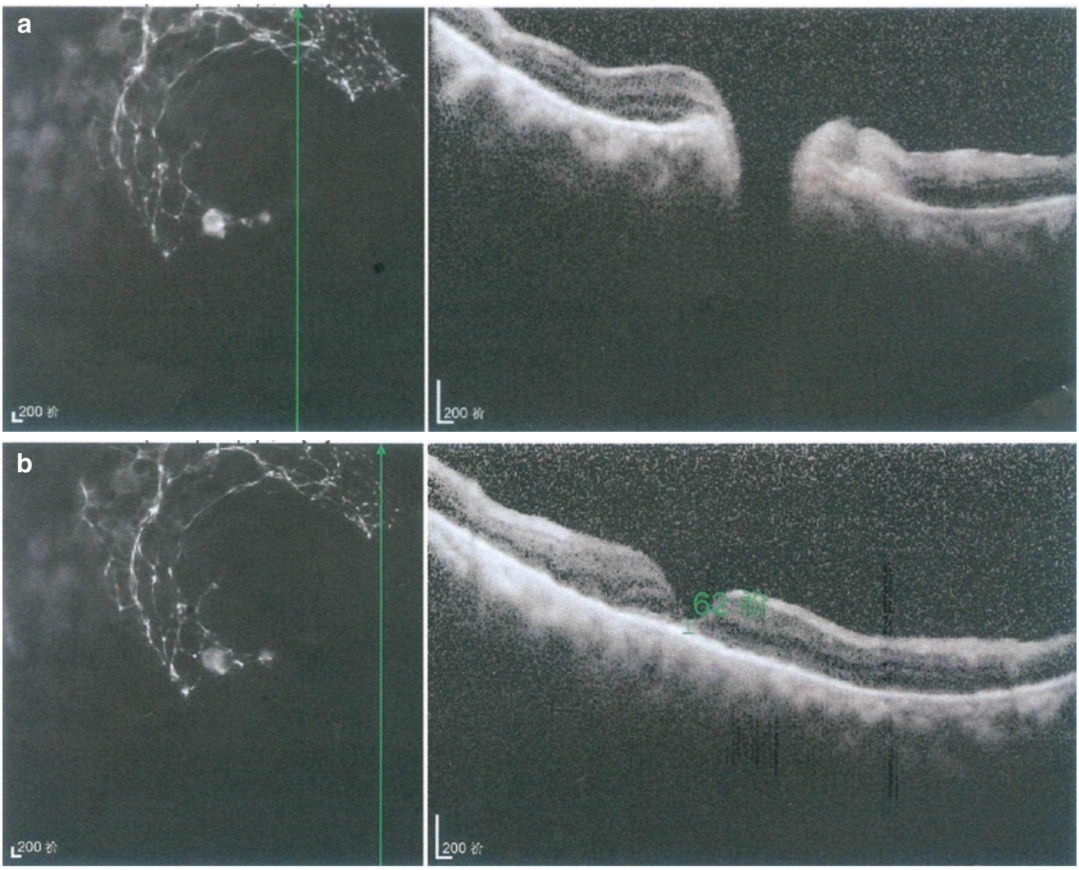

Fig. 12.14 The OCT scans taken at the 5 days after the primary operation. (**a**) The OCT B-scan through the site of the exit wound showing a full thickness of the retina and choroid hole. (**b**) The OCT B-scan through the fovea showing the deficiency of outer nuclear layer under fovea and irregularity of IS/OS (ellipsoid zone)

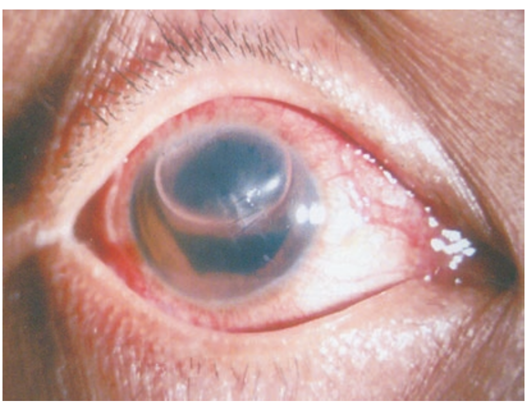

Fig. 12.15 The slit lamp photography taken at 10 days after the primary surgery showing congested bulbar conjunctiva, well-healed corneal wound with mild edema, aqueous flare (+), unresolved air bubble, irregular dilated pupil with the diameter of 7 mm, and lack of lens

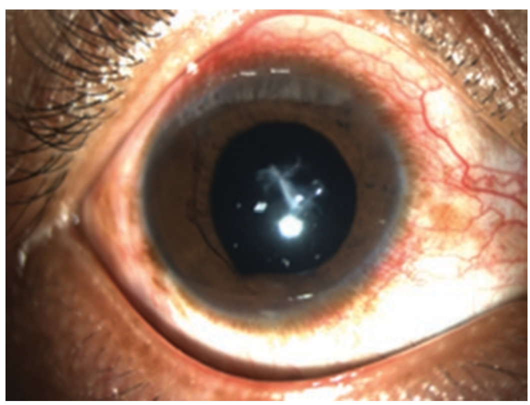

Fig. 12.16 The slit lamp image acquired at 3 months after the primary surgery showing slightly congested conjunctiva, corneal scar, normal depth anterior chamber, clear aqueous fluid, irregular pupil with the diameter of 7 mm, and aphakia

