Chapter 6

OCULAR TRAUMA SCALES

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INTRODUCTION

It is essential that we implement lessons learned from experienced military surgeons to improve surgical support for the injured soldier. Within this arena, ocular trauma scales may not appear to be as critical as, say, a discussion of the modern surgical approaches to treating an injury. However, trauma scales are a vital aspect of effective triage and focused readiness training. Trauma scales strengthen our readiness to restore soldiers with eye and orbital injuries by providing a triage framework for facilitating timely, accurate diagnoses and appropriate treatment. Trauma scales have also had a historical role of improving our ability to match injury patterns with the appropriate urgency of surgical support. We have realized the benefit of the Advanced Trauma Life Support (ATLS) system for soldiers with multiple trauma[1]; we must seek the same benefit to restore soldiers with sight-threatening injuries. Unit commanders can use the same database to recognize and prevent common injury patterns through the broad use of protective eye armor.

RATIONALE FOR USING TRAUMA SCALES

Efficient triage, initial stabilization, coordinated evacuation, and strong surgical team care are all vital elements of combat surgical support. An effective trauma scale can benefit each link in the chain. The Glasgow Coma Scale was introduced in 1974 as an evaluation tool for patients with severe head injuries.[2] This simple tool, with its index categories that include eye opening and verbal and motor evaluation, filled the need for a system that defined severe head trauma. The Glasgow Coma Scale provided a common language, and improved triage communication.

As with head trauma, prompt identification of severe ocular and orbital injuries is critical for reducing soldier morbidity and conserving military fighting strength. Because ocular and orbital injuries are frequently unrecognized or are obscured by other wounds, an effective triage tool is necessary so that sight-threatening injuries will not be overlooked. To rapidly identify soldiers with potentially vision-threatening wounds and to achieve broad use by field medics and other triage personnel, the ocular trauma scale must be simple and require little more than a penlight and a trained triage soldier.

The newly developed Madigan Eye and Orbit Trauma Scale (MEOTS)[3] achieves these objectives (Figure 6-1); the trauma index categories include vision, eyeball structure, proptosis, pupils, and motility. Although MEOTS has been applied effectively in a peacetime emergency room setting, its true value will not be completely validated until it has been used and evaluated in battlefield conditions.

Proper use of trauma scales requires a reference of common ocular trauma terms to clearly define the most common injury patterns. Significant works have provided a basic understanding of such terms as penetrating globe injuries, perforating injuries, and traumatic optic neuropathy. A standardized classification of ocular trauma is as important to military medicine as it is to the international ophthalmic community. The international classification presented in 1996 provided a simple anatomical scheme, which defined basic ocular injury patterns. The globe is consistently used as the tissue of reference, adding clarity to such terms as "penetration" or "perforation" (Table 6-1).[4] Under this system, a fragmentation injury with a corneal entrance wound and no exit wound would be identified as a penetrating ocular injury with a retained intraocular foreign body (IOFB). This system provides an effective classification for surgeons and command to review ocular injury patterns. The international Ocular Trauma Classification is useful for multivariate analyses of ocular injuries. However it does not provide a rapid numerical triage value for use on the battlefield, which is the main advantage of the MEOTS.

Ocular structures are at great risk in the modern battlefield. Severe ocular injuries represent 9% to 14% of total severe battlefield injuries. High-velocity, fragment injuries predominate, representing 78% of the serious ocular and adnexal injuries during the Persian Gulf War. But reported injuries greatly underestimate the number of soldiers who sustain corneal abrasions and superficial corneal foreign bodies (FBs).[5–7] Understanding the most common injury patterns is the first step toward implementing effective triage and, more important, encouraging command interest in injury prevention with eye armor.[8]

Ocular trauma scales and ocular trauma registries depend on lessons learned from previous conflicts to make clear progress toward improved readiness. These lessons have taught us that soldiers

MADIGAN EYE & ORBIT TRAUMA SCALE

Index	Points	Standards
Vision:		
Small Print: 20/40	3	
Large Print: 20/100	2	
Count Fingers:	1	Urgent Referral
Less than CF:	0	Urgent Referral
Eyeball Structure:		
Eyeball structurally intact:	3	
Possible Violation eye, Low suspicion:	2	
Possible Violation eye, High suspicion:	1	Shield, Surg. Support*
Gross Violation of eye:	0	Shield, Surg. Support**

*Apply Fox shield and Seek Urgent Ophthalmic Surgical Support. Increase suspicion with lid laceration, distortion of pupil, alteration in ocular chamber depth, clinical history at risk for penetrating or blunt injury.
**Adult patients consider Cipro PO or IV, Prepare for surgery.

Index	Points	Standards
Proptosis: "Bulging"		
No displacement of eye	2	
Proptosis ≤ 3 mm	1	CT
Gross Proptosis > 3 mm, orbit Tense	0	Urgent, Steroid, CT**

**Lateral canthotomy, it a relative afferent pupil defect (APD) is present. High dose IV Steroids to reduce compression of optic nerve. Ophthalmic surgical support.

Index	Points	Standards
Pupils: Consider Neurosurgical & Ocular Trauma		
Equal, Reactive, No APD*	2	
Unequal or Possible APD	1	
Dilated pupil, Definite APD	0	Urgent, See proptosis

*(APD) Afferent Pupillary Defect (swinging light test)

Index	Points	Standards
Motility:		
No subjective or objective problem	2	
Double vision, or restriction	1	CT
Eyeball barely moves, "Frozen"	0	Urgent, CT, see proptosis

Overall Score: MAX 12

Patients with a total score ≤ 6 require urgent treatment to maintain sight. An initial score > 6 does not exclude a blinding injury. See Urgent referral guidelines listed above. *, ** All previous surgical support standards still apply.

Fig. 6-1. The Madigan Eye and Orbit Trauma Scale (MEOTS) was developed at Madigan Army Medical Center, Tacoma, Washington. The five categories on which the scale is based are Vision, Eyeball Structure, Proptosis, Pupils, and Motility (in red, above); each category has at least three criteria, for which "points" are assigned during an examination for trauma of the eye and orbit. The maximum overall score—the total points scored above—is the cumulative from all categories. Scores of 7 and above do not exclude a blinding injury; SCORES OF 6 AND LOWER REQUIRE URGENT TREATMENT.

should wear polycarbonate ballistic protective eyewear to prevent most injuries. Moreover, soldiers with sight-threatening injuries must be identified in the triage process so they can receive timely surgical care. Senior, experienced ophthalmologists with field operating surgical equipment should be positioned with head trauma teams so they can repair injuries that, if delayed, would have little potential for retained sight. These concepts are not new, reflecting the afteraction reviews of numerous ophthalmologists with experience spanning the years from the Vietnam War to the Persian Gulf War.[6,7,9]

Ocular trauma scales and trauma registries have many functions, including

- defining injury patterns,
- facilitating effective triage,
- improving surgical readiness,
- predicting visual prognosis, and
- serving as a critical command briefing element on the military perspective of ocular trauma.

