Chapter 23

ENUCLEATION AND EVISCERATION

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INTRODUCTION

Although historically the eyes have suffered an inordinately high rate of injury relative to the total body surface area in harm's way,[1] the loss of an eye in combat is an exceedingly costly, largely preventable catastrophe (Figure 23-1). During the Vietnam War, at least 1,200 eyes were removed secondary to a combat-related injury, and the US Library of Congress estimates that the long- and short-term costs associated with serious eye injuries in that war exceeded $4 billion.[2] The incidence of eye injuries has increased with each conflict in the 20th century. For example, World War I data document an incidence of eye injuries of 2.0% to 2.5%, but the rate of such injuries during the Persian Gulf War was 13%[3]; fragments from explosive munitions accounted for 78% of the serious eye injuries and 94% of the enucleations reported during the latter war.[4] Most of these injuries could have been prevented with readily available ballistic eye armor. Military ophthalmologists must be versed in enucleation and evisceration, but greater efforts should be directed toward force education and injury prevention (Figure 23-2).

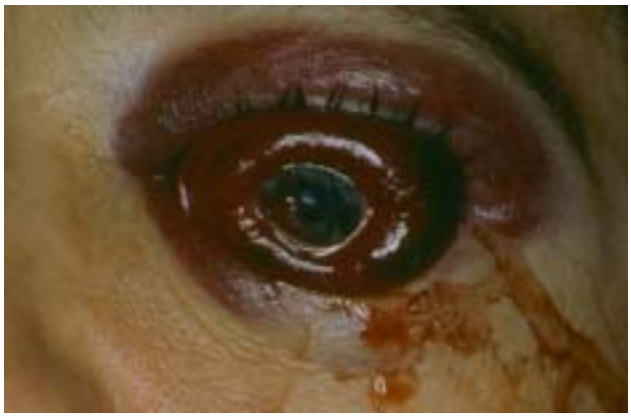

Fig. 23-1. Massive retrobulbar hemorrhage associated with a low-velocity metal fragment. Surgical attempts to repair this double, perforating globe injury (entrance and exit wounds) were unsuccessful, and the eye was enucleated. This injury could have been prevented with appropriate eye protection.

HISTORY OF EYE REMOVAL AND PROSTHESES

References to ocular surgical procedures predate 2000 BCE (before the common era). Sumerian law limited what a practitioner could charge for successful eye operations; for those procedures deemed unsuccessful, the penalty was amputation of the surgeon's hands.[5] In the mid 16th century, extirpa-

Fig. 23-2. (**a**) A short-range thermal blast induced significant damage to the face of this individual. The periocular area was spared by the patient's protective eyewear. (**b**) The polycarbonate lenses have been significantly pitted by the heat and flying debris. The blast was of sufficient intensity that its heat melted the side shields.

tion of the eye was described.[6] The disfiguring procedure was more akin to a subtotal exenteration, including removal of portions of the conjunctiva, extraocular muscles, and orbital fascia. The patient could not be fitted with an ocular prosthesis. In the mid 1800s, O'Ferral and Bonnet[7] developed a more accepted technique, which involved transecting the extraocular muscles at their scleral insertions and preserving Tenon's capsule. Their description is most consistent with enucleation as we know it today.[8]

The first description of an evisceration is credited to Beer in 1817.[9] While he was performing a glaucoma procedure, the eye experienced an expulsive hemorrhage and Beer removed the ocular contents. In 1874, Noyes[10] published his experience in removing the contents of severely infected eyes, and it is he who is credited with first using evisceration as a routine procedure.

In 1884, Mules[11] placed a glass sphere into an eviscerated scleral shell, initiating the search for the perfect implant. The early implants were hollow glass spheres and had unacceptably high extrusion rates. Throughout the early part of the 20th century, numerous implant materials were investigated, including gold, silver, vitallium (a cobalt–chromium alloy), platinum, aluminum, cartilage, bone, fat, fascia lata, sponge, wool, rubber, silk, catgut, peat, agar, asbestos, cork, ivory, paraffin, and cellulose. Concerns about the simple spheres' tendency to migrate, incomplete translation of socket motility to the prosthesis, and inadequate volume replacement led to the development of several unique implants. Shape and texture modifications sought to isolate the extraocular muscles to their respective quadrants to limit implant migration. Anterior implant projections, some with exposed coupling pegs, were engineered to create a direct linkage with the prosthesis and maximize motility. Several implants met the goal of improved prosthesis motility but at the expense of unacceptably high exposure and extrusion rates. Others developed donor sclera–covering techniques for the acrylic and silicone spheres, historically the best tolerated of any implant design, allowing the muscles to be sutured to the implant. The latter technique remains an acceptable adjunct to enucleation surgery today, with the same acrylic and silicone spheres acceptable as evisceration implants.

