# Field Diagnosis and Treatment of Ophthalmic Trauma

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## ABSTRACT

Identification and management of injuries to the eyes and ocular adnexa is commonly encountered by frontline medical personnel. This brief review is intended for the Special Forces Medic of all branches and describes the clinical presentation of common ophthalmic and periocular trauma with appropriate management strategies. Prompt recognition of these wounds facilitates early treatment and optimized visual outcomes for affected Soldiers and civilians alike. KEYWORDS: *trauma, eye, ophthalmology, vision, open globe*

## Introduction

*"Avoiding danger is no safer in the long run than outright exposure. The fearful are caught as often as the bold." . . . "Alone we can do so little, together we can do so much."* —Helen Keller

The above quotation describes the historical difficulties and advances in preventing vision loss during war. Despite attempts to prevent eye trauma, those combat injuries in have always been a consequence of armed conflict. Strategies to protect the eyes during combat are documented as early as the 15th century for helmet wearing troops; for a comprehensive review of the evolution of eye armoring attempts we refer the interested reader to LaPiana's excellent publication.[1]

The periocular soft tissue (including the eyelids and underlying orbicularis oculi muscle) combine with the bony orbit to provide excellent natural protection to the eye from minor injury. As this protection is often inadequate in a combat setting, the U.S. military mandated the use of ballistic protective eyewear as standard issue equipment for deployment in 2004.[2] Compliance with the Military Combat Eye Protection (MCEP) program has improved, resulting in a sharp decline in the rate of inpatient admissions for eye injuries, despite increased enemy attacks.[2,3]

Preservation of vision is facilitated by understanding the epidemiology of these wounds, and regular publications report the extent and nature of ocular trauma experienced by servicemembers.[4,5,6] Eye injuries are currently tracked and analyzed via the Tri-Service Vision Conservation and Readiness Program (TSVCRP) at the U.S. Army Public Health Command and with the Armed Forces Health Surveillance Center (AFHSC); these entities generate quarterly reports that monitor the incidence and also emerging trends of ophthalmic injuries.[2]

The use of high-velocity projectiles and explosive fragmentation devices commonly results in multiple facial and ocular combat wounds. Improvised explosive devices (IEDs) and secondary fragment projectiles such as dirt, rock, glass, and metal are all capable of causing penetrating and blunt eye injuries.[7] A study of ophthalmic injuries presenting to a Combat Support Hospital (CSH) during the Iraqi insurgency of January through September 2004 reported that 82% of all wounds were caused by munitions fragmentation, the most common being the improvised explosive device (51%). Of the 207 severe ocular and adnexal injuries recorded, there were 132 open globes and 24 of the 41 globe removals performed were associated with an IED.[8] Medical personnel must therefore maintain a high index of suspicion for ocular injury, and be certain to include at least some form of vision assessment and documentation if ocular injury is suspected by the nature and mechanism of the associated wounds.

A survey of 11 conflicts from World War I to Somalia reveals that head and neck injuries averaged 15% (range 4–24%) of all penetrating wounds.[9] In the Vietnam War, 50% of penetrating eye wounds ultimately lost vision.[9] Eye injuries are identified in 5–10% of all combat casualties, and treatment requires specialized ophthalmic care within 24–48 hours.[7] A 1998 retrospective study of world-wide military eye injuries for that year reported that orbital fractures, contusions, and open wounds to the ocular adnexa and orbit accounted for the vast majority (85%) of hospitalization, while most (80%) ambulatory visits involved superficial wounds and cornea/conjunctival foreign bodies.[6]

As expected, wartime injury rates and distributions are somewhat different. Specific analyses of 767 emergent patient visits for ocular complaints to a combat support hospital during Operations Desert Shield and Desert Storm showed a 14% incidence (108 cases) of actual ocular injury or disease. Most commonly, these injuries included corneal foreign bodies (18 cases), ocular burns (14 cases), and traumatic iritis (8 cases), while likely diseases were blepharitis and conjunctivitis (16 cases). Interestingly, 13 patients treated in support of the ground war were Iraqi prisoners, and 13% of all ground war casualties (19/149) were ophthalmic injuries.[10]