Away from the battlefield, ocular trauma scales have prognostic counseling applications. Visual

TABLE 6-1

DEFINITIONS OF OCULAR TRAUMATOLOGY TERMS

Term	Definition	Comments
Eyewall	Sclera and cornea	Technically, the wall of the eye has three tunics (coats) posterior to the limbus; therefore, for clinical purposes, it is best to restrict the term "eyewall" to the rigid structures of the sclera and cornea.
Closed-globe injury	Eyewall does not have a full-thickness wound	Either there is no corneal or scleral wound at all (contusion) or it is only of partial thickness (lamellar laceration). Rarely, a contusion and a lamellar laceration coexist.*
Open-globe injury	Full-thickness wound of the eyewall	The cornea, the sclera, or both sustained a through-and-through injury. Depending on the inciting object's characteristics and the injury's circumstances, ruptures and lacerations are distinguished. The choroid and the retina may be intact, prolapsed, or damaged.
Rupture	Full-thickness wound of the eyewall, caused by a blunt object; the impact results in momentary increase of the intraocular pressure and an inside-out injury mechanism	The eye is a ball filled with incompressible liquid; a blunt object with sufficient momentum creates energy transfer over a large surface area, greatly increasing intraocular pressure. The eyewall gives way at its weakest point, which may or may not be at the impact site. The actual wound is produced by an inside-out force; consequently, tissue herniation is very frequent and can be substantial.
Laceration	Full-thickness wound of the eyewall, usually caused by a sharp object; the wound occurs at the impact site by an outside-in mechanism	Further classification is based on whether an exit wound or an intraocular foreign body is also present. Occasionally, an object may create a posterior exit wound while remaining, at least partially, intraocular.
Penetrating injury	Single laceration of the eyewall, usually caused by a sharp object.	No exit wound has occurred. If more than one entrance wound is present, each must have been caused by a different agent.
Intraocular foreign body (IOFB) injury	Retained foreign object causing entrance laceration	Technically, an IOFB is a penetrating injury, but it is grouped separately because of the different clinical implications (treatment modality, timing, endophthalmitis rate, etc).
Perforating injury	Two full-thickness lacerations (entrance + exit) of the eyewall, usually caused by a sharp object or missile	The two wounds must have been caused by the same agent.

*The injury is so atypical that characterization is very difficult; the clinician should use his or her best judgment based on the information provided here.

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outcomes and enucleation rates depend on the nature and extent of the injury as well as on the availability of surgical support. These factors are important to ensure command distribution of assets to areas where they will have the greatest impact. Soldiers with nonfatal, multitraumatic injuries often have salvageable, but injured, eyes.[7] Retaining soldiers with useful vision requires forward placement of experienced surgeons and effective combat surgical support.[6,9]

WARTIME OCULAR INJURY PATTERNS

A comprehensive military perspective requires the compilation of trauma data from multiple sources. The international classification system (see Table 6-1) was an important step toward the development of a common ocular trauma language; however, the terminology for traumatic optic neuropathy and orbital injuries was not included. Chemical injuries, burns, laser injuries, and extensive craniofacial trauma are all of great importance to military ophthalmologists but are excluded from many civilian trauma classification systems.[10,11] Small, high-velocity fragment injuries predominate in nonfatal ocular trauma in wartime, and these injuries are also excluded from many civilian trauma series.[4,11–13]

A wartime injury pattern base must be established to set the stage for effective use of ocular trauma scales. The first step is to acknowledge the injury patterns observed by military ophthalmologists in previous conflicts.[5–7,9] The second step is to reflect this body of experience in a simplified trauma scale that can be used as an effective triage and readiness training tool. On the battlefield, medics must rapidly identify the most severe ocular injuries in a sea of soldiers who have corneal FBs.

Sustaining the force requires the capacity to treat common, minor injuries that would otherwise degrade a soldier's ability to fight. Ocular trauma scales must enable the separation at triage of corneal abrasions and superficial FBs from penetrating fragmentation injuries. Corneal FBs requiring slitlamp removal were extremely common during the Persian Gulf War.[7] During the 1967 Arab–Israeli Six-Day War, 46% of the total Israeli injured sustained corneal injuries from FBs, mostly from sand and rock missiles associated with blast injuries. These minor corneal injuries degraded the ability of injured Israeli soldiers to fight or to assist in their own evacuation off the battlefield. Although temporary, corneal FBs are not minor when they degrade a soldier's ability to fight. Many can be prevented by simply using protective eye armor. Polycarbonate eyewear can also prevent most serious eye injuries resulting from small, high-velocity fragments.[5]

High-velocity fragments are the principal cause of severe eye injuries in modern combat.[6,7,14] Small, high-velocity fragments that might be stopped easily by heavy clothing and skin can penetrate the eye with devastating results.[9] Of the 35 enucleations performed during the Persian Gulf War, 94% were the result of fragmenting munitions. Several authors have reported on the incidence and clinical presentation of fragmentation injuries from shells, grenades, and mines. Fragmentation wounds caused more than 80% of ocular injuries during World Wars I and II, 72% during the Korean War, 78% during the 1967 Arab–Israeli Six-Day War, and 78% during the Persian Gulf War.[7,14] In nonlethal trauma, most high-velocity fragments are quite small. This was true of the military ophthalmology experience in the Vietnam War, where most of the fragments that were removed from the eye and adnexal structures had a mass less than 100 mg (Figure 6-2).[6] In the Persian Gulf War, 40% of corneal scleral lacerations from blast fragments were less than 10 mm in length, caused by proportionately small fragments.[7]

In addition to the high percentage of fragment injuries, wartime ophthalmic wounds have several distinguishing characteristics. These injuries are typically multiple, often presenting with adnexal, bilateral ocular, and concurrent orbital injury patterns. The injury patterns are complex, contaminated, and severe.[5,6,9] Frequently, secondary missiles from gravel and organic material cause more damage than the primary missile.[9] Unlike civilian case series, military trauma scales have no exclusion criteria for complex wounds, burns, or chemi-

Fig. 6-2. These foreign bodies (FBs) were removed from the eye, orbital, and adnexal soft tissue of soldiers and Marines at the US Naval Hospital, Da Nang, Vietnam, 1968–1969, by Drs. Sponaugle and Mackinley. Note that more than twice as many small (< 100 mg) FBs were removed than medium (100–500 mg) and large (> 500 mg) FBs *combined*. Photograph: Courtesy of Francis G. LaPiana, Colonel, Medical Corps, US Army (Ret), Washington, DC.

cal injury patterns.[3,4]

Vesicant agents, such as mustard gas, remain a constant medical threat and have significant ocular morbidity. These persistent, rapidly absorbed, oil-droplet agents have a latent period followed by mucosal activation, making the eye an especially vulnerable target. Six to 12 hours after exposure, soldiers may present with ocular, skin, gastrointestinal, and pulmonary symptoms. The corneal epithelium is particularly vulnerable, and the result is pain, photophobia, tearing, and reduced vision.[15]

Military ophthalmologists have provided a thorough accounting of wartime injury patterns[5–7,9]; their experience provides the basis for future triage and readiness training. When we implement an ocular trauma triage and readiness training module, we must continue to ask the question, "Will it work on the battlefield?"

