Chapter 14

MANAGEMENT OF PENETRATING INJURIES WITH A RETAINED INTRAOCULAR FOREIGN BODY

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INTRODUCTION

Penetrating ocular injuries with an associated retained intraocular foreign body (IOFB) constitute a significant portion of ocular trauma in the military. A steady increase in eye-related injuries, from 2% during World War I and World War II to 13% in the Persian Gulf War, could be attributed to the evolution of modern warfare this century.[1,2] The lethality to the eye has increased, owing to the use of new technology in weapon systems such as improved fragmentation munitions, which produce large numbers of tiny fragments. With this increase in ocular trauma, penetrating injuries with associated IOFBs account for 31% to 85% of significant injuries to the eye (Table 14-1).

In the past 2 decades, advances in understanding the pathophysiology of traumatic injuries to the retina and vitreous as well as new vitreoretinal surgical techniques have made management of traumatized eyes with IOFBs more predictable. With the evolution of these advancements, a new expediency in diagnosis and management of retained IOFBs challenges today's military ophthalmologists. Whether timely and prompt management will save or improve vision in those who sustain eye injuries in future armed conflicts remains to be determined.

The setting and occurrence of penetrating injuries with retained IOFBs have evolved as society and industrialization evolved in the 20th century. With the emergence of an industrial base, occupational eye injuries were far more common in the city, compared with rural agrarian settings. From a military perspective, non-warfare-related injuries mirrored those of occupational and accidental injuries. The setting of warfare-related eye injuries, however, was directly related to the type and use of armaments generating high-velocity metal fragments.

TABLE 14-1

INTRAOCULAR FOREIGN BODIES IN WAR

War	Penetrated Eyes With Retained IOFBs (%)	Nonmagnetic IOFBs (%)	Enucleation Resulting From IOFBs (%)
WW2 (US Army)[1]	63.7	55.4	30.8
WW2 (British Army: Libyan campaign 1941–1943)[2]	75.3	—	25.4
Vietnam[3]	32.7	22.2	—
Arab–Israeli Six-Day War (in Jerusalem)[4]	65.3	17.6	11.8
Arab–Israeli Six-Day War (compiled record, all cases)[5]	42.9	23.8	—
Lebanon[6]	84.6	66.7	27.3
Iran–Iraq[7]	31.1	90	—
Persian Gulf[8]	32.7	—	—

—: data not reported
IOFB: intraocular foreign body
Data sources: (1) Bellows JG. Observations on 300 consecutive cases of ocular war injuries. *Am J Ophthalmol.* 1947;30:309–323. (2) Dansey-Browning GC. The value of ophthalmic treatment in the field. *Br J Ophthalmol.* 1944;28:87–97. (3) Hoefle FB. Initial treatment of eye injuries. *Arch Ophthalmol.* 1968;79:33–35. (4) Gombos GM. Ocular war injuries in Jerusalem. *Am J Ophthalmol.* 1969;68:474–478. (5) Treister G. Ocular casualties in the Six-Day War. *Am J Ophthalmol.* 1969;68:669–675. (6) Moisseiev J, Belkin M, Bartov E, Treister G. Severe combat eye injuries in the Lebanon War. *Isr J Med Sci.* 1984;20:339–344. (7) Lashkari K, Lashkari M, Kim A, Crane WG, Jalkh AE. Combat-related eye trauma: A review of 5,320 cases. *Int Ophthalmol Clin.* 1995;35:193–203. (8) Mader TH, Aragones JV, Chandler AC, et al. Ocular and ocular adnexal injuries treated by United States military ophthalmologists during Operations Desert Shield and Desert Storm. *Ophthalmology.* 1993;100:1462–1467.

Occupational and Domestic Perspectives

Since antiquity, open globe injuries with a retained IOFB have intrigued and dismayed those caring for the eye. In industrialized European cities at the turn of the 20th century, the incidence of retained IOFBs was one per 1,000, but in rural cities the incidence was markedly lower. Worldwide, the percentage of ocular injuries with a retained IOFB has remained remarkably consistent over the years. In an industrial series out of the Munich Clinic[3] in 1933, penetrating injuries with a retained IOFB accounted for 39.2% of cases, with two thirds of IOFBs located in the posterior segment. More recently, the National Eye Trauma System Registry[4] reported a retained IOFB present in 35% of the injured workers between 1985 and 1991, with a trend toward stable or improved vision following treatment.

From an occupational or accidental viewpoint, the etiology of most retained IOFBs was an isolated metal projectile generated by hammering metal on metal. Less-frequent causes were handling wire, welding, drilling, grinding, and working with machinery; wood was an even less frequent source of IOFBs. In the occupational setting, an injury involving both eyes with IOFBs or one eye with multiple IOFBs is rare.[5]

In the military, the nature of IOFBs unrelated to combat mirror those in the occupational series. An unpublished series from Brooke Army Medical Center,[6] for example, showed that 50% of IOFBs resulted from metal striking metal. Explosions producing fragments accounted for another 29% of IOFBs (Figure 14-1).

Military Perspective

Warfare-related wounds, on the other hand, tend to be different from occupational and accidental trauma. War-induced, penetrating ocular injuries typically result from shell fragments, grenades, bullets, mines, booby traps, and armored warfare. Clearly, the risk of ocular injury during modern warfare depends on the strategy through which commanders utilize their forces and weapons. Not surprisingly, the incidence of IOFBs is higher in situations involving armor, artillery, and mine warfare. Exploding fragmentation munitions cause multiple, high-velocity, fragment injuries not only adjacent to but also up to several hundred feet away from the blast. These injuries typically involve multiple IOFBs, affect the posterior segment, and often result in bilateral ocular injuries. The incidence of

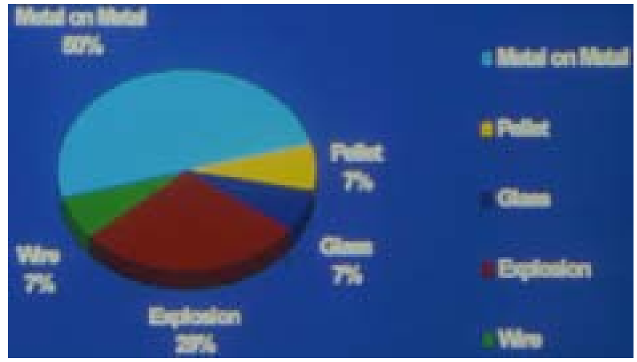

Fig. 14-1. Etiology of penetrating intraocular foreign bodies managed at Brooke Army Medical Center from 1982 to 1993.

these injuries with IOFBs can be modified by the aggressive use of eye protection (eye armor) introduced in the 1980s to protect the warrior's vision.

The composition of the IOFB in warfare has major treatment implications. Whereas only 10% of retained IOFBs in the industrial and accidental setting are nonmagnetic, up to 90% are nonmagnetic in war (see Table 14-1).[7,8] These nonmagnetic IOFBs cannot be removed with external magnets. For example, landmines are increasingly composed of plastic and synthetic materials, making detection of IOFBs more difficult.[9]

As in occupational settings, the size and shape of the IOFB has a direct effect on visual outcome. The concussion of a large IOFB severely disrupts all layers of the eye. Larger, blunt IOFBs frequently result in a poorer visual prognosis, whereas small, sharp projectiles may penetrate cleanly with minimal disruption of ocular architecture.[10,11]

Penetrating ocular injuries with retained IOFBs are usually associated with multisystem trauma and generally occur on battlefields remote from specialists. Frequently, definitive treatment tends to be delayed. These wounds require initial stabilization by a multispecialty team performing surgery to save life and limb. The ophthalmologist contributes with repairs to the open globe and ocular adnexa within the theater. Current medical doctrine advocates prompt aeromedical evacuation to permit a vitreoretinal specialist located in the communication zone to remove the IOFB and manage any other vitreoretinal complications associated with the initial trauma. The delay in final repair and the means of transport must be considered when managing penetrating eye injuries with an IOFB.

The introduction of pars plana vitrectomy in the 1970s resulted in new techniques to permit controlled access to IOFBs and related intraocular complications. Only recently have modern vitreoretinal techniques been used to treat penetrating war injuries with IOFBs.[8,12] With changing strategies in managing war injuries, miniaturization of instrumentation, and changing medical doctrine, specialists are now available closer to the battlefield to manage serious ocular injuries. Time will tell whether the new technologies will improve the outcome from potentially blinding battlefield wounds.

POTENTIAL COMPLICATIONS

The severity of complications related to an IOFB in conjunction with a penetrating injury is generally related to the site of the initial impact, size of the entry wound, composition of the IOFB, and presence of an exit wound. A smaller IOFB usually results in fewer complications and better visual results.[13] These complications and their management have an impact on salvaging vision and the globe.