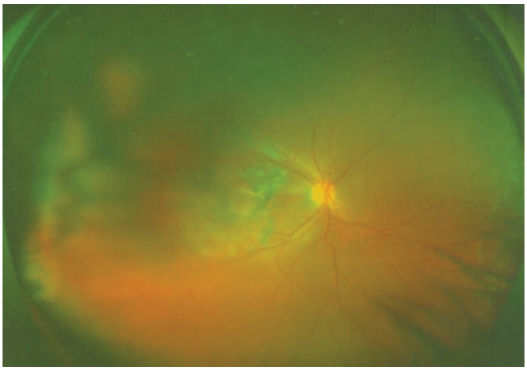

Fig. 12.17 The wide-field color fundus image taken at 3 months after the primary surgery showing flat retina with laser spots

Since the IOFB was erected in the vitreous body, it is reasonable to judge the foreign body penetrating through the posterior eyewall and generating a full-thickness hole which helps supporting the IOFB stay vertical to the eyewall. Hence, a detailed strategy for removing the large foreign body with as little damage as possible should be designed carefully before the surgery.

Vitrectomy has been proved to be of a high efficacy for the treatment of perforating ocular injuries complicating with foreign bodies located at the posterior global wall, with a low incidence of postoperative complications [18]. The final visual outcome depends on the macular or the optic nerve involvement and the final retinal stability [11, 19]. Since the IOFB in this patient penetrated the retina close to the fovea at the temporal side and the OCT confirmed the damage of the trauma to the fovea, the final best corrected visual acuity was 0.02. The timing of IOFB removal was still controversial. Guevara-Villarreal DA and Rodríguez-Valdés PJ advise to perform IOFB extraction immediately when endoophthalmitis suspected; otherwise it can be delayed for a few days until corneal edema resolves and allows a better visualization during vitrectomy, intraocular inflammation is controlled, and suprachoroidal hemorrhage liquefies and thus can be drained if necessary. These processes usually take 3–14 days [20]. Appropriate therapeutic regimen should be selected in terms of different situations. In the current case, vitrectomy was performed for removing the IOFB, and the key point of the surgery was taking out the IOFB with less further damage. A new incision at the limbus with a slightly wider than the diameter of the IOFB was made for removing the foreign body, which allows no second trauma to the full-thickness laceration at the center of the cornea. Gently and slowly pulling the foreign body out of the posterior eyewall is essential to keep a stable IOP and avoid hemorrhage. If the IOFB was surrounded by fibrosis and/or the retina, complete separation needs to be done before removing the IOFB for preventing iatrogenic retinal detachment.

No specific management was performed to the exit wound in this case given that the size of the wound was small based on surgeon's observation and the IOP was maintained at a stable level during the surgery. Filling the eyeball with C2F6 which is a kind of inert gas is a good option to maintain the IOP after surgery and keep the wound dry. Although some gas may leak from the eye, the rest gas can still stabilize the pressure by expansion. Careful monitoring of the IOP should be indicated since the unclosed posterior wound could possibly result in low IOP which may cause choroidal detachment and retinal detachment. Once IOP is low, another fluid-air exchange needs to be performed for maintaining the IOP in a normal range.

12.4 Case #3: An Ocular Penetrating Injury?

12.4.1 Case Description

A 16-year-old man without any ocular disease history complained of sudden vision loss and severe sharp pain in the right eye approximately 2 h after foreign body (FB) injured the eye when he was striking the metal with a hammer. The visual acuity of this eye was 0.03. The slit lamp examination showed moderate conjunctival hyperemia, mild chemosis, a full-thickness self-sealed 2.5-mm-long corneal laceration inferior to the pupil, +1 flare, and shallow anterior chamber inferiorly (Fig. 12.18a). The penetrating