TRIAGE APPLICATIONS OF OCULAR TRAUMA SCALES

Battlefield triage presents a unique challenge for field medics and triage personnel. Wartime experience, combined with combat-oriented triage training, will improve our readiness to restore soldiers with ocular injuries. MEOTS is a triage training module that uses simple observational categories and a penlight to identify soldiers with sight-threatening injuries[3] (see Figure 6-1). A soldier with basic medic skills can be trained to perform ocular triage using MEOTS. Sight-threatening injuries are recognized by their overall pattern. For example, a retrobulbar hematoma is recognized by decrease in vision, proptosis, abnormal pupils with an afferent pupillary defect (APD), and reduced motility (Figure 6-3). An open globe is recognized by an overall low trauma score, a clinical history of risk for penetrating or blunt trauma, and by evidence of violation of the globe (Figure 6-4). Recognition of sight-threatening injuries triggers urgent intervention. For example, identification of an open globe activates both the application of a Fox shield and urgent ophthalmic surgical support (Figure 6-5). It is

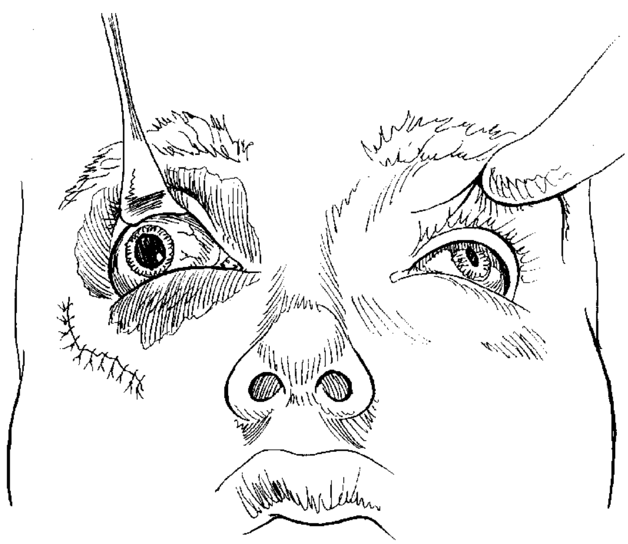


Fig. 6-3. Retrobulbar hemorrhage. Applying the Madigan Eye and Orbit Trauma Scale (MEOTS) to this injured soldier facilitates prompt recognition and treatment for of a retrobulbar hemorrhage. Urgent action is triggered by recognition of: vision reduced to Count Fingers, a firm proptotic orbit with evidence of facial trauma, unequal pupils with a definite afferent pupillary defect, and a frozen globe. A lateral canthotomy/cantholysis, cold compresses, elevation of the head, high-dose steroids, and ophthalmic surgical support restored this soldier to normal function. MEOTS score: total 4 of 12. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

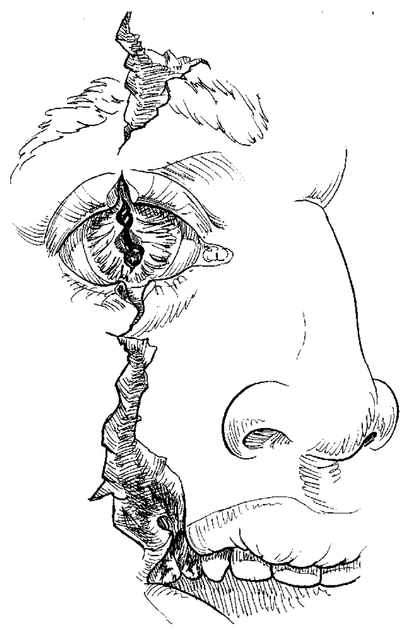


Fig. 6-4 Extensive facial trauma with a corneal-scleral laceration. Gross violation of the globe is recognized by: vision of bare light perception, contiguous lacerations and fractures with gross violation of the eye, no view of a pupil, and an eye that does not move normally. The soldier requires a Fox shield, oral or intravenous ciprofloxacin, and immediate ophthalmic surgical support. MEOTS score: total 1 of 12. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

Fig. 6-5. Fox shield for an open globe. The injured soldier receives an immediate protective shield for gross violation of the right eye caused by glass fragments, and careful examination of the left eye. Urgent ophthalmic surgical support is required.

vital that we provide our triage personnel with focused training and basic equipment to yield the benefits of improved surgical readiness.

The training module for MEOTS follows a simple, commonsense approach for each index category. The act of measuring *visual acuity* is the most critical starting point. Medics are trained to use the small print and large print on a 4 in. x 4 in. gauze dressing, the count fingers method, and a penlight to determine levels of visual acuity. The overall score and injury pattern dictate the need for urgent intervention and referral. Critical points on individual indices, such as vision less than or equal to count fingers, require urgent referral.

During the MEOTS training module, medics are given multiple examples of an open globe. They are trained to recognize an open globe based on a mechanism of injury and *eyeball structure* criteria, including the following:

- adjacent lid lacerations,
- loss of normal eye anatomy,
- distortion of the pupil, and
- alterations in ocular chamber depth.

Medics are trained to recognize *proptosis* by observing the injured soldier's face from above and noting a relative proptosis in the frontal view. Medics are trained to gently palpate the orbit if absolutely no signs of an open globe are present. A firm, proptotic orbit prompts immediate reassessment of pupils, vision, and motility to exclude a blinding orbital hemorrhage.

The *pupil* examination involves a large dose of common sense. A dilated pupil in a comatose patient with head trauma is considered to be evidence of brain injury until proven otherwise. The swinging flashlight test is used to assess for a relative APD. A definite APD is a critical finding for evidence of an orbital hemorrhage or optic nerve injury.

The *motility* examination is based on both the subjective complaint of double vision and the objective evidence of restricted movement. A "frozen globe," with severely limited motility, prompts an urgent assessment of the orbit. Multiple examples of open globes and severe, sight-threatening orbital injuries are presented during MEOTS training to strengthen overall pattern recognition and reinforce the need for immediate intervention.