Anterior segment complications include corneal and corneoscleral lacerations, penetration or perforation, lenticular perforation, cataract, retained IOFB within the anterior chamber, hyphema, and angle recession. Most projectiles associated with combat-related ocular injuries have relatively high mass and velocity, causing them to perforate the anterior segment or sclera or both and come to rest in the posterior segment.[8,14,15]

With posterior segment involvement, the ocular complications are frequent and the resultant vision often worse.[7,16] Posterior segment complications typically involve vitreous or preretinal hemorrhage, retinal tear, retinal detachment, incarcerated retina, endophthalmitis, epiretinal membrane formation, the physiological effects of a retained IOFB, and sympathetic ophthalmia. Typically, vitreous or preretinal hemorrhage accompanies the retained IOFB, often obscuring retinal details. This vitreous hemorrhage may be extensive, preventing identification of the foreign body (FB) and associated retinal damage such as retinal holes, tears, or detachments. Ancillary testing is vital for determining the presence of an IOFB or associated complications when confronted with opaque vitreous. The findings of additional complications on ancillary testing determine the course and timing of surgical intervention.

Vitreous Hemorrhage

Vitreous hemorrhage initially does not cause damage. However, the organization of the hemorrhage, its fibrocellular contents, and inflammatory elements from the initial injury within the vitreous scaffold promote the development of fibrous contractile tissue. This tissue contracts over time, causing either traction on the retina and ciliary body and subsequent tractional retinal detachment or hypotony. This retinal traction, which can be anterior–posterior, circumferential, or subretinal, is directly attributable to the initial penetrating injury.[17]

Retinal Tears and Detachments

A retinal tear or break occurs either when the IOFB strikes or embeds in the retina or from the mechanical blunt trauma of the IOFB striking the globe. This complication may be obscured by a dense vitreous hemorrhage and so may not be detected initially. Unrecognized retinal tears or breaks can be the source for rhegmatogenous (rhegma, Greek for *rent*) retinal detachments. Early recognition of these tears or breaks and appropriate management may prevent retinal detachments (Figure 14-2).

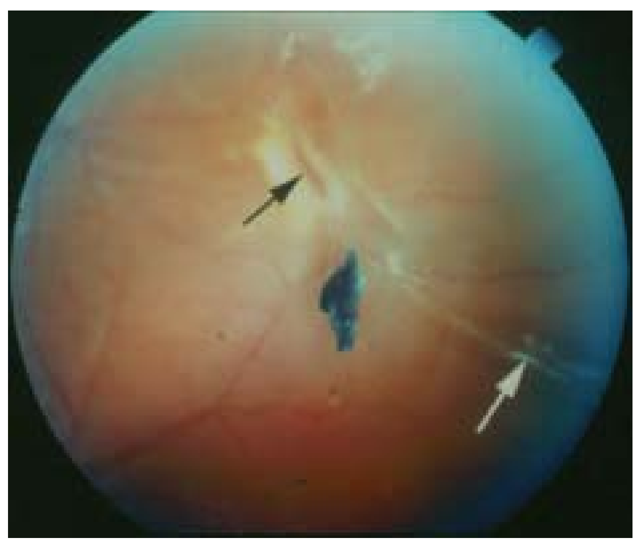

Fig. 14-2. This posterior segment photograph reveals a black retained metallic intraocular foreign body (IOFB, center) within the vitreous and the associated retinal detachment. The IOFB struck the retina, creating a retinal hole (dark arrow) causing this retinal detachment. A track of old vitreous blood is seen streaking from the entry wound to the retinal hole (white arrow). Photograph: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

Retinal detachments, either rhegmatogenous or tractional, can complicate these penetrating injuries. Tractional detachments typically occur days to weeks after the injury. A rhegmatogenous retinal detachment is frequently a result of the initial trauma. This complication results from retinal lacerations or retinal breaks as a result of the mechanical disruption of the retina, the vitreous, or both.

Although an acute retinal detachment may be obscured by dense vitreous hemorrhage, it can easily be detected with echography. Echography should be performed as soon as safety permits, because the detection of an early retinal detachment would prompt pars plana vitrectomy. These detachments frequently do well with vitreoretinal surgery. Reactivation of intraocular bleeding during early repair of traumatic retinal detachment usually portends a poorer prognosis and can frequently be avoided if vitrectomy is delayed from 7 to 14 days.[18]

Incarceration of the retina, specifically posteriorly, through the sclera generally has a poorer prognosis. Either posterior extraction of the subretinal or intraretinal IOFB or impaction of the FB into the sclera causes retinal incarceration. This incarceration results in retinal traction, which frequently leads to retinal tears and detachment. This complication is repaired using scleral buckling, vitreoretinal techniques, or both.

Endophthalmitis

Infectious endophthalmitis is an uncommon but urgent concern when associated with a retained IOFB. The incidence of endophthalmitis with a retained IOFB is approximately 7% to 13%.[13,19] Compounding this complication is the difficulty in diagnosing endophthalmitis in the setting of acute trauma.[7,19–23] Several factors determine whether the severely injured eye develops clinical endophthalmitis. One series[22] reported 26% of eyes with positive surveillance intraocular cultures, although only 13% developed culture-proven endophthalmitis. Of particular note, a high incidence of *Bacillus cereus* endophthalmitis associated with retained IOFB has been reported[7,24] with rapid clinical onset and abysmal loss of vision and the eye. *Bacillus cereus* endophthalmitis is associated with organic contamination of the IOFB from the soil, which may be of particular military significance because of the increased use of landmines.[20] (For additional information, interested readers should consult Chapter 17, Posttraumatic Endophthalmitis, in this textbook.)

Inflammatory Changes and Physiological Effects

Epiretinal membranes are fibrocellular sheets on the surface of the retina that are composed of a variety of cells such as fibrous astrocytes, fibrocytes, retinal pigment epithelial (RPE) cells, macrophages, and fibrous tissue. The formation of an epiretinal membrane is frequently caused by penetrating injuries and is due to the presence of blood in the vitreous, choroidal hemorrhage under the retina, or a hole or tear in the retina. The contraction of these cellular elements contorts the retinal surface and distorts central vision. Cystoid macular edema and retinal traction can also result from these membranes. Epiretinal membranes may account for poor central vision despite successful IOFB removal.[25]

The physiological effects of a retained IOFB depend on its composition and whether it generates an inflammatory response (Exhibit 14-1). An acute inflammatory reaction surrounding the IOFB can obscure its location or cause adhesion between the vitreous and the retina. This fibrous tissue can cause traction or rhegmatogenous retinal detachments. An IOFB composed of iron or copper retained for a prolonged period of time can result in siderosis (iron) or chalcosis (copper), as discussed in Chapter 15, Metallosis Bulbi.

Although initial management of metallic IOFBs frequently involves their removal, recent evidence suggests that in certain cases, patients with retained IOFBs may do well with careful observation and monitoring.[26] The indication for removal depends more on the associated trauma created by the IOFB than the FB itself. The presence of mitigating factors, such as a small, peripheral entry site, minimal vitreous hemorrhaging, absence of traumatic cataract, lack of retinal holes or tears, or minimal peripheral vitreoretinal traction would allow close observation rather than immediate removal of the IOFB. However, a large entry site, significant vitreous hemorrhage, possible retinal holes or tears, retinal traction, or retinal detachment would suggest intervention with pars plana vitrectomy and IOFB removal.

Sympathetic Ophthalmia

Sympathetic ophthalmia is a rare complication of penetrating injuries with an IOFB; there have been no reported cases in military conflicts since World War II.[27–30] Five enucleated eyes from World War II were examined at the Armed Forces Institute of Pathology. Four eyes contained nonmagnetic

EXHIBIT 14-1

COMPOSITION OF INTRAOCULAR FOREIGN BODIES

Inert or Precious Metals
- Glass
- Porcelain
- Plastic
- Gunpowder
- Sand
- Coal
- Concrete
- Rubber (organic)
- Silver
- Quartz
- Stone
- Rock
- Cordite
- Clay
- Carbon
- Solder (two parts lead to one part tin)
- Gold
- Platinum

Somewhat Inert
- Lead (shot)
- Zinc
- Aluminum
- Cotton fiber

Inflammatory
- Copper
- Nickel
- Steel
- Iron
- Mercury
- Vegetable matter (contaminated)

Source: Duke-Elder S, MacFaul P. Inert materials. In: Duke-Elder S, ed. *System of Ophthalmology.* Vol 14. St Louis, Mo: CV Mosby; 1972: 501–551.

IOFBs, whereas the fifth contained a metallic IOFB. Most of the patients involved had retained the IOFBs for 2 months to 36 years with vague clinical histories.[31] Clearly, advances in managing penetrating trauma have nearly eliminated this devastating complication. (For further information, interested readers should see Chapter 16, Sympathetic Ophthalmia, in this textbook.