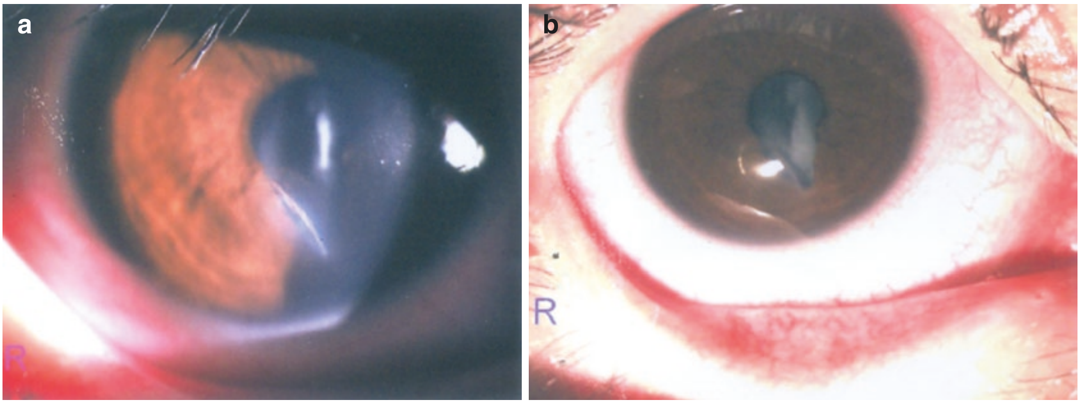

Fig. 12.18 The slit lamp images of the patients. (**a**) Conjunctival hyperemia, chemosis, and the full-thickness cornea wound below the center of the cornea. (**b**) The iris laceration at 5 o'clock position and the traumatic cataract caused by the foreign body

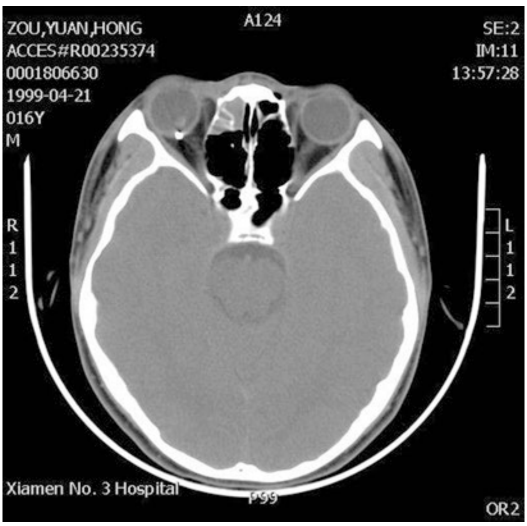

Fig. 12.19 The CT scan showing the metallic foreign body just located at the posterior global wall

injury of the iris at 5 o'clock position and dense traumatic cataract with disruption of anterior lens capsule were noticed as well (Fig. 12.18b). No vitreous body was observed in the anterior chamber. Vitreous and fundus could not be visualized due to media opacification. The axial computerized tomography (CT) scan of the orbit revealed a hyperdense FB located in the posterior global wall of the right eye suggesting ocular wall FB and a media-dense substance anterior to the FB which might be the vitreous hemorrhage (Fig. 12.19). B-scan ultrasonography of the right eye showed vitreous hemorrhage and strong echoes with posterior acoustic shadow which cloud be the FB (Fig. 12.20). The primary diagnosis of an ocular penetrating injury, corneal laceration, traumatic cataract, vitreous hemorrhage, and a metallic intraocular FB was made based on all the examinations. Corneal laceration repair, pars plana vitrectomy, lensectomy, and removal of the metallic intraocular FB were arranged. However, the metallic FB was found inserted into the ocular wall and generated an exit wound, instead of staying in the vitreous cavity. The posterior wound was about 1.5PD and located below the inferior arcade. Ocular perforating injury was made based on the surgical finding. Intravitreal tamponades of gas and laser photocoagulation was used to close the wound track. A 0.5 × 1 × 3 mm metal plate was extracted by magnet behind the eyeball (Fig. 12.21). The retina remained attached at 3 months after the gas was complete absorbed (Fig. 12.22). Four months later, the patient underwent intraocular lens implantation (Fig. 12.23), and the best corrected visual acuity was 0.3.

12.4.2 Tips and Pearls

In this case, the patient was diagnosed with an ocular penetrating injury, corneal laceration,

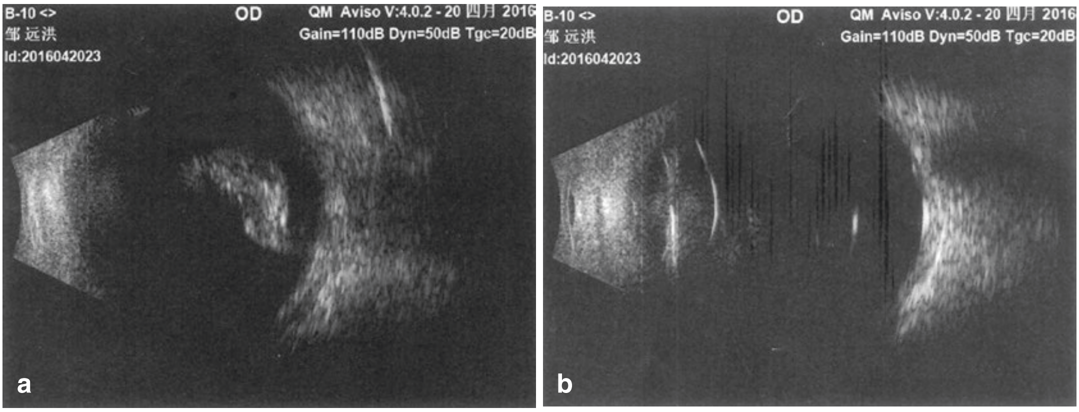

Fig. 12.20 B-scan ultrasonography of the injured eye. (**a**) The vitreous hemorrhage was manifested as moving internal echoes in posterior segment. (**b**) The possible foreign body located at the posterior eyewall