Since the early to mid 1990s, porous implants (hydroxyapatite and porous polyethylene) have become the choice for many surgeons. The interconnecting porous channels allow fibrovascular ingrowth throughout the implant. This ingrowth stabilizes the implant position and limits migration. After the implant has completely fibrovascularized, it may be drilled and an anterior projecting coupling peg placed. Although early results of the pegging process have been promising, recent reports of complications are emerging.[12] The long-term prognosis for drilling of implants and placing of pegs is not yet known.

PREOPERATIVE PLANNING

Decision to Remove the Eye

The psychological effect of losing an eye may present greater difficulties for the patient than the physical disability.[13] The preoperative time spent addressing eye removal, as well as discussing life after losing an eye, will reap benefits in postoperative recovery and acceptance. Photographs of other anophthalmic patients are useful as the prospective patient tries to understand the process. It may be helpful to facilitate a meeting between the patient facing eye removal and one who has completed the process. Psychiatric referral is appropriate for patients who manifest increased difficulty coping with the loss.

Preoperative Counseling

It is vitally important that the patient be prepared for surgery and the rehabilitation to follow. Pain is variable in the immediate postoperative period, and patients should be assured that appropriate medication will be provided. The patient must be prepared to wear a conformer for 5 to 7 weeks until the socket is ready to be fitted with a prosthesis. In addition, the patient must understand that the fitting process may require several appointments over as many weeks.

Goals of Rehabilitating the Anophthalmic Socket

Communication between the ophthalmologist and the ocularist is integral to a good outcome. The ophthalmologist must select an implant of appropriate volume to allow for optimal prosthetic size. Too small an implant necessitates an inappropriately large prosthesis to fill the orbital volume, and this may limit motility and transmit excess weight to the lower eyelid. Over time, the excess weight will result in laxity of the lower eyelid with a resultant asymmetric appearance. On the other hand, too

large an implant limits the ocularist's ability to fashion a prosthesis with simulated anterior chamber depth without imparting a proptotic appearance to the orbit.

The ocularist can modify the prosthesis to adjust lid position, correct for a shortened conjunctival culde-sac, and improve motility. The posterior surface of the prosthesis can be vaulted in cases of conjunctival irritation or breakdown. Patients who elect to undergo implant pegging to maximize prosthetic motility (discussed later) rely on the ophthalmologist and the ocularist to coordinate their care. The ocularist can provide a prosthetic template to assist the ophthalmologist in peg placement and centration. Following the peg placement, the ocularist will modify the implant to allow implant–prosthetic coupling.

Eye removal and socket rehabilitation are not procedures to relegate to minimally supervised junior residents. This is the primary procedure that will determine long-term success and promote rapid patient rehabilitation. Less-than-optimal surgical technique can lead to subsequent procedures to address implant exposure, implant extrusion, implant migration, socket contraction, chronic pain, and lid malposition. The same impeccable attention that the ophthalmologist commits to microsurgical ocular procedures is essential for surgery of the anophthalmic socket. Preservation of conjunctiva, implant placement and sizing, anatomical reinsertion of extraocular muscles, and tension-free wound closure are integral to a successful outcome.

Decision to Enucleate or Eviscerate

The patient needs to understand the available options and to participate in the choice between *enucleation* (removal of the globe and a segment of the anterior optic nerve) and *evisceration* (removal of the ocular contents with preservation of the sclera and, in some cases, the cornea). The ophthalmologist must guide the patient to the most appropriate procedure if absolute indications or contraindications exist. Some patients may take comfort in evisceration and equate the retention of the scleral shell to keeping the eye. Conversely, the appropriately selected evisceration candidate may find the minimal risk of sympathetic ophthalmia to be unacceptable and elect for enucleation. (Although a consensus does not exist, most authors agree that penetrating trauma increases the risk of sympathetic ophthalmia and is a contraindication to evisceration. For war-related ocular trauma that leads to loss of useful vision, enucleation removes the uveal tissue implicated in inciting inflammation in the sympathizing eye. For further information, see Chapter 16, Sympathetic Ophthalmia.)