CLINICAL HISTORY AND EXAMINATION

Military ophthalmologists should understand and utilize the latest classification for mechanical injuries of the eye, such as the Ocular Trauma Classification Group[32] or the proposed Madigan Eye and Orbit Trauma Scale (MEOTS),[33] which are used to standardize how ocular trauma is classified and how outcomes are reported. (For further information, see Chapter 6, Ocular Trauma Scales.) For example, the Ocular Trauma Classification Group system uses the type of injury, the grade of visual acuity, pupil reactivity, and the location of injury for purposes of standardization and prognostic significance. Using this classification, an eye with a retained IOFB would be classified as an open globe injury with laceration and IOFB. The grade is based on the visual acuity, the presence or absence of an afferent pupillary defect, and the location of the penetration by zone. Consistent use of one or the other classification groups can improve communication between specialists.

History

Although basic techniques in the ocular history and examination were covered previously (see Chapter 3, Ocular Trauma: History and Examination), specific salient features related to IOFBs are important for proper management. A complete accounting of the nature and circumstances of the initial and associated injuries is vital. This information should be obtained directly from the patient, indirectly from accompanying individuals, or from the triage card accompanying the soldier. The circumstances surrounding the initial injury are helpful when discerning the risk of an IOFB (eg, was the patient using a tool while repairing a vehicle, working with explosives, or surrounded by exploding shells and gunfire?). It is also helpful to know if protective eyewear or glasses were worn.

While documenting the ocular history, the past ocular history is important for determining the visual prognosis. A history of poor vision from preexisting disease or trauma is common and may be related to a history of amblyopia (crossed eyes or lazy eye), previous ocular trauma, or surgery. For disability and medicolegal considerations, determining a preinjury visual acuity is beneficial.

Previous ocular surgical interventions related to the initial injury must be clearly documented as the patient proceeds through the military health care system. From the time of injury until final disposition, a careful detailed accounting of procedures, including tetanus history and diagnostic tests, should be documented and transferred with the patient. The details and timing of primary globe repair, observations at the time of surgery to include the extent of the wound, management of prolapsing intraocular contents, and associated complications during the repair need to be documented clearly. Should intraocular tissue be removed during the initial repair of the globe, the histopathological findings should be forwarded with the patient's record. This information is essential when determining further management. The use of prophylactic antibiotics, route of administration, duration, and type should be documented for assisting subsequent management. Notation of the best visual acuity following initial repair is also beneficial when determining subsequent management.

Fig. 14-3. External photograph showing a subconjunctival hemorrhage covering the penetration site of a retained intraocular foreign body (IOFB). A penetration site from a small foreign body frequently appears harmless; a high index of suspicion based on clinical history leads to a dilated posterior segment examination with discovery of the IOFB or other signs suggestive of the presence of a foreign body. Photograph: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

Examination

A complete ocular examination is critical to determine the extent and degree of the injury. Direct visualization is the best diagnostic method for determining type, quantity, and potential composition of the IOFB. General anesthesia may be required to perform a thorough eye examination safely without further extruding intraocular contents.

All traumatic ocular injuries need to have an initial visual acuity documented. The presenting visual acuity is the most important prognostic indicator for final visual outcome. Since an initial vi-

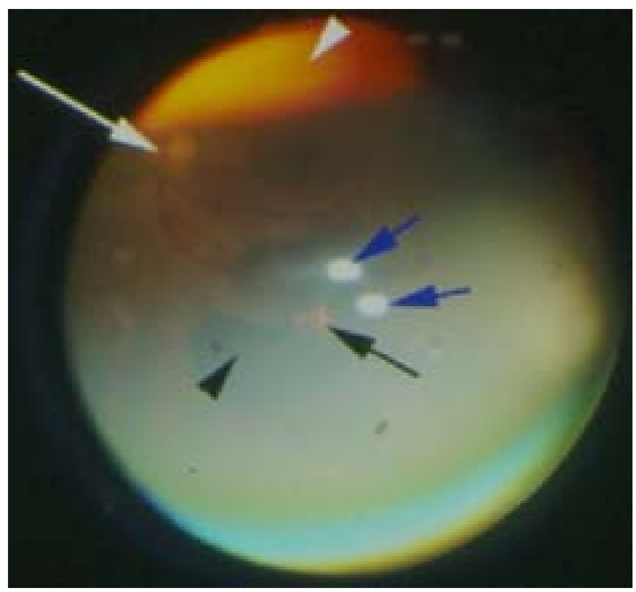

Fig. 14-4. This fundus photograph through a 20-diopter lens shows a fresh preretinal hemorrhage (black arrowhead) nearly covering a retained intraocular foreign body (IOFB; black arrow). Prompt retinal examination through a dilated pupil is critical to visualize the IOFB before hemorrhage, inflammation, or cataract obscures the view. The optic nerve (white arrow) and retinal arteries and veins are noted. The two elliptical white spots (blue arrows) and the orange ellipse (white arrowhead) are light reflections. Photograph: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

sual acuity of no light perception (NLP) carries a grave prognosis, assessment using the light source from the indirect ophthalmoscope set on high intensity is essential. Careful attention in patching the uninjured eye or covering it well when eliciting light perception is important in verifying NLP of the injured eye.

The presence or absence of an afferent pupillary defect (APD) also has prognostic implications. Some series suggest a worse prognosis for patients presenting with an initial APD.[12]

Clues from the motility and slitlamp examinations can support the presence of an open globe. The motility of the eye may be restricted because of a lack of scleral integrity from the perforation or penetration. Slitlamp biomicroscopy aids in detecting subtle conjunctival chemosis, subconjunctival hemorrhage (Figure 14-3), penetration or laceration of the cornea or limbus, deepened anterior chamber, microscopic or frank hyphema, as well as FBs of the cornea, anterior chamber, iris, and crystalline lens. Careful inspection of the anterior vitreous may reveal hemorrhage or stranding of the vitreous mixed with blood extending from the site of ocular penetration into the eye.

Prompt fundus examination of ocular trauma is imperative. Delay in examining a penetrating injury with a retained IOFB may result in an obscured view of the IOFB or retina from hyphema, cataract formation, or vitreous hemorrhage (Figure 14-4). Other complications such as a retinal tear, detachment, or dialysis may be missed or unsuspected. The examiner should note all IOFBs and their locations. A drawing of the retina to document the location and size of the IOFBs and associated complications is beneficial. This drawing should accompany the patient. A clue to the location of the IOFB is stranding of the vitreous and blood tracking to the resting location of the IOFB within the vitreous, retina, choroid, or exit site from the globe (see Figure 14-2).

DIAGNOSTIC IMAGING

In addition to the complete ocular examination, imaging of an ocular penetrating injury to rule out the presence of an IOFB is critical to the visual outcome of the eye. If corneal edema, hyphema, traumatic cataract, or vitreous hemorrhage preclude a thorough posterior segment evaluation for a retained IOFB, ancillary studies such as echography, radiographic imaging, or computed tomography (CT) should be performed to exclude a retained FB. Magnetic resonance imaging (MRI) should be discouraged because the strong magnetic fields generated can shift iron-containing FBs and create further intraocular damage. However, should a CT confirm a nonmetallic IOFB, an MRI would be superior to CT for detecting a piece of wood or plastic ranging in size from 3 to 5 mm.[34]

Plain Film Radiography

When used in conjunction with a clinical examination suggesting a possible IOFB, plain film radiographs are useful for identifying and localizing the object. Bray and Griffiths[35] reported that in no case was an IOFB detected on plain film radiograph without evidence of ocular penetration. The presence of any media opacification to the posterior segment should alert the examiner to the potential for an IOFB.

In battlefield settings, the use of dental film with dental X-ray capability can determine the presence or absence of a metallic IOFB. Wood and plastic are not visualized as easily.

Computed Tomography

As was discussed in Chapter 4, Imaging of Ocular and Adnexal Trauma, localization of an IOFB by CT is considered the standard. Thin, 1.5-mm axial sections at 1-mm intervals provide overlapping images (called stacks) and can frequently detect even the smallest IOFBs. CT imaging can detect an IOFB as small as 0.048 mm^3 for metallic objects and 1.82 mm^3 for automobile glass.[36,37] Advantages of CT scanning include the need for only minimal patient cooperation, no need for contact with the globe, the ability to localize anterior FBs, and the ability to image nonopaque materials such as wood, plastic, and glass.[38]

Nevertheless, CT scanning can miss multiple, small IOFBs that are masked by scanning artifacts cast by larger adjacent IOFBs (Figure 14-5). Wood and plastic are poorly imaged, and IOFBs that either are embedded in the retina or located posterior to the globe are frequently missed.[39,40] One report[40] suggests that metallic IOFBs smaller than 1 mm in size are difficult to image.