Improved Readiness

Ocular trauma is an important battlefield injury because of its frequent occurrence and its effect on a soldier's capacity to fight. Although the eye constitutes only 0.1% of the frontal body surface, it is extremely vulnerable to small fragments that on other parts of the body would have minimal effect. Ocular injuries are common, representing more than 9% of all battle injuries in the Vietnam War and 12% to 17% of battle injuries in World War II.[6] Ocular wounds are associated with landmine injuries and the increasing range of explosives.[11] Ocular trauma increases with a static battlefront, as soldiers must take to trenches and foxholes where the body is protected while the head and eyes are exposed for observation and fire. Battlefield eye injuries are severe. In World War II and the Vietnam War, 50% of ocular penetrating injuries resulted in enucleation.[6] The need for ocular trauma readiness is clear.

The primary goal for military ophthalmologists is to improve readiness through prevention and expert surgical management of eye and orbital injuries in soldiers. Ocular trauma scores can help achieve this goal by providing tools for both the command and unit levels of training. The collective body of ocular trauma score literature is most notable for its diversity. The focus and intended application are equally diverse for each system.

Several trauma scales provide excellent prognostic and research applications, including those from the United States Eye Injury Registry[10] and the Ocular Trauma Classification Group.[11] Ocular trauma scales of this caliber provide valuable command data regarding probable visual outcomes based on the soldier's mechanism of injury, initial vision, and a panel of prognostic factors. The data are based on an initial examination and operative findings from the first surgical repair. The readiness applications of these types of trauma scales are more global, providing probabilities of visual outcomes at 6 months and a database for trauma research. Trauma scales of this nature could be used to assess the visual outcomes of ocular trauma following an entire conflict.

Most ocular trauma scales include surgical findings in their assessment. Such data are of little use in a battalion aid station. Readiness training for medics and triage personnel requires a battlefield focus of sustaining the fighting force and instilling confidence in our ability to restore injured soldiers. The MEOTS trauma scale is designed for use in the field with acutely injured soldiers. This scale provides a readiness-training tool designed to identify and initiate care for soldiers with immediate, sight-threatening injuries. Restoration of the injured soldier requires effective triage, prompt first line of care, timely evacuation, and strong forward surgical support.

A hands-on active training environment is created through the use of multiple gross clinical examples, a plastic skull, Fox shields, field surgical instruments, and an experienced instructor. Figures 6-6 through 6-19 show a cross-section of the injury patterns and treatment modalities. Out of respect for severely injured soldiers and their families, some wartime images are limited to presentations in small-group settings.

A laminated trauma scale card serves as a pocket reference and training aid (see Figure 6-1). This trauma scale and the 45-minute training module help medics and triage personnel to decide rapidly which ocular injury to evacuate first, and why. It also helps the triage personnel to determine the urgency status of a given injury and to provide first-line care. Treatment examples include Fox shields and ophthalmic surgical support for open globes, lateral canthotomy for orbital injuries with optic nerve compression, and irrigation of chemical injuries (see Figures 6-5, 6-12, 6-13, and 6-14).

The MEOTS training module has gained support at many national and international meetings. The most vigorous reception, however, has been at the military unit level of instruction. The training module has been well received by multiple units, including medics of the 2/75 Ranger battalion, forward surgical teams, combat support hospitals, emergency department personnel, and members of several facial trauma teams. This decentralized training module is best suited for direct unit instruction

Fig. 6-6. Recognition of an open globe in a soldier with multiple trauma. Airway and breathing are always prime concerns in the primary survey of a multiply injured soldier, such as this one with multiple facial fractures and an open globe. The Madigan Eye and Orbit Trauma Scale (MEOTS) is a useful triage tool to be applied during the secondary survey for serious injuries.
The soldier's eyelids were swollen shut, yet serious eye injuries were anticipated, considering the deep lacerations and fractures above and below the eye. The eyelids were carefully retracted to obtain a patient vision and inspect the eye. MEOTS examination demonstrated the following: Vision: bare light perception (MEOTS 0); Eyeball Structure: gross violation (MEOTS 0); Proptosis: < 3 mm (MEOTS 1); Pupil: grossly abnormal (MEOTS 0); Motility: barely moved (MEOTS 0). Under the care of a cohesive Facial Trauma Team, this soldier returned to duty with an intact eye, normal face, and useful vision. MEOTS score: total 1 of 12.

Fig. 6-7. Extensive laceration of the eyelid prompts examination of the eye to exclude injury. A complex, full-thickness injury of the eyelid raises great concern for the underlying globe. In this case, the eye was intact. Ophthalmic surgical support was required to "clear" the eye and repair the eyelid. Repair of the eyelid could be delayed until all soldiers with open globes are repaired. MEOTS score: total 11 of 12.

Fig. 6-8. Open globe with a scleral wound. This soldier's open globe is readily identified by its Madigan Eye and Orbit Trauma Scale (MEOTS) findings of Vision: Count Fingers (MEOTS 1); Eyeball Structure: gross violation as evident by the scleral wound, alteration in ocular chamber depth, distortion of the pupil, blood inside the eye, and a history of penetrating injury (MEOTS 0); Proptosis: no (MEOTS 2); Pupils: abnormal with possible afferent pupillary defect (MEOTS 1); Motility: abnormal (MEOTS 1). Immediate action was required on identification of the open globe. MEOTS score: total 5 of 12. Photograph: Courtesy of Francis G. LaPiana, MD, Colonel, Medical Corps, US Army (Ret), Washington, DC.

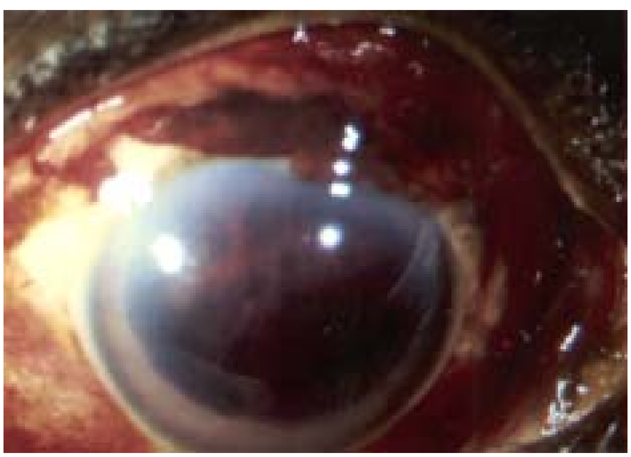


Fig. 6-9. Open globe with critically abnormal findings in all categories. Some very serious injuries are difficult to recognize; however, critical findings in all categories of the Madigan Eye and Orbit Trauma Scale (MEOTS) help identify the serious nature of this injury. A ruptured globe with prolapsed uvea and no view of a pupil results in critical deficits in the categories of Vision (MEOTS 0); Eyeball Structure (MEOTS 1); Proptosis (MEOTS 1); Pupils (MEOTS 0); and Motility (MEOTS 1). Medics evaluating this soldier *must* apply a Fox shield and seek urgent ophthalmic surgical support. MEOTS score: total 3 of 12.