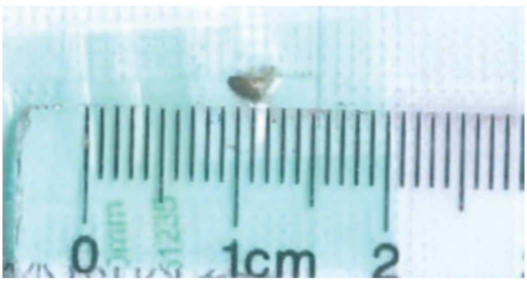

Fig. 12.21 The 0.5 × 1 × 3 mm metal plate was extracted by magnet behind the eyeball during the surgery

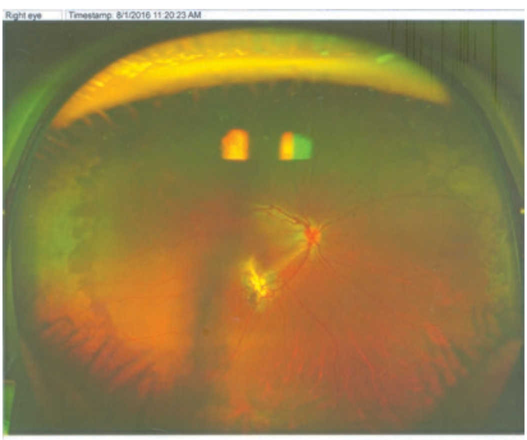

Fig. 12.22 The wide-field color fundus photograph showing the retina scar around the exit wound inferior to the macula after C3F8 gas completely absorbed 3 months after vitrectomy

traumatic cataract, vitreous hemorrhage, and a metallic intraocular FB in the emergency room, because a well-defined hyperdense FB was just

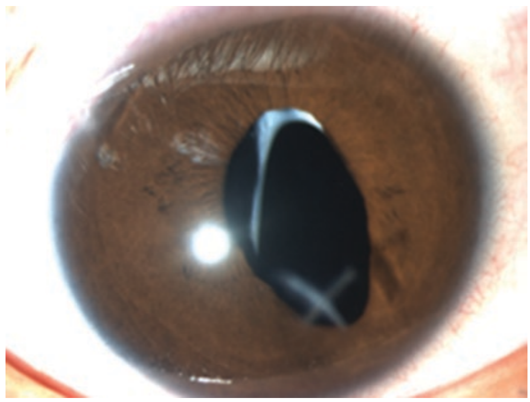

Fig. 12.23 The slit lamp examination of the right eye 4 months after vitrectomy showing transplant cornea, clear aqueous fluid, irregular pupil, and well-centered IOL

located in the eyewall and vitreous hemorrhage was seen in the posterior segment of the right eye according to the orbital CT scans and B-scan ultrasonography and the shape of the eyeball was regular, which also suggested unbroken posterior eyewall. However, the FB was found inserted into the eyewall during the surgery, and wounds on the retina, choroid, and sclera caused by the FB were confirmed when the FB was extracted by magnet. After the FB were removed, the intraocular pressure was reduced, and the conjunctival edema was observed, which was mainly due to the slight leakage of intraocular infusion fluid through the full-thickness wound of the posterior eyeball. Finally the final diagnosis of ocular perforating injury with intraorbital FB was made, instead of ocular penetrating injury with intraocular FB.

Coexistence of ocular surface and intraocular damages often limit intraoperative visualization, and a perforating through-and-through injury should be suspected if the IOFB cannot be identified during vitrectomy [8]. The surgeon found the FB was located within the "hole" of the ocular wall. The retinal lesion around the wound was "sealed" by laser photocoagulation before the FB was taken out by magnet. This preparatory work avoids secondary damage to the surrounding retina caused by removing the FB, such as retinal detachment. When the FB was taken out, the exit wound may lead to perfusion leakage, ocular hypotension, orbital pressure increase, and choroidal detachment. It was reported that a same size Tenon's capsule, absorbable gelatin sponge, or sodium hyaluronate could be used to seal the wound, but the efficiency is still controversial. The posterior pole wound in this case was small and half sealed by the dense orbital tissue, so the surgeon decided not to close the wound of posterior eyewall. C3F8 gas was used to tamponade the vitreous cavity, and the surface tension between liquid and gas could help in wound healing. C3F8 is a better material to maintain the stability of intraocular pressure than liquid. Because liquid can leak into the orbital cavity through the wound, and C3F8 was expanding gas, even if part of gas leaked, the expansion of the subsequent volume could still compensate to stabilize the intraocular pressure. The key step of using gas to heal the wound was closing the three-channel sclerotomy as soon as possible when the gas-fluid exchange is completed.