Echography

Echography (or ultrasonography) is excellent for detecting and localizing an IOFB and for assessing intraocular complications. However, *direct-contact echography of a suspected open globe is contraindicated for fear of expelling intraocular contents.* With the ad-

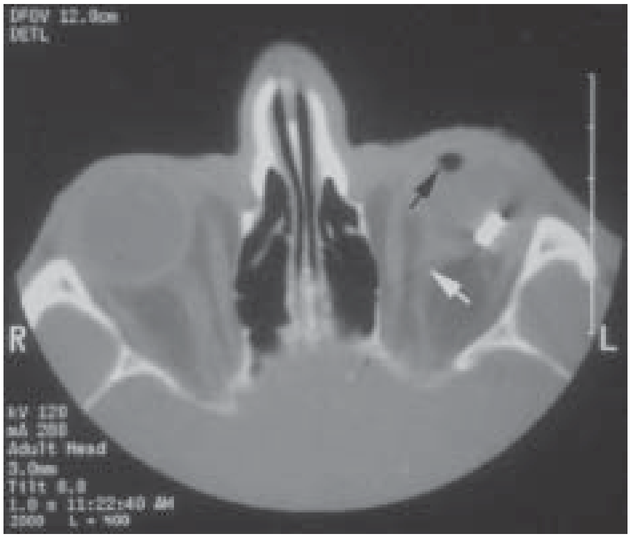

Fig. 14-5. A computed tomography (CT) scan of a large retained intraocular foreign body (IOFB, white rectangle) with intraocular air (black arrow) and radiating scanning artifact from the metallic IOFB (white arrow). Computed tomography scan: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

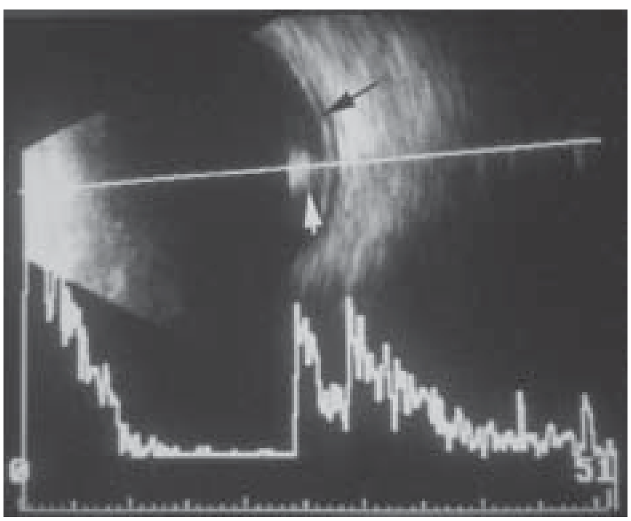

Fig. 14-6. A combined A- and B-scan ultrasound of a penetrating injury with retained metallic intraocular foreign body (IOFB). The vector line for the A-scan passes through the metallic foreign body and indicates an initial high reflectivity spike and high internal echoes, indicated by the A-scan scale at the bottom of the scan. On the B-scan, the white arrow demonstrates “tailing” of echoes posterior to the metallic foreign body. The black arrow shows a low-lying retinal detachment. Echography scan: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

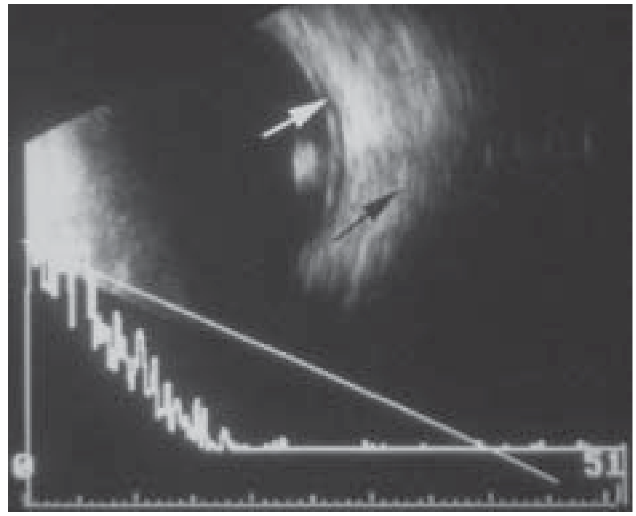

Fig. 14-7. A combined A- and B-scan ultrasound of a penetrating injury with retained metallic intraocular foreign body (IOFB). The vector line for the A-scan has been moved to show the shadowing behind the IOFB and the anechoic zone extending into the sclera (black arrow). Note the low-lying retinal detachment caused by a hole from the IOFB (white arrow). Echography scan: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

vances in electronic miniaturization, portable echography is readily available at forward locations on the battlefield to evaluate ocular injuries with an IOFB. Ultrasonic characteristics of an IOFB include

- high initial reflectivity,
- high internal echoes,
- tailing of echoes behind the IOFB, and
- shadowing behind the FB from absorbed sound waves, which result in an anechoic zone behind the IOFB (Figures 14-6 and 14-7).

The IOFB can be located by using as landmarks other ocular structures or tissue changes such as vitreous hemorrhage, choroidal detachment, and retinal detachment.

Studies also show that echography can determine the extent of such injuries as retinal detachment, subretinal hemorrhage, massive choroidal effusions, and hemorrhage that affect the visual prognosis. This information affects decisions about the surgical removal of the IOFB.[41,42] Echography after globe repair is also helpful for establishing other complications such as retinal detachment.

MANAGEMENT

The meticulous, prompt closure of any breach of the globe is a prerequisite for successful management of a retained IOFB. Whether IOFB removal is immediate or delayed, the importance of reestablishing ocular anatomical integrity is vital to ensure return of most physiological functions of the eye while awaiting further surgical management. Furthermore, the longer the globe remains open or decompressed, the greater the risk of complications (eg, expulsion of intraocular contents, serous or hemorrhagic exudation, corneal decompensation, expulsive hemorrhage, fibrous/endothelial downgrowth, endophthalmitis, progressing cataract formation, ciliary body detachment or hemorrhage, retinal detachment, proliferative vitreo-retinopathy). All these complications related to delayed globe repair often result in poorer visual prognoses.

Prompt closure also promotes healing and fibrosis at the entry site. These wounds must be made watertight to permit further reparative procedures such as scleral buckling and pars plana vitrectomy. Finally, reestablishment of ocular integrity permits safe evacuation to tertiary care facilities for management of complications secondary to the penetrating injury and the IOFB.

Primary Management

Immediate Globe Closure Without Primary Removal of IOFB

The decision whether to remove an IOFB in conjunction with the primary repair of the penetrating injury hinges on several factors. The primary ophthalmologist may lack the experience, proper microsurgical equipment, or ancillary support for managing the ocular complications of the initial injury or from the IOFB. Vitreoretinal surgeons, on the other hand, are trained to manage IOFBs and associated intraocular complications but are rarely located at forward medical care areas. Therefore, patients with this type of injury require prompt evacuation to support areas.

The primary ophthalmologist should close the globe primarily and evacuate the patient—as soon as he or she is stable for transport—for further reparative and rehabilitative care. The patient should not be given anticoagulants or antiplatelet agents because these could cause further intraocular hemorrhage and complications. Following the initial globe repair, complications (eg, hyphema, endophthalmitis, lens-induced glaucoma) should be monitored closely and treated promptly prior to evacuation. The primary ophthalmologist should consider prophylactic treatment of these complications, because patients are not accompanied by ophthalmologists en route to tertiary care facilities. *There is no monitoring of vision-threatening complications during patient transport in the aeromedical evacuation system.*

Some benefits may be realized by delaying removal of retained IOFBs. The literature suggests that delayed vitrectomy surgery (defined as more than 3 d but within 14 d of the initial repair) may be beneficial. By delaying surgery, the vitreous hemorrhage may promote a posterior vitreous detachment that can simplify the vitrectomy and other microsurgical techniques in removing an IOFB or repositioning a detached retina.

If the IOFB is not removed primarily following primary globe repair, the use of broad-spectrum prophylactic intravenous, subconjunctival, and topical antibiotics is indicated. Penetrating ocular injuries with an IOFB have a 7%[19] to 26%[20] risk of endophthalmitis. Unlike normal eyes, in which intravenous antibiotics have poor intravitreal penetration, in eyes with a penetrated globe, bactericidal levels are achieved when treating posttraumatic endophthalmitis caused by Gram-positive microorganisms.[43] Furthermore, adequate prophylaxis should be considered because the patient will spend many hours or days in the aeromedical evacuation system without observation by an ophthalmologist for endophthalmitis.

The disadvantages of delayed removal of IOFBs include development of media opacification from the cornea, hyphema, lens opacification, vitreous hemorrhage, and reactive inflammation. In addition, encapsulation of the IOFB may complicate later removal. These disadvantageous are, in general, manageable with modern vitreoretinal techniques.