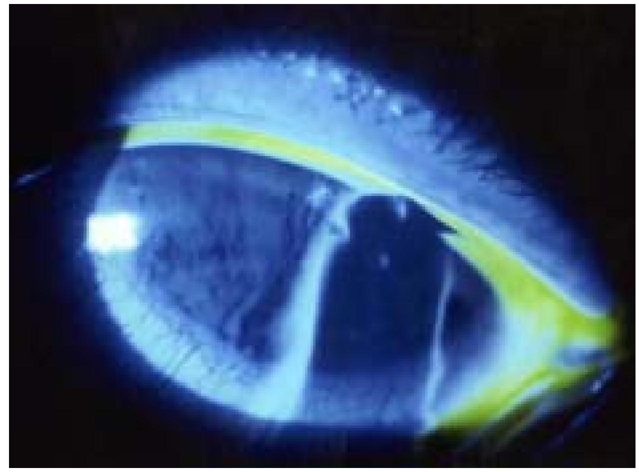
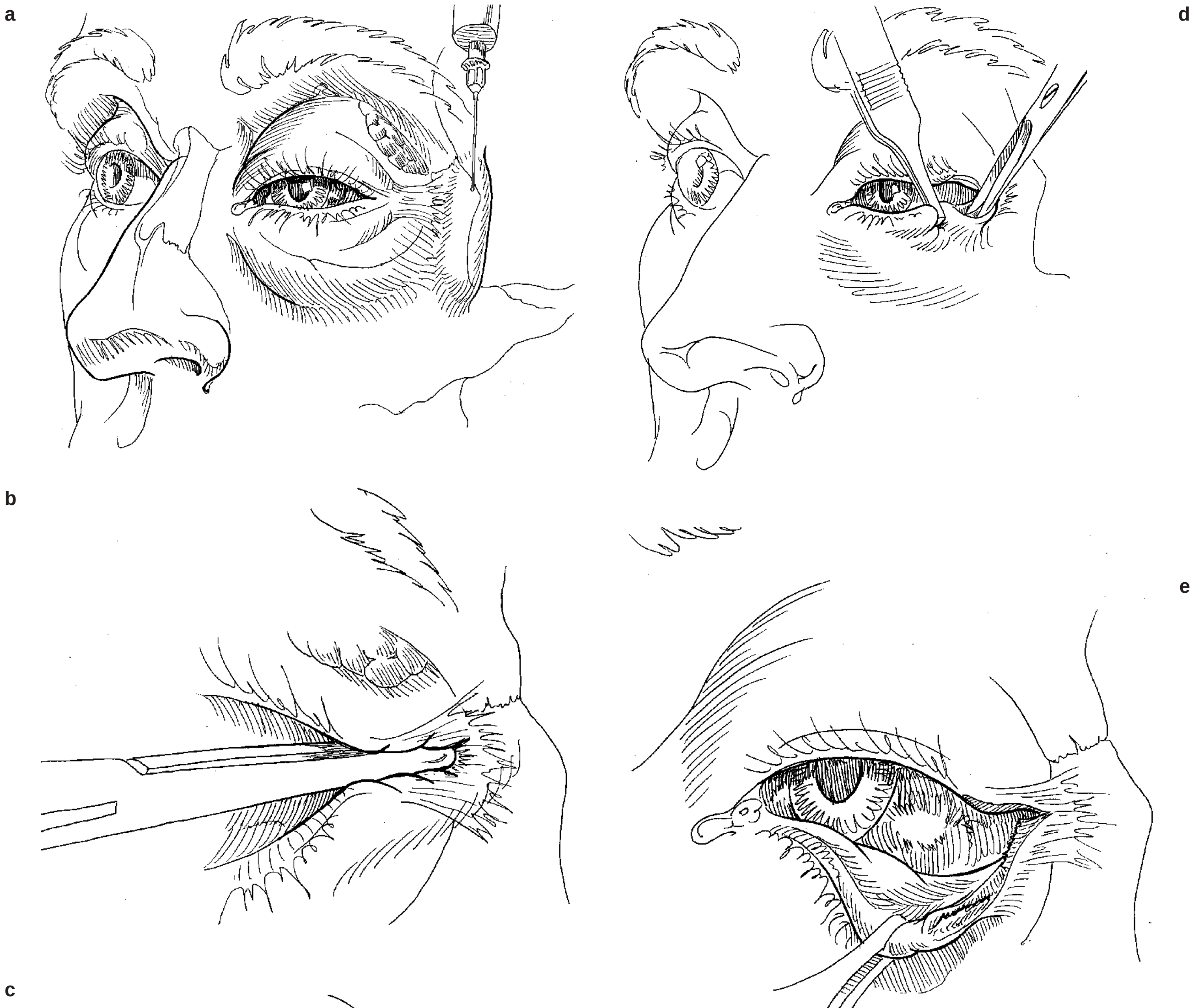


Fig. 6-10. Penetrating wound with leakage of aqueous fluid. A history of a penetrating injury leads to prompt assessment of this penetrating wound, application of a Fox shield, and urgent ophthalmic surgical support. Field units should consider giving 1.5 g oral ciprofloxacin as a loading dose for all open globe injuries to reduce the risk of serious infection. MEOTS score: total 6 of 12.

Fig. 6-11. Endophthalmitis following a penetrating wound from a wire. A history of a penetrating injury is critical. The soldier with a corneal wound can develop an eye full of pus in less than 24 hours. The findings of endophthalmitis include Vision: light perception (MEOTS 0); Eyeball Structure: severe pain; a hot, red eye; and a corneal wound with pus layered in the anterior chamber (MEOTS 0); Pupil: no view through the pupil, which is adherent to a traumatic white cataract (MEOTS 0). An inflammatory infiltrate is probably filling the posterior segment of the eye, as well. Medics in a field unit should give a loading dose of 1.5 g oral ciprofloxacin, apply a Fox shield, and immediately evacuate this soldier to a unit with ophthalmic surgical support. MEOTS score: total 3 of 12. Photograph: Courtesy of Thadeus Krolicki, MD, Wausau, Wisc.