A recent study of active component eye injuries (2000–2010) reports that the majority of injuries requiring hospitalization involved the orbit, while a diagnostic code of "high risk of blindness" was also characteristic for many admissions.[2] While the improved use of MCEP has stabilized and even reduced the rates of vision threatening wounds, there is no doubt that all such injuries can not be prevented. Prompt identification and treatment is critical to maximizing vision potential after these devastating orbital and ocular wounds. Given the climate of today's operational profile, Special Forces medical personnel will continue to provide care for civilians and enemy combatants. A strong clinical background in the diagnosis and treatment of ophthalmic diseases provides excellent pathways, particularly to build rapport and trust supporting "hearts and minds" initiatives.[11]

The goal of this targeted review is to ensure that SF providers are able to recognize injuries that threaten vision and provide appropriate stabilization, treatment and evacuation to higher care levels as indicated. We have chosen five main categories of injury to discuss below.

1. Recognition of open globe
2. Blunt globe trauma: iritis, corneal abrasion, superficial foreign bodies
3. Penetrating globe trauma: open globe and intraocular foreign bodies
4. Periocular adnexal injury: eyelid and brow lacerations
5. Orbital fractures

We intentionally chose to present the "key points" and representative illustrations only; for detailed referenced descriptions of each entity please see Emergency War Surgery[9] and Smith and Nesi's Ophthalmic Plastic and Reconstructive Surgery, 3rd edition.[12]

## 1. Recognition of open globe

Open globe is often a difficult diagnosis, with variable vision from no light perception (NLP) to normal vision depending upon the location, duration, and extent of the laceration. There are, however, signs and symptoms, which suggest a greater likelihood of open globe in the setting of trauma (see Appendix I for a brief approach to management of the ocular trauma patient)

*Vision:* Always establish a baseline visual acuity. It is often helpful to compare vision to the contralateral uninjured eye. Vision loss in the absence of obvious anterior segment disease may suggest penetrating trauma. Vision may be quantified by a Snellen chart in ambulatory patients or by near card, newsprint, labels on medications/ i.v. bags, by counting fingers, and by perception of light.

*Eyelids and ocular adnexa:* Any trauma capable of causing a lid laceration must be assumed to have injured the underlying globe until proven otherwise. Careful exploration often reveals potentially vision-threatening injury. A cotton tip applicator facilitates upper lid eversion for inspection of the conjunctiva and fornices for foreign bodies or injury (Figure 1). For management of these wounds, see below.

*Anterior segment:* Always search for obvious corneal or scleral lacerations. Subconjunctival hemorrhage may mask underlying scleral rupture or laceration—from blunt force or from projectiles. Chemosis is billowing edema of the conjunctiva and it too may mask underlying injury when associated with subconjunctival heme. The presence of a conjunctival or corneal foreign body may be associated with other fragments that have penetrated the globe, but such injuries may or may not be seen with subconjunctival hemorrhage. Hyphema, which is blood in the anterior chamber, may also be seen with open globes. It can be caused by both blunt and penetrating trauma.

**Figure 1** *Eversion technique: The upper eyelid is everted using a cotton tipped applicator to allow inspection of the conjunctiva for foreign bodies. Eversion is facilitated by grasping the lashes with gentle outward and superior traction, while the applicator is used with downward pressure to evert the tarsal plate.*

*Iris/Pupils:* Take care to inspect the iris; an irregularly shaped pupil can be seen in open globe. If the wound penetrated the cornea or anterior sclera, the iris tissue maybe found protruding through the wound (sealing or "plugging" the laceration). If found, do not attempt to reduce the entrapment. Abnormal or asymmetric pupil response to light suggests significant injury to the visual pathway.