Immediate Globe Closure With Primary Removal of IOFB

Factors to consider in primary removal of an IOFB in conjunction with wound repair include the complexity of the injury, the location of the IOFB, the experience of the surgeon, the availability of micro-vitreoretinal instruments, the ability to ensure proper repositioning of intraocular contents, and the ability to handle complications of such removal. Some authors[44] suggest removing an IOFB immediately during primary repair of an open globe, reasoning that the IOFB can incite intraocular inflammation, which can result in encapsulation of the IOFB and cause a difficult future removal. An additional indication for primary removal is to reduce local toxic effects of the IOFB.

A more compelling reason for immediate removal is that there is an increased incidence of endophthalmitis associated with IOFBs. In the setting of penetrating trauma, diagnosing endophthalmitis is difficult. Associated findings from the penetrating injury itself include severe eyelid edema, conjunctival chemosis, corneal haze, hypopyon, vitreous inflammation, and/or retinal necrosis, all of which mask the key features of endophthalmitis. Should the appropriate personnel and equipment be present for IOFB removal, and if the IOFB is easily accessible at the time of primary closure, then early IOFB removal at that time is acceptable.

Observation

The removal of an IOFB is based on balancing the risk of ocular complications against the benefits of potential vision. Clearly, a reactive IOFB (usually copper or iron) should be removed promptly to avoid metal toxicity and intense inflammation. Also, an IOFB contaminated with organic material poses an increased risk of bacterial endophthalmitis. Inert materials (see Exhibit 14-1) pose a difficult management decision. In the absence of complications or symptoms, observation of an IOFB is indicated for small, inert, or chronically encapsulated IOFBs. Reports from the Iran–Iraq War (1980–1988)[8] and Israel[26] suggest that careful observation of retained IOFBs may be safe without secondary complications and with preservation of visual acuity of 20/80 or better, despite the presence of an IOFB over several years.

External Magnet Extraction of Retained IOFB

Improved intraocular vitreoretinal techniques permit a controlled and direct means of removing an IOFB and dealing with intraocular complications. Intraocular removal of an IOFB has generally replaced external magnetic techniques for removing an IOFB. However, before modern vitreoretinal techniques came into use, immediate removal of the IOFB was facilitated with external magnets. These magnets are either electromagnetic or of rare earth metals. Considerable literature exists supporting the use of external magnets for the prompt removal of a magnetic IOFB, although most vitreoretinal surgeons consider that the use of magnets has been superseded by modern intraocular techniques. The Bronson magnet is a cumbersome, handheld device still in use in many locations (Figure 14-8). Its advantages include powerful graduated force with interchangeable tips. It is particularly good for anterior segment IOFBs. The disadvantages include bulkiness, possibility of incorrect use, and the fact that

Fig. 14-8. The Bronson electromagnet, consisting of the amplifier box, foot pedal, and a large, handheld magnet.

Fig. 14-9. The large Bronson electromagnet with the fine point attachment (top) is compared with the rare earth intraocular magnet (bottom).

no metallic items can be near the eye during use. A smaller electromagnetic magnet is the JEDMED, which sacrifices power for size. Intraocular rare earth magnets lose up to 15% of their force per year and require remagnetizing yearly (Figure 14-9).

An IOFB in the posterior segment is more challenging to properly remove using the external magnet. Careful case selection is important. Small, posterior-segment IOFBs that are positioned within the midvitreous, located anteriorly, and associated with minimal vitreous hemorrhage are ideal candidates for extraction through a sclerotomy at the pars plana. IOFB removal in eyes with intraretinal hemorrhage, fibrous encapsulation, or copious amounts of vitreous hemorrhage should be avoided. When the IOFB is encased in fibrous tissue or lying directly on the retina, manipulation with an external magnet can result in retinal tears and detachments.[45]

Enucleation

Following a penetrating injury with IOFB, an eye may appear to be severely and irreparably damaged. Careful inspection, however, often reveals no loss of scleral or corneal tissue. Generally, eyes with retained pellets or BBs have a poor visual prognosis, although the globe may be salvaged. As a general principle, *do not enucleate an injured eye primarily unless restoration of the globe is impossible.*

Careful documentation of NLP vision as outlined previously is important. Although the prognosis of an eye with an initial vision of NLP is poor, the globe may be salvageable. Useful vision has been regained in eyes with dense vitreous hemorrhages and small IOFBs after pars plana vitrectomy. The use of the intense indirect ophthalmoscope light is very important in evaluating for NLP.

Summary of Primary Management

Although there may be subtle variations in the primary management of a penetrating globe injury with retained IOFB, the principles of prompt globe repair and referral to an experienced posterior-segment surgeon are key for salvaging any useful vision. A summary and decision tree on the management of these injuries is seen in Figure 14-10.

Secondary Management

Anterior Segment Management

Numerous factors play important roles in the decision about when to remove an IOFB. Generally, the eye is surgically closed and the decision to extract the IOFB is left to the vitreoretinal specialist, who is qualified in the instrumentation and manipulation of the retina. Should the eye recover somewhat normal anatomical and physiological function following initial repair of the penetrating or perforating site, the patient is transported within 72 hours or when deemed stable to a vitreoretinal specialist for definitive care.

The postoperative visual acuity following the initial repair of the penetrated or perforated globe weighs heavily in the decision to pursue additional reparative processes. If the preoperative and postoperative vision assessments are NLP, and if there is no anatomical reconstitution of the globe, then the military vitreoretinal surgeon should consider performing an enucleation to decrease the risk of sympathetic ophthalmia. Improved vitreoretinal techniques now offer the possibility of ocular preservation and visual restoration in cases previously considered hopeless. In most situations, however, a patient with prolonged NLP vision does not recover any vision and is usually managed with an enucleation.

Using vitreoretinal techniques, the vitreoretinal surgeon secures and stabilizes structures beginning from the anterior segment proceeding to the posterior segment. Thus, the integrity of the cornea, anterior chamber, iris, and lens is ensured before the posterior segment is addressed. Failure to stabilize structures in the anterior segment frequently limits the visualization of the posterior segment. Without good visualization, vitreoretinal techniques are of limited value.

Should the cornea be cloudy from endothelial folds or decompensation from the initial trauma or repair, a period of watchful waiting to permit recovery of corneal endothelium function can facilitate the view of the posterior segment. On average, in a healthy person and in the absence of any preexisting corneal disease, the cornea may regain its clear translucent appearance within 3 to 7 days to permit adequate viewing of the posterior segment. During this watchful waiting, sutured penetrated sites can continue to heal and scar. These fibrosed sites can then tolerate the higher internal pressure required by pars plana vitrectomy. In addition, this waiting can allow clearing of blood in the anterior chamber and reestablishment of the blood-aqueous barrier. On the other hand, factors against waiting for this clearing process include violation of the lens capsule, which can leak a high concentration of lens protein. The lens protein attracts inflammatory cells, resulting in intense anterior chamber inflammation