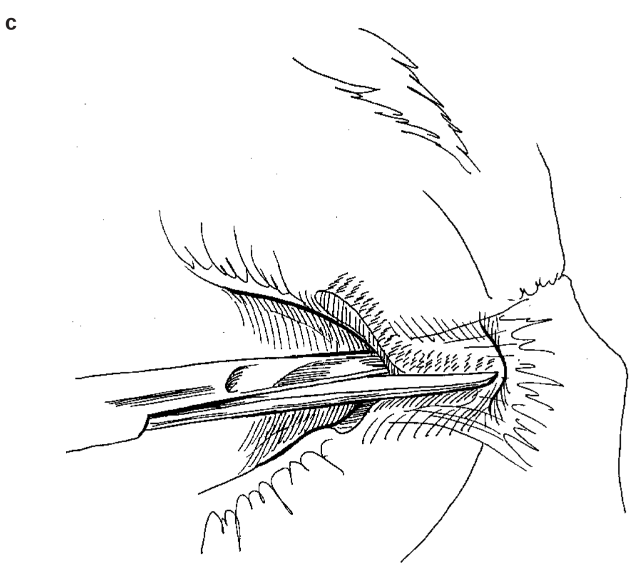


Fig. 6-12. Lateral canthotomy and inferior cantholysis are indicated for casualties presenting with serious orbital hemorrhage. These soldiers present with a history of trauma, decreased vision, firm proptosis, an abnormal pupil, and decreased motility. *Do not perform such procedures if the eyeball structure has been violated. If the eye is sliced open, apply a Fox shield for protection and seek immediate ophthalmic surgical support.* If the eyeball is intact, check the Madigan Eye and Orbit Trauma Score (MEOTS) categories: Vision, Eyeball Structure, Proptosis, Pupils, and Motility. Cut the lower lid if the orbit is swollen hard and is squeezing on an intact eyeball. The procedure is as follows:

a

b

Fig. 6-13. (**a**) Orbital hemorrhage following blunt trauma with a crowbar, in an alert soldier with no neck pain. An orbital hemorrhage is identified by the Madigan Eye and Orbit Trauma Scale (MEOTS) criteria of Vision: reduced to large print (MEOTS 2); Eyeball Structure: appears intact (MEOTS 3); Proptosis: firm (MEOTS 0) Pupil: dilated, poorly responsive right pupil with consideration of both orbital and potential neurosurgical causes (MEOTS 0); Motility: frozen right eye (MEOTS 0). (**b**) The result of a lateral canthotomy and cantholysis. A lateral canthotomy was performed, releasing the blinding pressure of a firm, swollen orbit. One week later, the Head and Facial Trauma Team returned the soldier to duty; he had regained completely normal function. MEOTS score: total 5 of 12.

Fig. 6-12. *continued*

(**a**) Step 1: Injection. Inject 3 mL of 2% lidocaine with epinephrine 1:100,000 in a single, slow, vertical injection. Inject lateral to the orbital rim, with the needle pass at a depth just beneath the skin. Apply gentle pressure for 2 minutes over the injection site and away from the eye.

(**b**) Step 2: Horizontal clamp. Clamp the lateral canthal tendon with a thin hemostat in a straight horizontal position, pulling away from the swollen eye.

(**c**) Step 3: Horizontal cut. Using scissors, make a 1-cm horizontal incision of the lateral canthal tendon in the middle of the crush mark.

(**d**) Step 4: With scissors parallel to the face and tips pointing toward the chin, cut the lower eyelid. Grasp the lateral lower lid with a large-toothed forceps, pulling the eyelid away from the face. This pulls the inferior crus (band) of the lateral canthal tendon tight as a rope so it can be easily cut loose from the orbital rim. You can "strum" this band with closed scissors to feel what needs to be cut. Use a pair of blunt-tipped scissors to cut the inferior crus. Keep the scissors parallel (flat) to the face with tips pointed toward the chin. Place the inner blade just anterior to the conjunctiva and the outer blade just deep to the skin. The eyelid should pull freely away from the face, releasing pressure on the globe. Cut residual lateral attachments of the lower eyelid if it does not move freely. (Remember, you can feel the residual attachment bands best when you grab the eyelid with forceps and pull toward the ceiling, making the bands tight and easy to cut.) Do not be concerned about cutting half a centimeter of conjunctiva or skin, just keep the scissors out of the eyeball and orbital fat.

(**e**) Step 5: Success. The lower eyelid has been cut, relieving orbital compression. Compression of vital vascular structures in the orbit has been reduced by releasing the restraining belt of the lower eyelid. As the edema and hemorrhage resolve, the eyeball will recede back into the orbital space. If the intact cornea is exposed, apply hourly copious erythromycin ophthalmic ointment or ophthalmic lubricant ointment to prevent devastating corneal desiccation and infection. Relieving orbital pressure must be followed by lubricating protection of the cornea and urgent ophthalmic surgical support. Do NOT apply absorbent gauze dressings over an exposed cornea. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

a

b

Fig. 6-14. (**a**) Orbital hemorrhage from a punch resulting in complete blindness. The severity of injury from optic nerve compression within a swollen orbit was not appreciated on initial presentation with Count Fingers vision under very swollen eyelids. Twelve hours after initial presentation, the soldier was urgently referred when he could no longer detect light in his left eye. The Madigan Eye and Orbit Trauma Scale (MEOTS) findings included Vision: No Light Perception (MEOTS 0); Eyeball Structure: intact (MEOTS 3); Proptosis: > 3 mm and rock hard (MEOTS 0); Pupil: dilated with a definite afferent pupillary defect (MEOTS 0); Motility: frozen (MEOTS 0). (**b**) Postlateral canthotomy and cantholysis. The soldier's vision remained at no light pereption (NLP) despite immediate action including canthotomy/cantholysis, 2.5 g intravenous methylprednisolone, and surgical decompression of the orbit. MEOTS score: total 3 of 12.

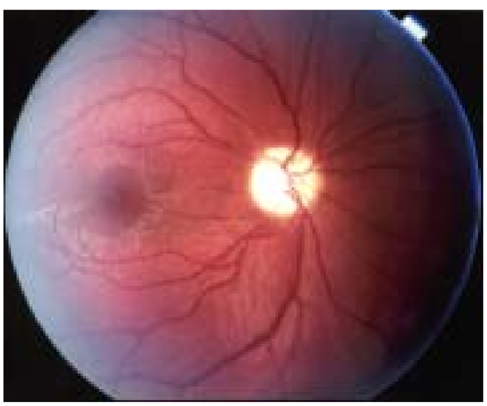


Fig. 6-15. Appearance of a blind optic nerve head 6 months after orbital compression. Gross pallor of the optic nerve head is a delayed finding when the optic nerve loses its blood supply in a rock-hard, traumatized orbit.