Otherwise-untreatable intraocular malignancies and cases that require histopathological review for assessment of the tumor margins dictate enucleation. In addition, a small, phthisical eye may preclude adequate volume replacement following evisceration. On the other hand, in cases of endophthalmitis, evisceration offers a relative barrier to posterior spread of the infection, assuming that no posterior scleral incisions are necessary to accommodate the appropriately sized implant. Evisceration may impart less disruption to the orbital tissues, does not require disinsertion of the rectus muscles, and may enhance cosmesis. In cases appropriate for either procedure, the surgeon should pursue the technique that allows for the most consistent results in his or her hands.[14]

ENUCLEATION

Enucleation involves removing both the globe and a segment of the anterior optic nerve, with care taken to preserve the conjunctiva, Tenon's capsule, and the extraocular muscles. The goals of enucleation and evisceration surgery are found in Exhibit 23-1. The indications for enucleation include severe trauma, intraocular tumors, and cases at risk for sympathetic ophthalmia. In the setting of eye injury secondary to war wounds, enucleation is more commonly the procedure of choice. It is these severe wounds with uveal prolapse that are at greater risk for sympathetic ophthalmia, and early removal of the inciting eye minimizes this risk. The presence of a known or suspected ocular tumor that is untreatable by other means dictates enucleation over evisceration. In a blind, painful eye with opaque media, enucleation is the better choice and precludes the possibility of eviscerating an occult tumor.

Enucleation surgery is best performed under general anesthesia but, with a cooperative patient, can successfully be undertaken with a retrobulbar anesthetic block alone. An epinephrine-containing retrobulbar block is a recommended adjunct to general anesthesia. Lidocaine with epinephrine is injected into the perilimbal bulbar conjunctiva to promote hemostasis, and the fluid wave assists in dissecting the conjunctiva and Tenon's capsule from the limbal sclera.

EXHIBIT 23-1

SURGICAL GOALS OF ENUCLEATION AND EVISCERATION

- To achieve a centrally placed inert implant with adequate anterior coverage.
- To achieve appropriate volume replacement in the orbit.
- To maintain deep fornices and eyelid support for the placement of a prosthesis.
- To provide symmetry with the contralateral orbit.
- To allow for maximum socket motility, with translation of forces to the prosthesis.

Curved tenotomy or Westcott scissors are used to perform a 360° limbal peritomy. In an effort to preserve the greatest amount of conjunctiva for closure, the tips of the scissors are used to elevate Tenon's capsule and the conjunctiva toward the corneal limbus before cutting (Figure 23-3). Curved Stevens scissors are then placed into the oblique quadrants and slid posteriorly along the sclera (Figure 23-4). The tips are spread and withdrawn to separate Tenon's capsule from the sclera (Figure 23-5).

The check ligaments are then identified by pulling the conjunctiva and Tenon's capsule away from the rectus muscles, and the anterior fibers are cut to better expose the insertion (Figure 23-6). Muscle hooks are passed in a serial fashion under the muscle to isolate and elevate it. As the toe of the hook emerges from under the muscle, it will be covered by a thin film of Tenon's capsule; a small snip in this tissue is necessary to complete the pass (Figure 23-7). A second muscle hook is passed through this track, and the muscle insertion is presented for

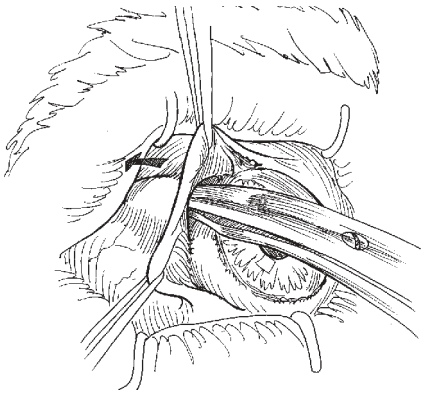

Fig. 23-4. Curved Stevens scissors are placed into the oblique quadrants (avoiding the rectus muscles), and the tips are slid posteriorly along the sclera. The natural curve of the scissors is used to follow the globe surface posteriorly. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

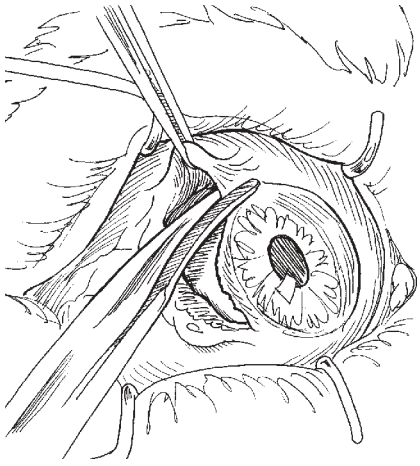

Fig. 23-3. A 360° limbal peritomy is performed. The scissors blade, deep to Tenon's capsule and conjunctiva, is slid firmly against the limbus before cutting. This step maximizes the amount of conjunctiva and Tenon's capsule preserved for closure over the implant. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