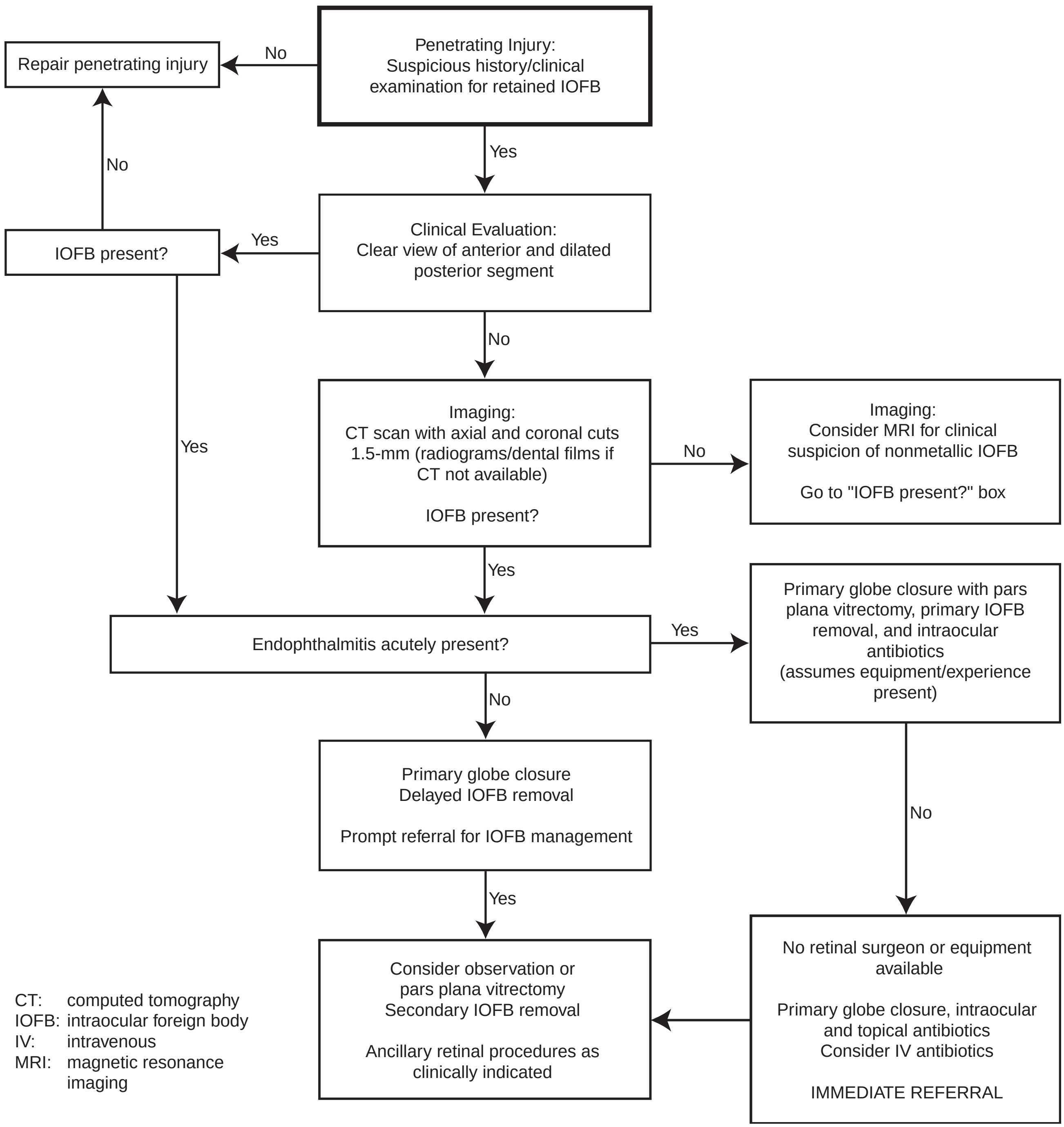

Fig. 14-10. Decision tree: Primary management of penetrating injuries with retained intraocular foreign bodies.

and a rise in the intraocular pressure. This inflammatory glaucoma compromises the corneal endothelium. To maintain a clear cornea, in this scenario, surgery must occur sooner.

When circumstances require intervention sooner or when the view of the posterior segment is compromised, the native cornea may be centrally excised and replaced with a temporary keratoprosthesis (KP). This highly refractive glass or silicon lens is secured with sutures and allows a clear view to the posterior segment for delicate vitreoretinal work (Figure 14-11). After the removal of the native cornea and before the placement of the KP lens, any blood, lens particles, or inflammatory debris is

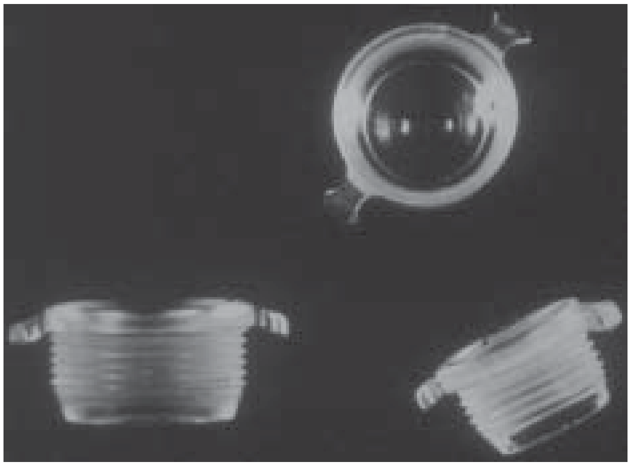

Fig. 14-11. Examples of the high-index, glass Landers-Foulks temporary keratoprosthesis (KP). Note the two flanges on the surface for suturing the KP to the globe.

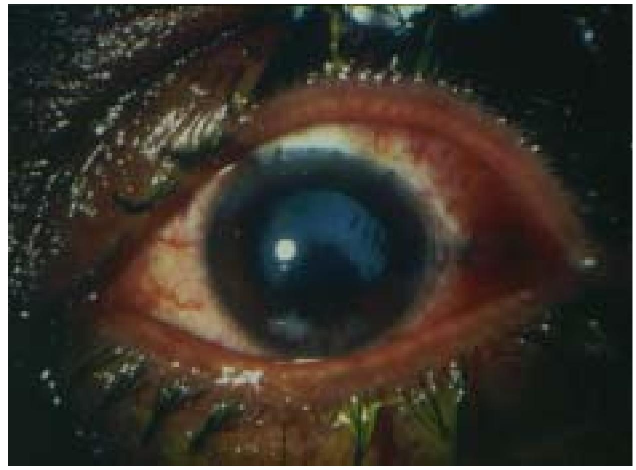

Fig. 14-12. An external photograph shows a sutured corneoscleral laceration with a white traumatic cataract. Note the fluffy cortex in the inferior anterior chamber. A black aperture is noted along the inferior margin of the cataract where the intraocular foreign body (IOFB) perforated the lens. Photograph: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

removed from the anterior chamber. The surgeon avoids incising the iris to prevent uncontrolled bleeding and further visual compromise. Once in place, the KP permits a clear, unobstructed view of the posterior segment. In addition, the KP facilitates a closed pressurized system for intraocular surgery and allows multiple vitreoretinal techniques to be performed during one surgery.

The KP offers a chance to salvage otherwise doomed eyes. For large IOFBs, one flange of the KP is released to permit retrieval anteriorly through the open cornea. Smaller IOFBs are removed at the pars plana. Once the intraocular surgery is completed, the KP is replaced with a donor cornea secured in place with 10-0 nylon sutures (ie, penetrating keratoplasty). Results in the use of the KP are mixed, due primarily to the severity of the initial trauma. Using the Landers-Foulks KP, 60% of noncombat eyes retained some vision, whereas 60% of the combat injuries had no vision,[46] although these results most likely reflect the severity of the initial injury rather then the use of the KP.

The next anatomical barrier to successful removal of IOFBs is the crystalline lens. In those cases where the IOFB entry site spares the lens, preserving lens integrity improves the chances of visual recovery. Therefore, surgical removal of the IOFB through the pars plana frequently preserves lens clarity. Successful removal of the IOFB, maintenance of lens clarity, and restoration of normal retina anatomy with no complications can preserve good visual acuity. However, should the anatomical integrity of the lens be compromised by the initial trauma, the primary surgical repair, or the secondary repair, then the lens can be removed in its entirety to permit visualization of the posterior segment and prevent the complications of lens-induced glaucoma (Figure 14-12). The surgical approach for the lentectomy (lensectomy) can be either anterior (through the anterior chamber) or posterior via the pars plana. Generally, the pars plana approach is preferred by vitreoretinal surgeons because (1) additional manipulation of the anterior segment can be avoided and (2) it allows universal access to both the posterior and the anterior segments (Figure 14-13). In certain cases, preservation of the anterior lens capsule during the pars plana lensectomy facilitates placement of an intraocular lens concurrently or at a later date.

An additional barrier to visualization of the posterior segment is at the iris plane. Frequently, a traumatized eye dilates poorly. Management of a miotic pupil is facilitated by flexible iris retractors or sutured retraction of the iris. Both methods are used in aphakic or traumatic cataract eyes. The placement of iris retractors in a phakic eye is avoided to prevent an iatrogenic anterior capsule tear or cataract formation. In addition, a transpupillary fibrin membrane can easily form from a hyphema or inflammation. The membrane can be dissolved with an intraocular injection of tissue plasminogen activator (tPA), surgically sectioned and aspirated, or it

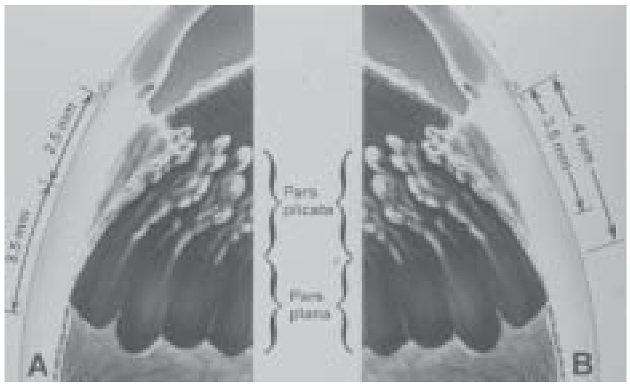

Fig. 14-13. Pars plana anatomy and locations of sclerotomies for vitreoretinal surgery. (**a**) The ciliary body is 7.0 mm in length and is composed of the anterior pars plicata ciliaris and the posterior pars plana ciliaris. The pars plicata measures 2.5 mm in length, whereas the pars plana measures 3.5 mm. The ora serrata, anterior edge of the retina, begins at the posterior margin of the pars plana. (**b**) Safe placement of sclerotomies for access to the vitreous is important to prevent iatrogenic injury to the pars plicata, anterior retina, or the crystalline lens. Sclerotomies are placed 3.5 mm posterior to the surgical limbus (noted by the anterior arrow) for aphakic (without a crystalline lens) and 4.0 mm for phakic (with crystalline lens) eyes. Avoid touching the crystalline lens to prevent an iatrogenic cataract and clouding of the lens during vitreoretinal surgery. Adapted with permission from Wilkinson CP, Rice TA. Anatomy and physiology. In: *Michels Retinal Detachment.* St Louis, Mo: CV Mosby; 1997: 8.

can be sectioned and removed with a vitreoretinal hook or pick to clear the pupillary space. Caution is necessary with the use of tPA because it can cause recurrent bleeding if used soon after the initial trauma.