Fig. 6-16. Traumatic enucleation of the eye and extensive optic nerve segment. The delicate multiple penetrating blood vessels to the orbital section of the optic nerve (arrow) are at risk of compression in the setting of a firm orbital hemorrhage. This pathology specimen resulted from blunt trauma with extrusion of the globe and amputation of the optic nerve from the orbital apex. The specimen shows a clear view of the small blood vessels that nourish the orbital segment of the optic nerve.

Fig. 6-17. This 70-year-old woman fell; as a result, she had a superior globe displacement caused by an inferior orbital hemorrhage. The patient had a normal vision and pupillary examination with less than 3 mm of proptosis, which was managed medically with modest oral steroids. A lateral canthotomy was not required. MEOTS score: total 10 of 12.

Fig. 6-18. Severe orbital hemorrhage associated with a zygomatic-maxillary complex fracture, requiring emergent treatment. This patient developed progressive orbital hemorrhage from blunt trauma complicated by vomiting and ingestion of alcohol and aspirin. The Madigan Eye and Orbit Trauma Scale (MEOTS) findings included Vision: reduced to Count Fingers (MEOTS 1); Eyeball Structure: intact (MEOTS 3); Proptosis: gross (MEOTS 0); Pupil: dilated with definite afferent pupillary defect (MEOTS 0); Motility: frozen (MEOTS 0). This patient received an emergent canthotomy/cantholysis plus high-dose intravenous (IV) steroids. Decadron (dexamethasone; mfg by Merck & Co, West Point, Pa) was administered IV, with a loading dose of 0.5 mg/kg (35 mg), followed by 10 mg IV every 8 hours for six doses, followed by an oral taper of prednisone. Surgical repair of the displaced fracture was performed without complication 1 week after the injury. The patient regained normal function. MEOTS score: total 4 of 12.

a

b

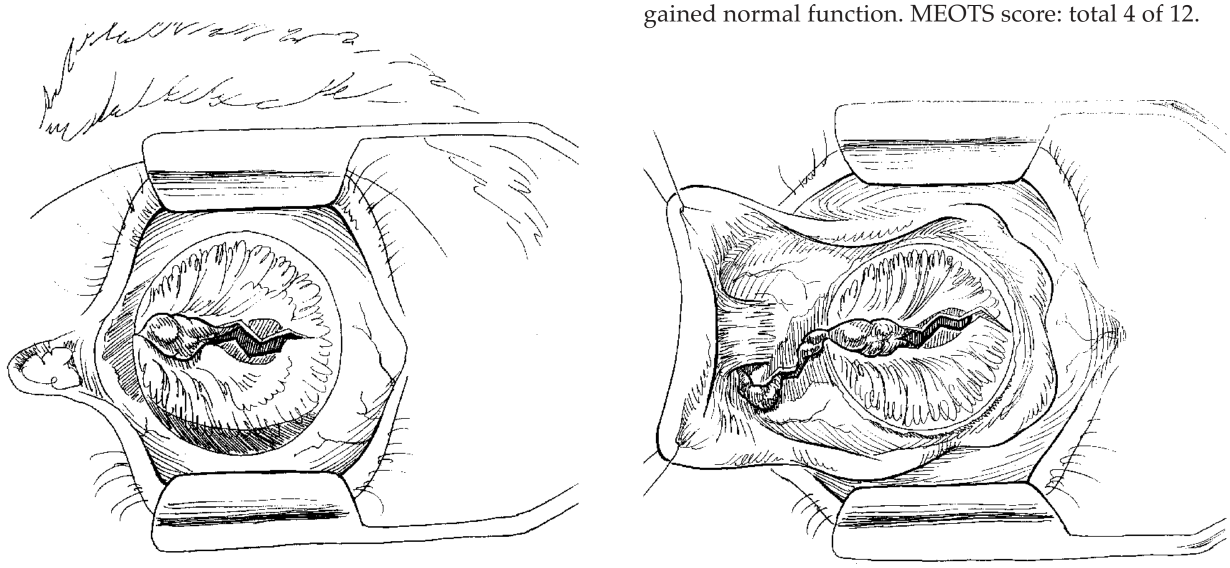


Fig. 6-19. For corneoscleral lacerations, the extent of injury is a critical predictive factor of visual outcome. (**a**) Following wound exploration the laceration was 11 mm in length. (**b**) In a different patient, after wound exploration the laceration was 21 mm in length, with a far worse prognosis.[1] (1) Grossman MD, Roberts DM, Barr CC. Ophthalmic aspects of orbital injury. *Clin Plast Surg*. 1992;19:71–85. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

in the aid station training room of any field or emergency trauma unit.

Prognostic Applications of Ocular Trauma Scales

Predicting visual outcomes is a major feature of a number of civilian and military ocular trauma scores. Numerous studies have shown that initial vision, extent of initial damage, and mechanism of injury are most predictive of ocular trauma outcome (Table 6-2; also see Figure 6-19). Although these concepts are valid, we must be vigilant in distinguishing between a civilian database and a battlefield environment. Many of these scales are not designed for battlefield use. The mechanism and extent of injuries are often restricted to subsets of mechanical globe injuries. IOFBs, complex contaminated injuries, burns, and chemical and craniofacial trauma are often not included.[11,12,16–18] In an excellent study regarding prognostic factors of corneoscleral lacerations, Barr[16] found the overall early (< 10 d) enucleation rate was 17%. This database of corneoscleral lacerations excluded injuries from retained IOFBs, globe perforation, burns or chemical injuries, and blunt trauma. Wartime experience has no such exclusion criteria; therefore, it is difficult to compare such studies to the enucleation rates following disruption of the globe during the Vietnam War (50%)[6,9] or the Persian Gulf War (18%).[7] These wartime enucleation rates represent the surgical outcomes of a very different group of wounds and battlefield circumstances.[6,7,9] However, keeping in mind the differences that exist in wartime, the prognostic applications of ocular trauma scales are worthy of examination.

The Ocular Trauma Score (OTS) developed by May and colleagues[10] is a product of the United States Eye Injury Registry and the Hungarian Eye Injury Registry. This group evaluated more than 2,000 mechanical injuries to the globe over a 10-year period. Initial vision was the most important predictor of final visual outcome. Probability of visual outcome at 6 months was further refined by adding the following predictive factors: globe rupture, endophthalmitis, perforating injury, retinal detachment, and the presence of an APD.

Next on the list of important predictors of final visual outcome, according to several major studies,[11,16–20] is the extent of injury (see Table 6-2). In a major study[13] of prognostic factors in corneoscleral lacerations, poor initial vision and extent of trauma, including the length of the corneoscleral laceration, were predictive of outcome. In this study, the enucleation rate was 4% for lacerations less than 9 mm in length and 68% for more-extensive lacerations (13–32 mm long) (see Figure 6-19).