*Motility/Proptosis:* Decreased unilateral motility may be caused by open globe, or it may be a result of edema involving the orbital and/or adnexal tissues. This must be distinguished from orbital compartment syndrome (OCS) caused by hemorrhage. OCS is a true ophthalmic emergency and requires immediate treatment to relieve the compression of the blood flow to the optic nerve to prevent permanent vision loss. We believe it less important to quantify intraocular pressure (IOP) via tonopen or similar instrument than it is to recognize OCS (by symptoms of decreased vision, a firm globe to palpation, proptosis, decreased motility, abnormal pupil response) and act quickly to relive the pressure. Decreased motility associated with OCS typically presents with significant proptosis, however this is not universal. Performing lateral canthotomy and cantholysis must be considered when there is a firm globe, proptosis, and vision loss in the setting of blunt trauma. The pupil may be nonreactive in the affected eye resulting in an afferent papillary defect (APD). This is identified by a decreased or absent direct light reflex in the affected eye while ipsilateral constriction is preserved when shining the light in the contralateral eye. Please see the excellent article (referenced below) in the JSOM for detailed descriptions of both orbital compartment syndrome and images for step-by-step performance of lateral canthotomy/cantholysis as emergent vision saving treatment.[13]

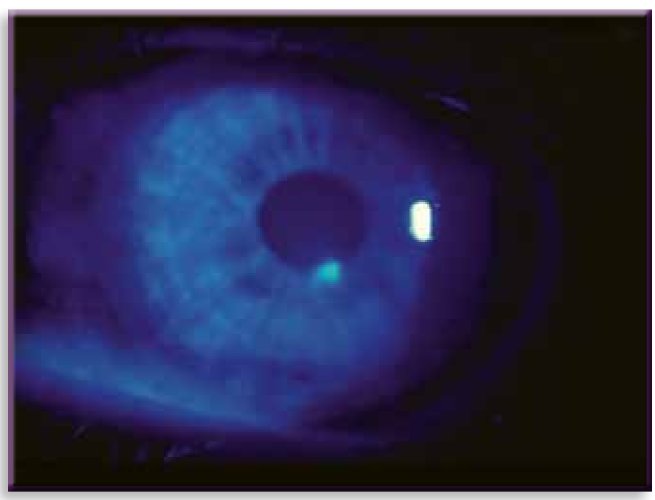
## 2. Blunt globe trauma: iritis, corneal abrasion, superficial foreign bodies

Ocular damage from blunt trauma—such as results from a fist or similar object—is often proportionate to the force of the injury. High-impact injuries are associated with globe rupture and orbital fractures. Corneal abrasions are a defect in the epithelial layer of the cornea and are marked by pain and variably decreased vision. Abrasions can be visualized with fluoroscein staining and a cobalt blue light source that causes the defect to be seen as a bright yellow-green (Figures 2–3).

These are treated with topical antibiotics and cycloplegia for pain control. There is little efficacy of narcotics for ocular pain issues. Abrasions must be examined daily until the epithlelial defect heals, to assure bacterial keratitis and ulceration do not arise. Corneal and conjunctival burns may present similarly, with decreased vision and foreign body sensation. Immediate and copious irrigation of the eye is indicated for suspected chemical burns. Ideally the pH can be initially checked with Litmus paper, but do not delay irrigation. Continue immediate irrigation with sterile saline or available water until pH normalizes. Foreign bodies embedded in the upper lid or conjunctiva may produce multiple linear vertical abrasions secondary to blinking, reinforcing the need for lid eversion and proper inspection of the lid, conjunctiva and fornices (Figure 4). It is important to avoid topical anesthetic drops (tetracaine, proparacaine, etc) in the treatment of corneal abrasions. These drops inhibit epithelial healing, which may allow an abrasion to progress to a corneal ulcer. Topical anesthetics also mask the pain of progressive disease leading to a delay in accurate diagnosis and treatment.