The poorest prognostic associations of FBs quoted in the literature are endophthalmitis, retinal detachment, and proliferative vitreoretinopathy (PVR). The delayed surgery until the media clear up decreases the chances for vision recovery, as PVR may develop within a few days, with irreversible damage to the retina. On the other hand, continuing surgery under poor visualization conditions carries the risk of inducing iatrogenic lesions that worsens the condition. For these reasons, FBs require prompt evaluation and management (in this case, the FB was taken out in the one-stage operation), considering they may quickly lead to vision-threatening complications [21–23].

12.5 Case #4: The Eye Hit by a Sheet Metal

12.5.1 Case Description

A 60-year-old man presented to our emergency clinic on 10 January 2017, with the chief complaint of trauma to his right eye by a foreign body occurring approximately 1 h ago. The right eye had no light perception with the T-1 intraocular pressure. The eyeball was found penetrated at the inferior nasal sclera. The cornea had light edema, the anterior chamber was bloody and cloudy, the diameter of the pupil was about 3 mm, and the pupillary light reflex was absent. The lens, vitreous body, and fundus were not clearly visualized (Fig. 12.24). Orbital X-ray and computerized tomography (CT) showed that the right eye had perforating injury, with high-density foreign body in the ball with the size about 9.68 × 5.69 mm. It showed that a small part of foreign body was located in the ball, and a large part of it was located outside the ball. The foreign body had streak artifacts, considered as the magnetic foreign body. Before the operation, vitreous sample was taken for bacterial culture examination but without any bacteria and mycelia (Fig. 12.25).

Scleral debridement and suture, intraocular foreign body removal, and anterior chamber irrigation were performed in the right eye. A metallic

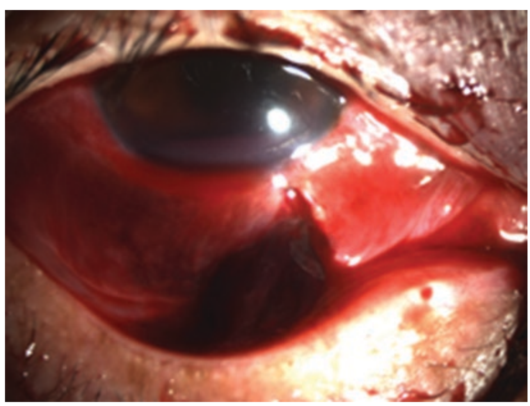

Fig. 12.24 The appearance of the injured eye before surgery. The eyeball was found penetrated at the inferior nasal sclera

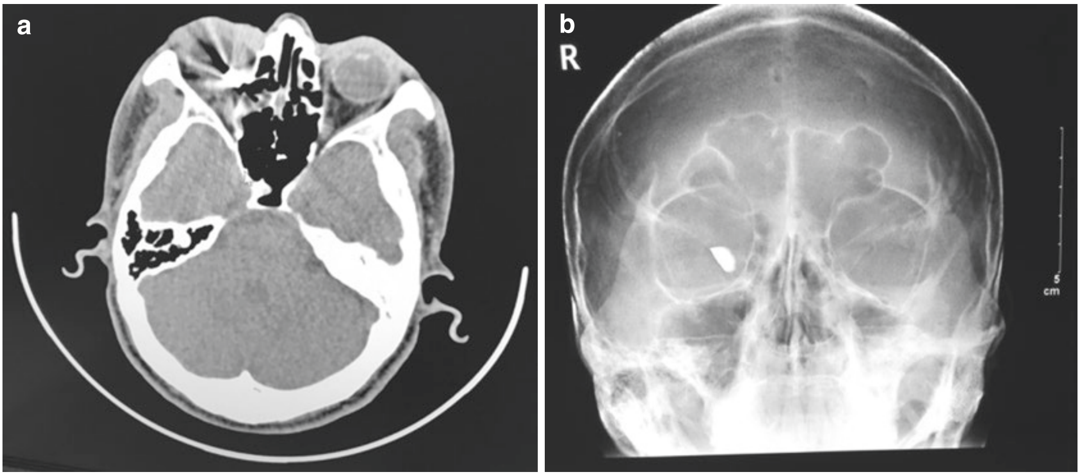

Fig. 12.25 Orbital CT (**a**) and X-ray (**b**) showing the right eye has perforating injury, with high-density foreign body in the ball, about 9.68 × 5.69 mm