Defining the posterior extent of injury is a major contribution of the Ocular Trauma Classification Group's classification of mechanical ocular injuries.[11] Patients were divided into two injury groups: those with open globe injuries and those with closed. The predictive factors supported by the study are the type of injury, initial vision, presence of an APD, and zone of injury.

In open globe injuries, the zones of injury are classified as I: corneal-limbal wounds; II: corneal scleral wounds less than 5 mm posterior to the limbus; and III: wounds extending more than 5 mm posterior from the limbus. Numerous studies[12,16,17,19,21–23] have identified the adverse relationship of posterior uveal prolapse; vitreous hemorrhage; and extrusion of intraocular contents with longer, more posterior wounds. A major contribution of the Ocular Trauma Classification Group study was this concept of posterior zone (III) wounds.

Mechanism of injury is another critical predictive factor, in addition to initial vision and extent of trauma. De Juan and colleagues[17,19] showed that blunt trauma and perforating injuries have significantly worse outcomes than injuries from sharp objects or penetrating missiles. However, military ophthalmologists must keep in mind that there is a great difference between the mechanism of an injury encountered in a civilian industrial setting and one encountered in a wartime environment. This difference is most evident with fragmentation wounds. Battlefield fragmentation wounds are not like metallic chips from hammers and chisels. If we consider only nonfatal injuries, then ocular fragmentation wounds from munitions tend to be caused by multiple, high-velocity, contaminated missiles (see Figure 6-2). Mechanism of injury is *the* critical prognostic factor that is most likely to be different in a battlefield versus a civilian database.

Command Perspective of Ocular Trauma Scales

Ocular trauma scales and trauma registries are critical elements of an effective command brief on ocular trauma. Only at the command level can we convert lessons learned by individual surgical units into broad, effective action. The critical message is that ocular trauma that degrades a soldier's ability to fight is a common battlefield event. The most vital command aspects of ocular trauma are prevention and ophthalmic surgical readiness.

TABLE 6-2

PROGNOSTIC FACTORS OF VISUAL OUTCOME

Study	Prognostic Factors of Visual Outcome	Comments
Ocular Trauma Score[1]	Initial visual acuity Globe rupture Endophthalmitis Perforating injury Retinal detachment Afferent pupillary defect (APD)	Initial vision is the most important predictor of final visual outcome. Cases limited to mechanical, nonburn eye injuries.
Prognostic Factors in Corneoscleral Lacerations[2]	Initial visual acuity Amount of hyphema Presence of posterior uveal prolapse or vitreous hemorrhage Length of laceration Extent of lens damage	Enucleation rate was 4% for lacerations < 9 mm and 68% for lacerations of 13 to 32 mm. Excluded from the study were all patients with retained intraocular foreign body (IOFB) or perforating globe injuries.
Penetrating Ocular Injuries: Types of Injuries and Visual Results[3]	Initial visual acuity Presence of an APD Type of injury Location and extent of penetrating wound Type of lens damage Presence and severity of vitreous hemorrhage Type of IOFB	This study emphasizes that the prognosis after penetrating injury is strongly influenced by the nature of the injury and the extent of initial damage. Blunt trauma has a less favorable outcome compared with sharp lacerations or missile injuries.
Multivariate Analysis of Prognostic Factors in Penetrating Ocular Injuries[4]	Initial visual acuity Mechanism of injury: blunt, sharp, or missile Length and location of laceration Laceration limited to the cornea Laceration anterior to the rectus muscle insertion Expulsion of the lens Posterior scleral laceration Severe vitreous hemorrhage Presence of an APD BB pellet IOFB	Initial vision and extent of injury are the most critical predictive factors of visual outcome. 12 eyes had BB pellet IOFB injuries. None of these patients achieved a final visual acuity of 20/800 or better.
Factors Influencing Final Visual Results in Severely Injured Eyes[5]	Visual-evoked potential Initial visual function Extent of injury	Study relies on visual-evoked potential as a gauge of central visual function in severely injured eyes. Damage to either the macula or optic nerve causes reduction in amplitude of the visual-evoked potential.

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The military need for protective eye armor is clear and well established.[6,7,9] Small fragments that might be stopped by the battle dress uniform and the skin may, even from a great distance, penetrate the eye.[5] Polycarbonate eye armor could prevent many of the small-fragment injuries and countless corneal FBs that degrade a soldier's ability to fight.[5–9,24]

The second critical command brief message is that ophthalmologists are required members of an effective head trauma team. Soldiers with craniofacial injuries frequently suffer occult, severe ocular trauma.[9] Combat eye injuries are rarely limited to the globe. In the 1967 Arab–Israeli Six-Day War, 72% of the ocular injuries had associated wounds, most commonly to the head and neck.[14] In his personal account of Vietnam War injuries, Hornblass[9] stressed the importance of including senior ophthalmologists in forward-positioned head-and-neck trauma teams. La Piana and Mader strongly support this concept (see Chapter 2, Lessons Learned), based on their experiences in the Vietnam War and the Persian Gulf War. These experienced leaders remind us that military ophthalmologists must work aggressively within the chain of command to obtain adequate resources, equipment, and experienced personnel to restore injured soldiers with ocular and orbital injuries.

SUMMARY

Ocular trauma scales in various forms are a vital aspect of effective triage and wartime readiness training. Trauma scales provide a triage and training framework that strengthens our ability to restore soldiers with eye and orbital injuries. Recognition of common injury patterns facilitates command input for prevention and combat health-support planning. Small, high-velocity fragments from munitions caused 78% of the serious ocular and ocular adnexal injuries during the Persian Gulf War; military command structure must be informed of such injury patterns to initiate protective eye armor measures.

Trauma scales and eye injury registries support critical efforts to obtain the equipment and trained personnel necessary to restore soldiers with sight-threatening injuries. In 1974, it would have been easy to overlook the value of a head trauma scale that evaluated such basic elements as eye opening and verbal and motor responses. Yet the Glasgow Coma Scale has provided the critical function of defining severe head trauma, providing a common language, and improving triage communication. We must seek the same benefit for soldiers with eye and orbital injuries. MEOTS, a triage training module developed at Madigan Army Medical Center, Tacoma, Washington, provides for recognition of immediate vision-threatening injuries and triggers urgent intervention, coordinated evacuation, and surgical support—all of which should make MEOTS a valuable tool on the battlefield. The use of MEOTS and other trauma scales improves triage, initial stabilization, coordinated evacuation, and utilization of surgical teams. MEOTS strengthens each link in the treatment chain and thus improves our capacity to provide effective ophthalmic combat surgical support.

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