**Figure 2** *Fluorscein staining of inferior conjunctival abrasion. A cobalt blue filter is necessary for the orange dye to emit a green staining as seen in the next photos; this can be done via the slit lamp or a pen light with filter.*

**Figure 3** *Positive fluorescein staining of a small corneal epithelial defect. An epithelial defect of less than 1 mm can still be visually disabling and painful.*



Superficial corneal foreign bodies can often be removed easily with a tuberculin needle at the slit lamp; this may

**Figure 4** *Multiple corenal abrasions likely caused by an embedded foreign body in the upper lid conjunctiva. Most abrasions are successfully treated with topical antibiotics and careful repeat exams to ensure ulceration does not develop.*

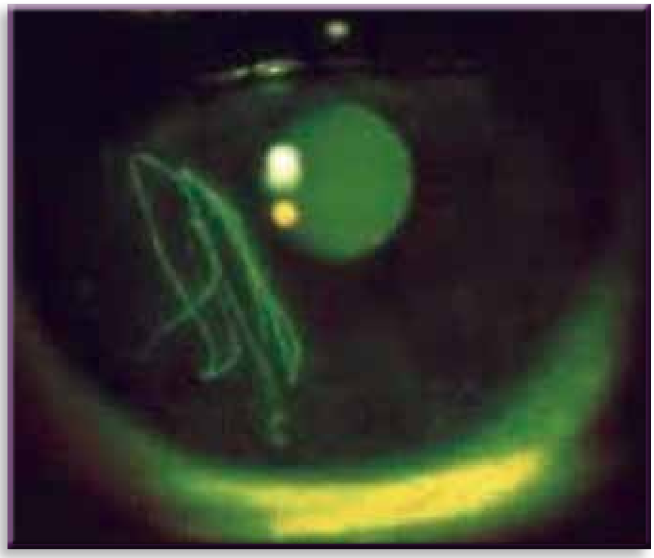
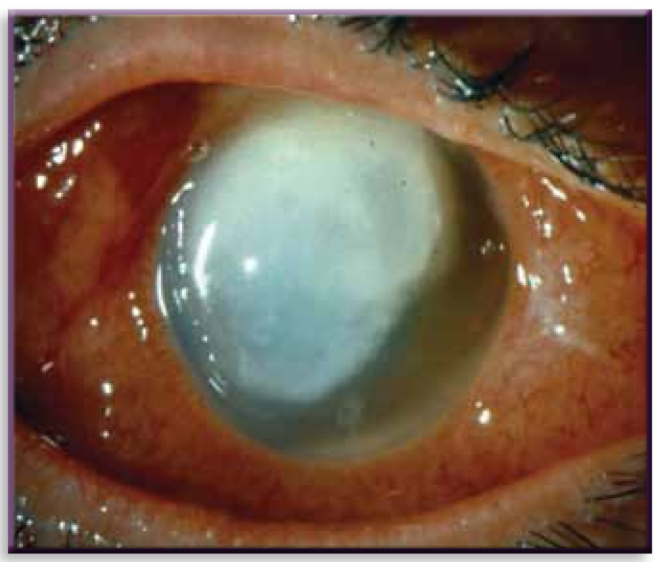


**Figure 5** *Removal of corneal foreign body using tuberculin syringe and needle. This is best done with stereoscopic magnification such as with a slit lamp.*

**Figure 6** *Corneal ulcer and enophthalmitis. There is a layered hypopyon in the inferior anterior chamber consisting of purulent material. This is a vision threatening scenario.*



not always be practical in more forward levels of care (Figure 5). It is often necessary to gently evert the eyelid over a cotton tip applicator to inspect the fornices for a foreign body. If you suspect an open globe, however, minimize manipulation of the eyelids and adnexa. Iritis is a common inflammatory sequelae of both blunt trauma and abrasions/foreign bodies. Iritis is treated with both topical cycloplegia and steroids until resolved. It is clinically characterized by variable photophobia and pain, and examination at the slit lamp shows cells and/or flare in the anterior chamber. Iritis must be distinguished from endopthalmitis, which usually has a more aggressive presentation and a history of penetrating injury (Figure 6).