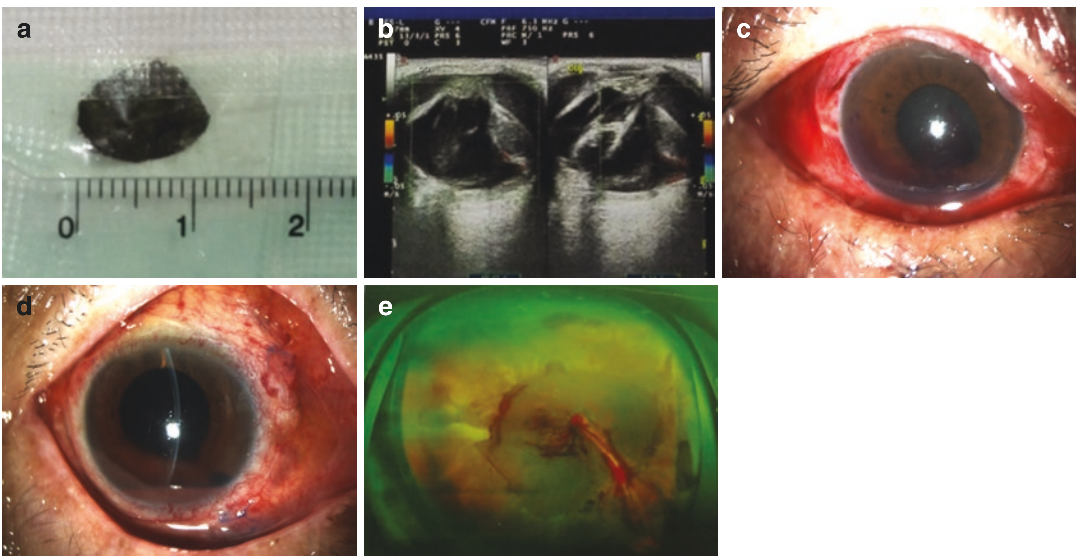

Fig. 12.26 (**a**) The removed metallic foreign body (size 12 × 9 × 3 mm). (**b**) Ocular ultrasound showing a V-shape membrane attached to the optic nerve head, indicative of a total retinal detachment and choroidal detachment. (**c**) The appearance of the eye after scleral debridement and suture and after the intraocular foreign body was successfully removed. (**d**) After a vitrectomy combined with silicone oil filling, a good anatomical result was achieved. (**e**) The pole part of the retina was missing, the surrounding residual retina was visible, and scleral laceration was visible

foreign body (size 12 × 9 × 3 mm) was removed (Fig. 12.26a) in the primary surgery (suture and debridement of sclera combined with removal of intraocular foreign body). After the surgery, ocular ultrasound showed a V-shape membrane attached to the optic nerve head, indicative of a total retinal detachment and choroidal detachment (Fig. 12.26b). And an anatomical healing of ocular surface was achieved after the primary surgery (Fig. 12.27c). A vitrectomy combined with silicone oil filling was performed at 8 days after the primary surgery, and the corrected visual acuity indicated no light perception in the right eye, with the intraocular pressure being 13.8 mmHg.

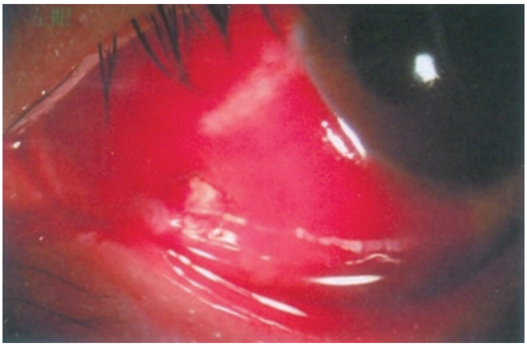

Fig. 12.27 The slit lamp image of the right eye showing subconjunctival hemorrhage with a conjunctival laceration

Three days after vitrectomy surgery, it showed conjunctival congestion and corneal light edema, hyphema with 1 mm height, the absence of lens, and intravitreal silicone oil filling. The part of the retina was missing, the surrounding residual retina was visible, and scleral scar was visible (Fig. 12.26d, e).

12.5.2 Tips and Pearls

Penetrating and perforating injuries involving the posterior segment of the globe often result in severe visual loss and carry a worse prognosis than blunt traumas, especially in young adults or children and if associated with an intraocular foreign body [8, 24]. In this case, the diagnosis of perforating injury was unclear due to the following factors: (1) The eyeball was found penetrated at the sclera. The anterior chamber was bloody and cloudy, and the vitreous body and the fundus were also not clear. Therefore, it was difficult to detect the injured site in the posterior part of the eyeball. (2) Orbital X-ray and CT showed the right eye had perforating injury, with high-density foreign body in the ball. However, it was difficult to detect the exact location of the high-density foreign body only based on CT, due to the radical streak artifact of such foreign body. We considered that the small part of foreign body was located in the ball and a large part of it was located outside the ball. We performed scleral debridement and suture, intraocular foreign body removal, and anterior chamber irrigation. A metallic foreign body (size 12 × 9 × 3 mm) was removed, and posterior scleral wound was found. It was confirmed the diagnosis of perforating injury.

In this case, vitrectomy was performed at 8 days after primary surgery, as we thought that time allows better recovery of the wound and development of spontaneous PVD, which makes vitrectomy safer and more likely to be completed [25]. In this case, a 23-gauge micro-vitreoretinal blade was used for the three sclerotomies at 3.5 mm from limbus. Vitrectomy was completed from the posterior to the anterior part as much as possible to clear the hemorrhage and hyperplasia of the posterior injury site. Laser was applied over the equatorial area and around any retinal tear and especially around the injury site. After air-PFC exchange, silicone oil was injected manually through the upper sclerotomy, considering that it was hard for the elderly to hold the prone position for a long time. In this case, it is not recommended to remove intraocular foreign body by primary surgery. The reason is that it could tear posterior scleral wound and increase the chance of bleeding, which is hard for the healing of posterior scleral wound. It is recommended to remove intraocular foreign body by vitrectomy.