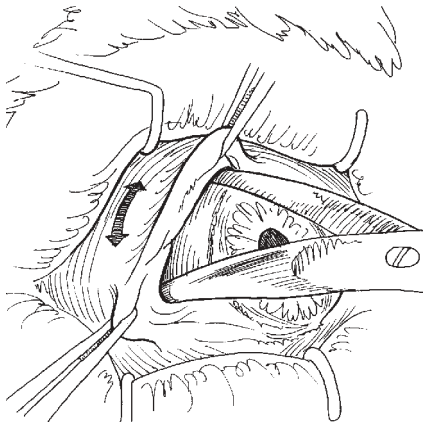

Fig. 23-5. The scissors tips are spread and withdrawn slowly (with the blades open). This action, repeated in each of the four oblique quadrants, separates Tenon's capsule from the outer surface of the globe. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

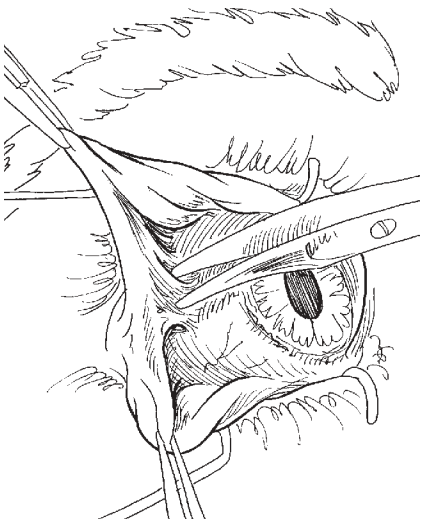

Fig. 23-6. The Tenon's capsule and conjunctival flap are elevated away from the globe to identify the check ligaments of the rectus muscles. Lysing these anterior tissue bridges improves visualization of the rectus muscle insertion. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

traction suture placement.

A double-armed 6-0 Vicryl (polyglactin) suture with spatulated needles is passed through the muscle parallel to and 3 to 5 mm from the muscle insertion. A locking bite is secured at each pole of the muscle (Figure 23-8). The muscle is disinserted from its attachment to the sclera using Westcott or tenotomy scissors. This procedure is repeated for each of the four rectus muscles (Figure 23-9).

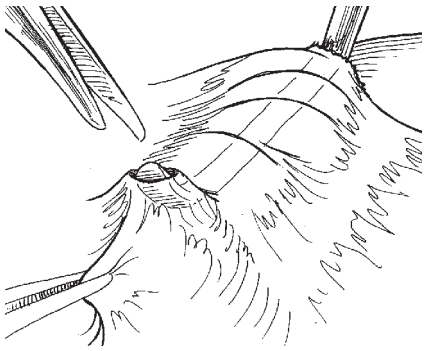

Fig. 23-7. Muscle hooks are used to isolate the insertions of the rectus muscles. As the toe of the hook emerges from under the muscle, it is covered by a thin layer of Tenon's capsule. A small snip in this tissue is necessary to complete the pass. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

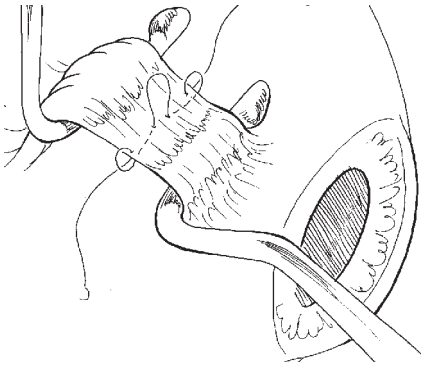

Fig. 23-8. Once the insertion has been isolated, a second hook is used to present the muscle for suture placement. A double-armed 6-0 Vicryl suture with spatulated needles is passed through the muscle parallel to and 3 to 5 mm from its insertion. A locking bite is secured at each margin of the muscle. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

When transecting the medial and lateral rectus, it is advisable to leave a small segment of tendon on the globe so that a traction suture can be attached to the eye. A 4-0 silk suture is whip-stitched through both tendon stumps to make manipulation of the eye easier.[15] This step facilitates oblique muscle identification and allows for controlled anterior