## 3. Penetrating globe trauma: open globe and intraocular foreign bodies

A Fox or similar shield should be placed over a suspected or obvious open globe immediately. Never put an occlusive or pressure dressing on the eye. Intraocular foreign bodies, whether in the anterior or posterior chamber, should not be removed outside of the operative suite. In place of topical antibiotics, it is best to commence intravenous or oral fluroquniolones, which have excellent penetrance to the vitreous. Emesis prophylaxis is also indicated such as prochlorperazine (Compazine), promethazine (Phenergan), or ondansetron (Zofran). Control of emesis is key to minimize the risk of intraocular contents expulsion during valsalva and straining. Succinylcholine should be avoided during anesthesia induction as muscle fasciculation increases intraocular pressure, which may also cause expulsion of uveal tissues and intraocular tissues. The patient should then be transferred to an ophthalmologist for urgent exploration and repair. Plain films and computed tomography (CT) scans can identify and localize metallic foreign bodies in the globe and orbit. Magnetic resonance imaging (MRI) should not be ordered if metallic foreign bodies are suspected based on mechanism of injury. The presence of a hyphema should raise suspicion for an occult penetrating globe injury (Figure 7). Even a small subconjunctival hemorrhage may mask an entry point for a projectile. Globe rupture in the absence of external physical signs is possible given the proper mechanism of injury. Globe rupture from blunt trauma commonly occurs at the extraocular muscle insertions and at the corneo-scleral junction where scleral tissue is relatively thin. Small diameter wounds to the cornea or corneo-scleral junction may be self-sealing with prolapsed uveal (iris) tissue clearly visible through the wound. The iris then acts as a barrier to anterior chamber collapse and loss of aqueous (Figure 8). It is imperative not to attempt reduction of prolapsed uvea as this will increase risk of endophthalmitis and also hyoptony. Proper management involves systemic antibiotics, placement of a Fox or similar rigid shield followed by transfer to an ophthalmologist for repair—"shield and ship". Penetrating injuries are also associated with sympathetic ophthalmia (SO). In theory, traumatic exposure of uveal antigens results in a hypersensitivity response leading to an autoimmune attack on the contralateral eye, which presents as uveitis and decreased vision. Fortunately SO is now uncommon due to increased surveillance and treatment with corticosteroids; most ophthalmologists will never see a single case.

**Figure 7** *Hyphema secondary to trauma. This can also result from spontaneous hemorrhage of tumors and neovascularization from diseases such as proliferative diabetic retinopathy or sickle cell anemia.*

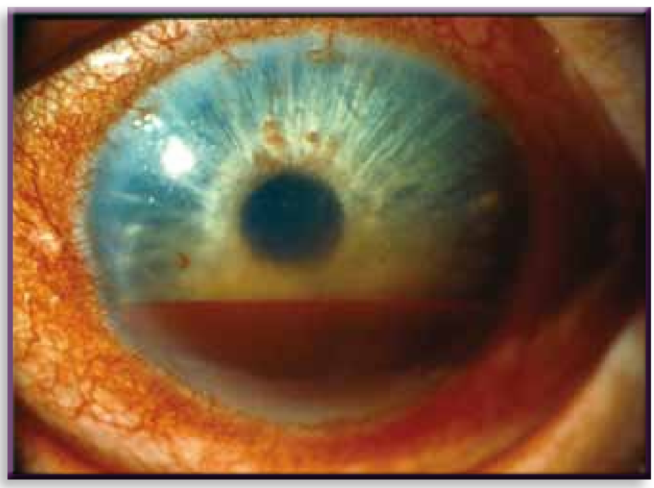


**Figure 8** *Open globe with uveal prolapse: the iris has "plugged" the corneal perforation. Do not attempt to reduce the prolapsed iris.*

### 4. Periocular adnexal injury: eyelid and brow lacerations

If fat is seen in the eyelid wound, the orbital septum has been violated and an injury to the levator muscle is more probable. This necessitates further surgical exploration and repair. Superficial lacerations may be repaired using plastic surgical techniques: choose the smallest caliber suture possible (usually 6–0) and remove sutures early (five to seven days). Full thickness lacerations of the eyelid involving the margin must be exactly reapproximated using several layers of 6–0 silk suture at the margin to prevent notching. Notching leads to corneal dessication. This repair is often best accomplished by an oculoplastic specialist or similarly experienced surgeon. If there is significant missing tissue or poor lid closure, antibiotic ointment should be placed on the cornea until definitive closure. Wounds to the ocular adnexa should be similar explored and closed in layered fashion with meticulous technique (Figures 9, 10, 11, 12, and 13). Remember that any traumatic injury capable of penetrating the lids and brow are also capable of damaging underlying structures—the eyes and the brain. Maintain a high index of suspicion.