Posterior Segment Management

Vitreoretinal surgery was modernized in the early 1970s with the introduction of closed intraocular surgery at the pars plana. The pars plana permits a safe posterior approach to the vitreous and retina. It is located between the ciliary body and the ora serrata (the leading edge of the retina). Incision of the sclera at this location is atraumatic and bloodless to the retina and ciliary body. Placement of an infusion cannula, fiberoptic light device, and microsurgical instrumentation (three-port divided instrumentation concept) through scleral incisions permits a closed, pressurized, well-controlled environment for manipulating the intraocular contents and removing the IOFB. Anterior vitrectomy for managing IOFBs is reserved for those cases where removal of the crystalline or damaged lens is anticipated or where the IOFB is so large that removal from an enlarged pars plana sclerotomy would jeopardize the anterior retina, vitreous base, or ciliary body. Anterior vitrectomy enters the eye at or near the corneal limbus. Vitreoretinal surgeons prefer the pars plana approach.

A principal concept of vitrectomy is the extensive removal of the vitreous gel, hemorrhage, and fibrous proliferation in trauma surgery. As mentioned previously in regard to managing penetrating injuries, removal of the vitreous scaffolding reduces the risk of fibrous proliferation and later contraction, which can cause tractional retinal detachment. Timely pars plana vitrectomy decreases the risk of retinal detachment associated with vitreous hemorrhage.[17] The significance of an extensive vitreous hemorrhage in the visual prognosis has been well described[7,10,47] and is discussed in the Prognosis section of this chapter. Furthermore, to remove the IOFB, vitreous attached to the IOFB must be excised, as well as any hemorrhage and inflammatory debris, to avoid direct traction on and potential tearing of the retina.

After all the attached vitreous and debris have been cautiously amputated (with the vitreous cutter), the IOFB, now freely mobile, is transported by intraocular forceps either to a pars plana incision or anteriorly through a corneal limbal incision. Frequently, the pars plana sclerotomy or the corneal limbal incision must be enlarged to ensure adequate space for removing the IOFB. Failure to have an adequate opening can cause the IOFB to be displaced from the forceps; a falling IOFB can strike and possibly damage the retina.

Several intraocular instruments have been used to secure IOFBs. Weak, rare earth intraocular magnets are used through a pars plana sclerotomy to attract a metallic IOFB and transport it to the midvitreous, away from the retina. Then, using intraocular microforceps, the IOFB is firmly grasped in the midvitreous and removed from the eye. The choice of microforceps depends on the size of the IOFB. Microforceps can also be used to retrieve nonmetallic IOFBs from the surface of the retina. The Wilson foreign body forceps has a retractable wire configuration permitting entry through the 1.2-mm pars plana sclerotomy and subsequent deployment of its three prongs for engaging the IOFB (Figures 14-14 and 14-15). A diamond-dusted IOFB forceps is used for larger IOFBs. Careful removal of the forceps and IOFB through the sclerotomy prevents damage to the retina, vitreous base, and ciliary body.

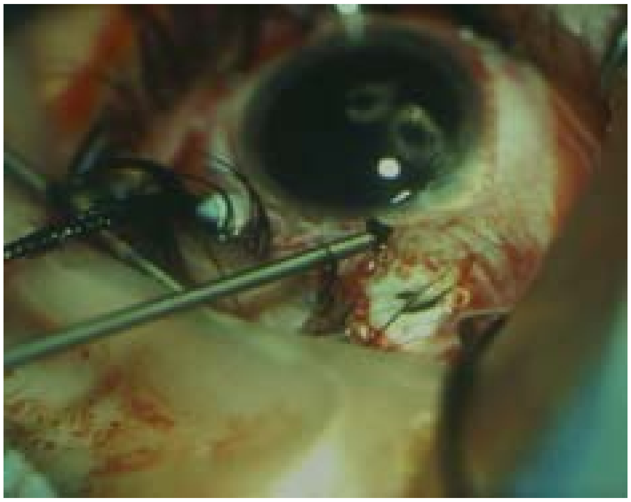

Fig. 14-14. This intraoperative photograph shows the extraction of an intraocular foreign body (IOFB) through the pars plana. The IOFB is shown captured at the end of the Wilson foreign body forceps after its extraction from the globe. Photograph: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

Site selection, whether anterior or posterior, for removing the IOFB is important to prevent complications. If the IOFB is smaller than 1.5 mm, removal through the sclerotomy is preferred; to aid removal, the surgeon can enlarge the sclerotomy in a circumferential or in a T-shaped fashion. If the IOFB is larger than 3.0 mm, removal through the limbus or clear cornea can avoid damage to peripheral retina, vitreous base, or ciliary body. In those cases, removal through the anterior segment prevents excessive enlargement of the sclerotomy. Anterior removal is facilitated by the absence of the lens (Figure 14-16).

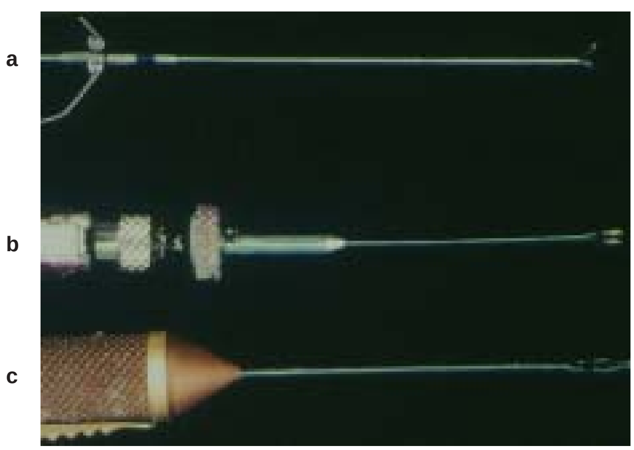

Fig. 14-15. Microforceps commonly used for removing an intraocular foreign body (IOFB). (**a**) The Wilson foreign body forceps with the delicate three-pronged wires deployed. (**b**) An L-shaped microforceps. (**c**) A diamond-dusted forceps for larger IOFBs.

After its removal, appropriate handling of the IOFB is important. An accurate measurement of the size and shape should be made and recorded (this information is helpful for accessing outcomes). The IOFB is then cultured for aerobic organisms (helpful when selecting prophylactic antibiotics or treating endophthalmitis).

Management of Intraocular Complications

The treatment of retinal breaks associated with IOFBs is controversial. Some authors[25,48] suggest some form of retinopexy—either cryopexy or laserpexy—in addition to retinal tamponade with air or gas. The use of cryoretinopexy can disperse intravitreal RPE cells, resulting in epiretinal membranes, proliferative vitreoretinopathy, or tractional retinal detachment. Laser retinopexy may also stimulate fibrous proliferation with epiretinal mem-

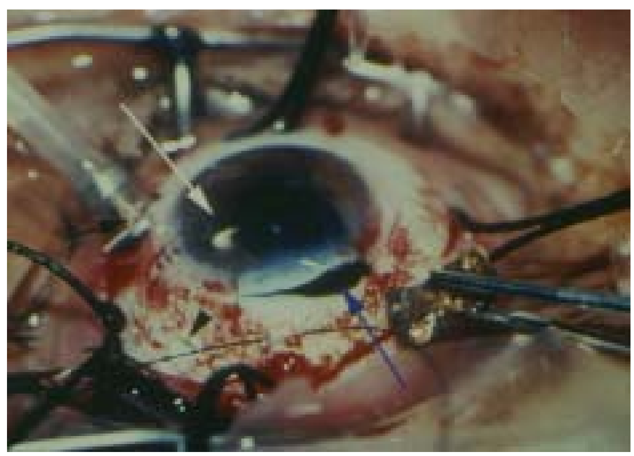

Fig. 14-16. This intraoperative photograph shows the removal of a large intraocular foreign body (IOFB) through a corneal-limbal incision. Note the infusion port (black, left-most arrow), which maintains intraocular pressure during surgery. Vitreoretinal tools are introduced into the eye through the pars plana sclerotomy (dark arrowhead). The iris is prolapsed through the corneal-limbal incision, where this large IOFB was extracted (blue arrow). After successful vitreoretinal surgery, the patient's vision returned to 20/25. The white arrow shows a light reflex. Photograph: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

brane formation, but this is more likely with cryoretinopexy. Other authors,[49] however, suggest that posterior segment breaks with associated subretinal hemorrhage can spontaneously develop a chorioretinal adhesion without the need for any mechanical tamponade or cryo/laser retinopexy. A handheld laser probe inserted through the pars plana sclerotomy is used in laser retinopexy within the eye (endolaser). Endolaser is used to create a chorioretinal adhesion between the retina and RPE.