12.6 Case #5: The Eye Hit by a Piece of Steel and Intraorbital Foreign Body

12.6.1 Case Description

A 24-year-old Chinese man that got shot on the left eye by steel presented in the emergency room with red painful eye and blurred vision. On the initial examinations, best-corrected visual acuity (BCVA) was 0.3. Slit lamp examination revealed subconjunctival hemorrhage with a conjunctival laceration about 2 mm length on the nasal side, but no foreign body was seen (Fig. 12.27). The anterior chamber was at normal depth with hyphema (Fig. 12.28). Hemorrhagic vitreous opacity and preretinal hemorrhage with retinal edema were seen on the nasal side (Fig. 12.29). Hyphema

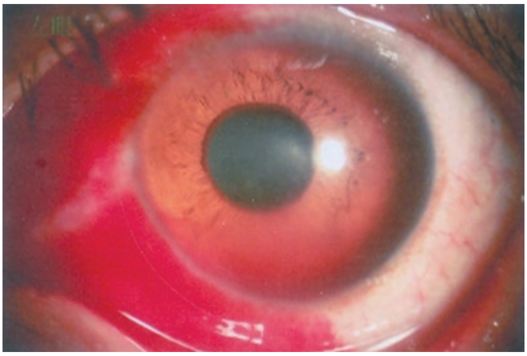

Fig. 12.28 The slit lamp image of the right eye showing hyphema

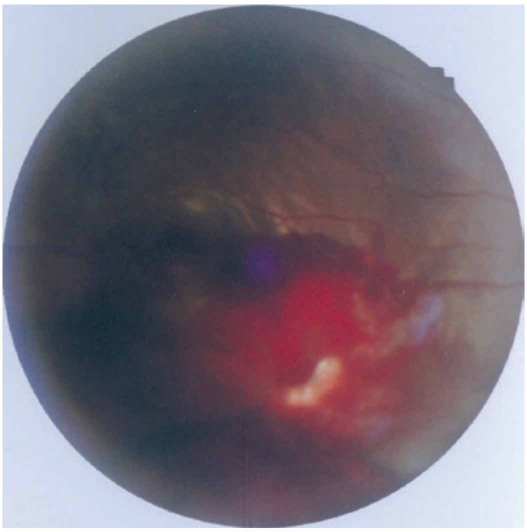

Fig. 12.29 Fundus image taken in the emergency room showing hemorrhagic vitreous opacity and retinal edema, with preretinal and subretinal hemorrhage and retinal laceration on the nasal side

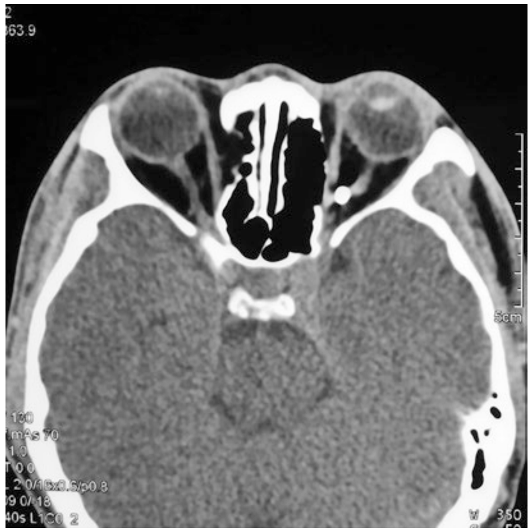

Fig. 12.30 Preoperative axial computed tomography (CT) scan revealing a metallic foreign body located in deep orbit muscles cones

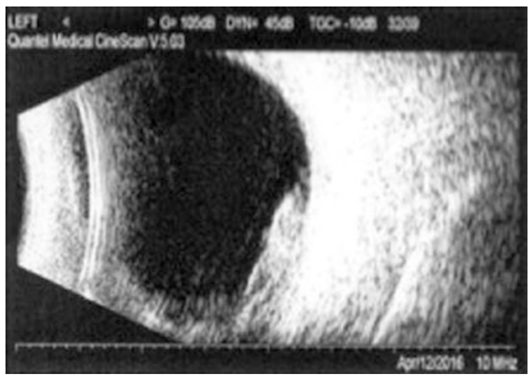

Fig. 12.31 Ocular ultrasonography B-scan demonstrating an abnormal echo on the inferior nasal side of the eyeball at the fifth day after the primary surgery

blocked the visualization of other structures of the eye. The intraocular pressure was 6.4 mmHg. Preoperative axial and coronal computed tomography (CT) revealed a metallic foreign body in deep orbit muscles cones (Fig. 12.30), which indicates ocular perforation injury. Scleral entrance wound and conjunctiva laceration were repaired with intravitreous antibiotic injection at primary repair. Ocular ultrasonography demonstrated an abnormal echo on the inferior nasal side of the eyeball at the fifth day after primary repair (Fig. 12.31). And fundus examination showed retinal laceration with periphery retinal detachment inferior nasally, with choroidal defect and closed scleral wound (Fig. 12.32). Eight days after primary repair, vitrectomy was performed with air-fluid exchange, laser photocoagulation, and silicone oil filling. The postoperative BCVA was 0.6 and intraocular pressure was 19.1 mmHg. The fundus examination showed laser points around the inferior nasal exit wound, with damaged choroid and uncovered sclera (Fig. 12.33). Two weeks later, orbital surgery was performed to search and remove the foreign body by open-