### 5. Orbital fractures

The orbital floor is the most clinically significant and most common orbital fracture. The orbital contents, including extraocular muscles, can be entrapped in the floor fracture (Figure 14). This causes an upgaze deficit of the affected globe. Manipulation of extraocular muscles can lead to bradycardia via the oculocardiac (vagal) reflex. This can be elicited—especially in children—with entrapment, where repair is therefore more urgent than most adult cases. Few floor fractures need emergent repair, and observation is often preferable to immediate surgical exploration.

**Figure 9** *Unrepaired full thickness lid laceration that has spontaneously granulated resulting in severe lagopthalmos and exposure keratopathy. This eye is in danger of perforation and enophthalmitis.*

**Figure 10** *Post-operative view of patient in Figure 9. The lid was incised, debrided, and then repaired in layers with isolation and repair of the levator muscle. Excellent lid closure resulted giving an opportunity for corneal healing as opposed to immediate enucleation.*

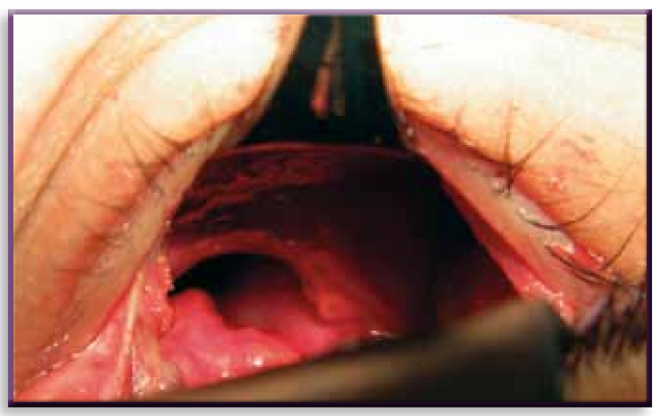
**Figure 11** *Multiple full thickness lid laceration after assault with box cutter. Intraoperative exam revealed left open globe, reinforcing the need for a high index of suspicion in such trauma cases.*

**Figure 12** *Post-operative view of same patient as Figure 10. Left globe was repaired, and full thickness lid repair was also successful.*

Repair is indicated if greater than 50% of the floor is comminuted, if there is significant enophthalmos, or in cases of true entrapment. Edema and hemorrhage of the extraocular muscles often masquerades as true entrapment by

**Figure 13** *Full thickness laceration of lower eyelid, which has been debrided and reconfigured for layered closure. The tarsal plate is clearly visible on the lateral lower lid just anterior to the globe. These wounds, from trauma or after excising tumors, must be closed in layers with careful attention to alignment of the tarsal plate and the lid margin to prevent notching and subsequent corneal compromise. In this case there was no associated globe injury.*

**Figure 14** *Intra-operative view of a floor fracture repair: visible are the entrapped orbital contents being reduced with a malleable retractor.*



limiting motility. Performance of forced ductions (instill topical anesthetic, grasp EOM insertion with 0.5 toothed forceps and manually elevate the globe noting resistance to movement) can clarify possible entrapment. Imaging with thin section (1–2mm) CT, both axial and coronal views is ideal and also yields additional data on associated injuries to the globe and optic canal/nerve as well as extent of retrobulbar hemorrhage. Again, avoid MRI if metallic intraorbital foreign bodies are suspected.

## APPENDIX I

General approach to evaluation of ocular trauma (based on references 7, 9, and 12).

1. Triage based on life threatening injury first, then vision, then limb

2. Check and document vision—loss of vision may be associated with serious injury
3. Determine severity of wounds—it may be difficult to determine major vs. minor ocular injuries
4. Fox shield or similar rigid shield (non-compressive) as globe protector
5. Start 4th generation systemic fluoroquniolone, tetanus toxoid, anti-emesis (cycloplegia as indicated)
6. Transfer to facility with ophthalmic surgical care for penetrating injuries, intraocular foreign bodies, suspected open globe

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