The use of a prophylactic scleral buckle is controversial when managing a penetrating injury with a retained IOFB. A scleral buckle is used mainly to support the retina at the vitreous base to prevent a tractional retinal detachment as fibrous tissue pulls and detaches the peripheral retina. No controlled clinical trials have investigated this issue. One series, which included war injuries, found that the use of a prophylactic scleral buckle resulted in a higher rate of retinal reattachment.[12] Should extensive hemorrhage exist or if the vitreous cannot be removed close to the vitreous base, then a scleral buckle encircling the globe can relieve fibrous traction and potentially prevent a tractional retinal detachment.

The use of prophylactic antibiotics is controversial, as well. To use prophylactic antibiotics appropriately, the surgeon must understand the main causative agents of posttraumatic endophthalmitis: *Staphylococcus epidermidis*, *Bacillus* species, and *Streptococcus* species. Topical, subconjunctival, and intravenous antibiotics are recommended for posttraumatic endophthalmitis prophylaxis.[43] Intracameral or intravitreal antibiotics are not recommended for routine prophylaxis. However, aeromedical personnel must be trained (1) to evaluate the signs and symptoms of endophthalmitis while evacuating the patient to a tertiary care facility and (2) to promptly refer suspected cases for immediate treatment.

Adjuvants for use in vitreoretinal surgery include intraocular agents for temporary tamponade and flattening of the retina. Perfluorocarbon liquids are heavier than water and can be used to reposition the retina. The perfluorocarbon liquid is subsequently removed and replaced with either air, expansile gases (eg, C_3F_8 or SF_6), or silicon oil at the conclusion of the surgery. In some cases, the perfluorocarbon liquid can float the IOFB off the surface of the retina, permitting the vitreoretinal surgeon to grasp it with microforceps and remove it. Caution should be used, however, because the IOFB can slide off the meniscus of the perfluorocarbon liquid and impale the retina, creating a hole or a hemorrhage.

Intraocular expansile gases are reserved for longer tamponade of retinal detachment. After the retina is repositioned against the RPE and lasered, air replaces the aqueous in the posterior segment. To help the retina adhere to the RPE, the air is exchanged for the longer-acting expansile gases. This gas stays within the eye for 2 to 8 weeks, depending on the type and concentration of the gas. *Unfortunately, patients treated with expansile gas should not travel by air because the gas can expand and increase intraocular pressure to dangerous levels, thereby compromising blood supply to the central retinal artery.*[50]

If the retina is firmly adhered to the RPE, the retina remains attached as the gas is resorbed and the poster segment filled with the patient's own aqueous. On the other hand, if fibrous tractional forces are stronger than the chorioretinal adhesion, or if new retinal breaks form or old breaks fail to close, the retina can detach. On occasion, silicon oil is used for long-acting tamponade. This tamponade lasts months but at some point—usually 6 months after the original surgery—the silicon oil is removed to prevent intraocular complications. One of the advantages of using silicon oil is that the patient is able to travel by air.

Postoperative management of vitreoretinal procedures for removing an IOFB includes monitoring for vitreous hemorrhage, endophthalmitis, elevated intraocular pressure, and retinal detachment. Should the lens be salvaged, careful observation for cataract formation and lens-induced glaucoma is important. Prophylactic topical antibiotics, corticosteroids, and cycloplegic agents are used to control postoperative inflammation and pain.

PROGNOSIS

Evaluating the prognosis of penetrating injuries with a retained IOFB is difficult. Frequently, the inciting injury itself causes ocular damage in addition to that resulting from the presence of an IOFB. This damage, too, affects the final visual acuity. The nature, location, extent, and complications from the initial injury frequently have a greater impact on visual outcome or even necessitate enucleation. Although an IOFB itself can cause chemical toxicity or an inflammatory reaction, most series on the management of penetration with an IOFB cite the characteristics of the initial injuries as determinants of prognosis.

With the advent of vitreoretinal surgery, controlled IOFB removal generally has replaced external magnet removal. In a small, uncontrolled study comparing primary external magnetic extraction with pars plana vitrectomy, visual outcomes seemed to favor external magnetic extraction.[51] However, Williams and colleagues[13] found no statistical difference in the postoperative visual acuity when comparing the two methods of removing the IOFB. Case selection, based on the location of the IOFB; its size, composition, and type; the extent of the associated ocular injury; and the experience of the surgeon, are all important for both techniques.

Several factors can determine visual prognosis, including

- the location of the perforation,
- the type of injury,
- initial visual acuity,
- the presence of afferent pupillary defect,
- prolapse of intraocular contents,
- the presence of an IOFB, and
- the presence of vitreous hemorrhage.

A perforation of the posterior segment frequently portends a poorer visual prognosis, compared with the anterior segment.[10,12,52] Factors that portend a better prognosis include good initial visual acuity; the absence of an afferent pupillary defect; and a small, sharp IOFB (Figure 14-17). A presenting visual acuity of 20/40 to 5/200 is a good prognostic indicator for final visual acuity. Interestingly, if the postoperative visual acuity was better then 5/200, then the chances of obtaining 20/50 vision or better are 40% to 90%.[10,13]

The factors associated with an adverse prognosis include blunt injury, prolapsing intraocular tissue, larger IOFB (> 3 mm in size), larger laceration size, and the presence of extensive vitreous hemorrhage. Penetrating injuries from spherical objects, such as BBs, are known to portend a poorer visual prognosis.[10,12,52]

Few reports directly compare visual outcomes following penetrating injuries with an IOFB sustained in an occupational or domestic setting with those sustained in combat. The effectiveness of modern vitreoretinal techniques, when compared with historical norms in managing these complex cases, suggests that final visual acuity may differ between these groups. Two recent series[8,12] suggest that even with modern vitreoretinal techniques, the visual prognosis of war injuries with an IOFB is worse than for occupational and domestic cases. Frequently, the nature of the injuries and the severe concussive effect of large and multiple missiles is cited in the poorer outcomes.[8,12]

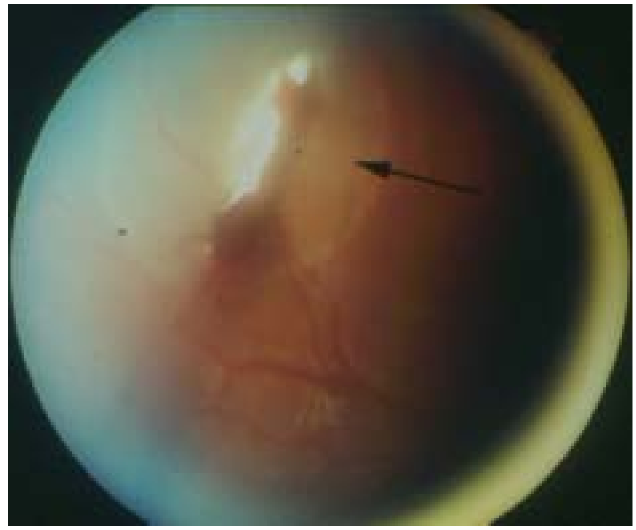

Fig. 14-17. A sharp, pointed metallic intraocular foreign body (IOFB) rests on the retina, covered by a small amount of vitreous hemorrhage in this photograph of the fundus. Note the ring of commotio retinae (arrow) under the IOFB, a result of the initial impact when the IOFB struck the retina. Photograph: Courtesy of Ophthalmology Service, Brooke Army Medical Center, Fort Sam Houston, Tex.

What have improved are enucleation rates for severely traumatized eyes with an IOFB. In the previtrectomy era, occupational and industrial enucleation rates were as high as 20% to 23%, but these have been reduced recently to 3% to 6%.[12,13,53] In combat-related IOFB injuries, there appears to be a trend toward fewer IOFB-related enucleations (see Table 14-1). Reduced enucleation rates may be attributed to vitreoretinal techniques that address secondary complications of the initial injury, the use of intraocular antibiotics, and the combination of vitrectomy and antibiotics in managing posttraumatic endophthalmitis.

SUMMARY

Ocular injuries, although infrequent, are increasing in number as the sophistication of warfare evolves. The management of penetrating ocular injuries with a retained IOFB has also evolved since the 1980s. Maintaining a high index of suspicion, making an early diagnosis, promptly closing open globes, and referring patients without delay to vitreoretinal specialists have all improved the management and outcomes of these serious injuries. Although the nature and extent of the initial injury usually portends the prognosis of vision, newly developed vitreoretinal surgical techniques may save or improve vision from these potentially devastating injuries in future armed conflicts. The actions taken by the general ophthalmologist during the initial management of these ocular injuries are important for salvaging eyesight.

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