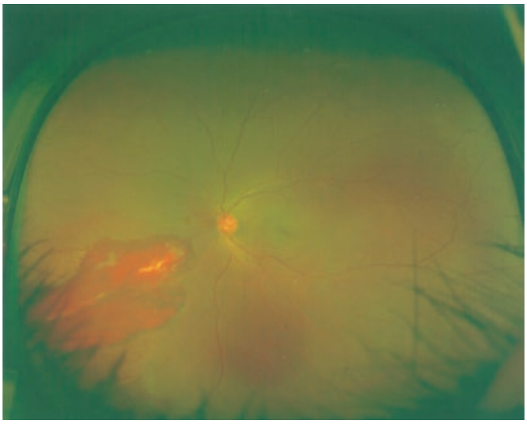

Fig. 12.32 Color fundus image showing retinal laceration with periphery retinal detachment on the inferior nasal side, with choroidal defect and closed scleral wound at the fifth day after the primary surgery

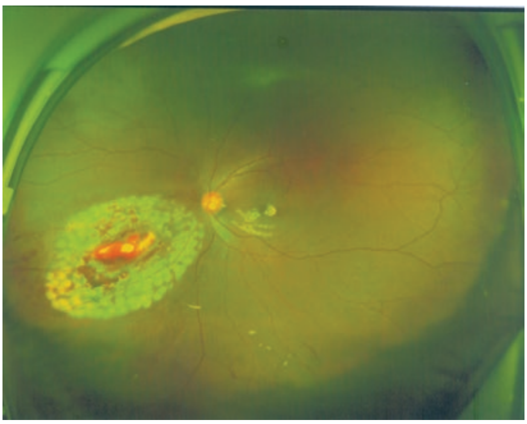

Fig. 12.33 Color fundus image showing laser points around the inferior nasal exit wound, with damaged choroid and uncovered sclera after vitrectomy

ing lateral orbital wall, but unfortunately, the steel shot was not found. Postoperative examination showed a normal eye position, with normal movement in 1 month after orbital surgery (Fig. 12.34).

12.6.2 Tips and Pearls

From the primary examinations, the conjunctival and scleral laceration had a distance to the cornea, and injury was not found in the corresponding iris, so the foreign body was more easily to enter posterior part of the eye without resistance

Fig. 12.34 Postoperative photography showing the normal eye position

from the iris. The roundish high-density foreign body with no radical streak artifacts located in deep orbit muscles cones on CT scans indicated the possibility of ocular perforation injury. Lower intraocular pressure (7 mmHg) was another evidence for the existence of posterior wound, as the anterior wound was self-closed well. However, the posterior wound was not visualized due to the blockage of vitreous, preretinal, and subretinal hemorrhage. The diagnosis of ocular perforation injury was confirmed by the fundus examination at the fifth day after primary repair, which revealed retinal laceration with periphery retinal detachment, choroidal defect, and closed scleral wound. The entrance and exit wounds were necessary for diagnosis with perforation injury [13]. If the fundus couldn't be examined clearly due to vitreous or retinal hemorrhage, proper observation time should be given for hemorrhage absorption. If necessary, vitrectomy could be performed for confirming the diagnosis and treatment.

Considering retinal laceration with periphery retinal detachment, vitrectomy was performed in this patient combined with local laser photocoagulation and silicone oil filling. Also vitrectomy prevented the eye from developing traumatic proliferative vitreoretinopathy and severe tractional retinal detachment. However, keeping prone position is also feasible for young patients with local retinal detachment instead of vitrectomy, because young people's vitreous is not completely liquefied and keeping prone position can help in pushing the detached retina back to the wall. Also, the growth factors from the retinal hemorrhage caused by the injury are beneficial to healing in this patient. So for such patients, close observation can be the first choice, and surgery needs to be performed, only if retinal detachment progresses.

Posteriorly located inorganic infraorbital foreign body should be left alone, unless they affect eyesight or ocular movement or causing acute or chronic inflammation or infection [13]. The objects causing ocular perforating injury are usually metal with high hardness and relatively low magnetism, which are usually well-tolerated and seldom lead to orbital siderosis [14]. It's known that the oxidative damage of iron on the surrounding tissue can be enhanced by ascorbic acid by increasing the production of hydroxyl radicals and lipid alkoxyl radicals [16, 17]. The fact with orbital tissue is that the lack of ascorbic acid leads to less possibility of such damage. As the foreign body was little in size and maybe got covered by fibrosis tissue gradually, it was difficult to locate and remove it even by opening lateral orbital wall in this patient.

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