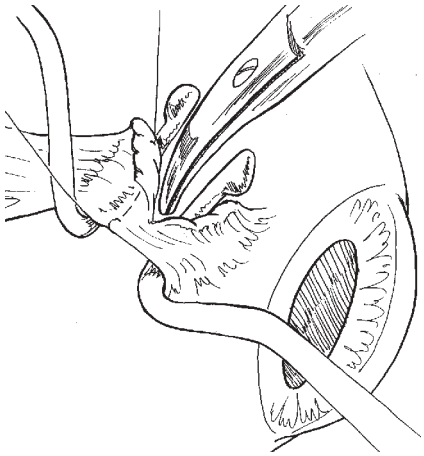

Fig. 23-9. The Vicryl-tagged rectus muscles are disinserted from their scleral attachments. The superior and inferior rectus muscles are cut flush with the sclera. When transecting the medial and lateral rectus muscles, a 3-mm stump of tendon is left on the globe to facilitate manipulation of the globe. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

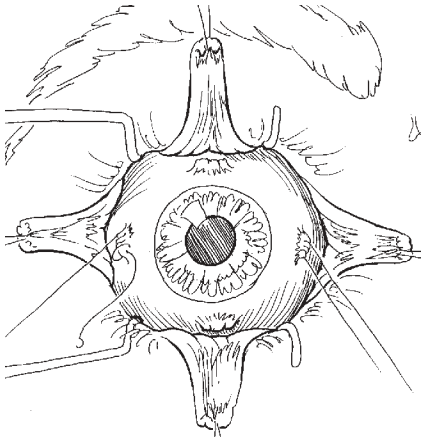

Fig. 23-10. A locking 4-0 silk traction suture is placed through both the medial and lateral rectus muscle stumps. This measure provides a handle to manipulate the globe during oblique muscle identification and also allows controlled anterior traction as the optic nerve is later transcected. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

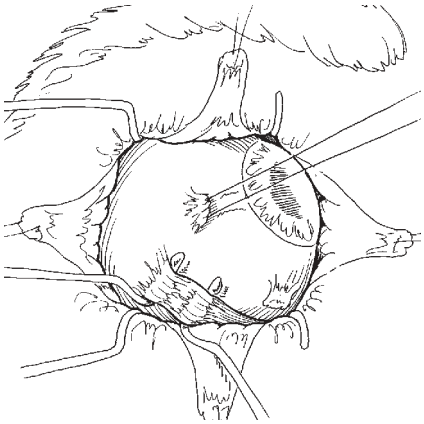

Fig. 23-12. Rotating the eye superiorly and medially presents the inferior oblique muscle, which is transected from its scleral insertion near the macula. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

traction as the optic nerve is later transected (Figure 23-10).

Rotating the eye inferiorly and medially allows for identification of the superior oblique tendon in the superolateral quadrant. The tendon is isolated with a muscle hook and transected at its scleral attachment (Figure 23-11). Next, the eye is rotated superiorly and medially to identify the inferior oblique muscle, which is transected free from its insertion near the macula (Figure 23-12).

Using silk traction sutures, the eye can be rotated about its primary axis to assess freedom of movement. Limitations to rotation suggest an incomplete rectus or oblique muscle disinsertion. Next, the eye is torted laterally, and curved enucleation scissors are inserted into the medial orbital space. The tips

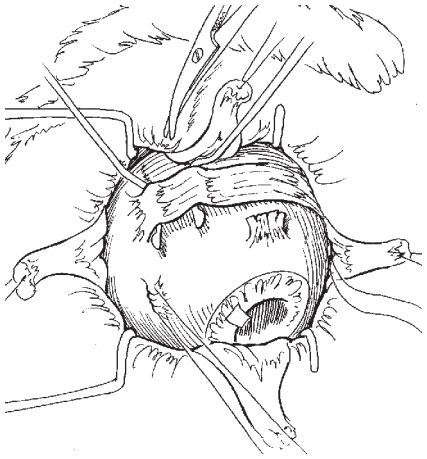

Fig. 23-11. The eye is rotated inferiorly and medially to expose the superolateral quadrant. The superior oblique tendon is isolated with a muscle hook and transected. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

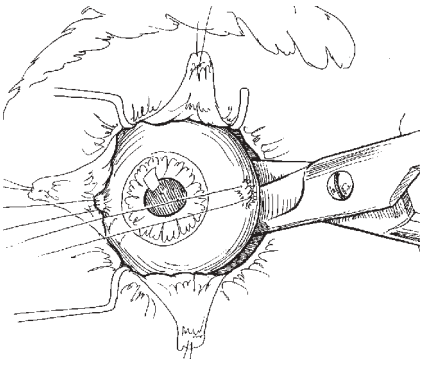

Fig. 23-13. The silk traction suture is used to rotate the globe and ensure that it is free from all muscular attachments. The eye is placed into lateral gaze, and enucleation scissors are slid into the medial space. With the tips of the scissors together, the optic nerve is strummed. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

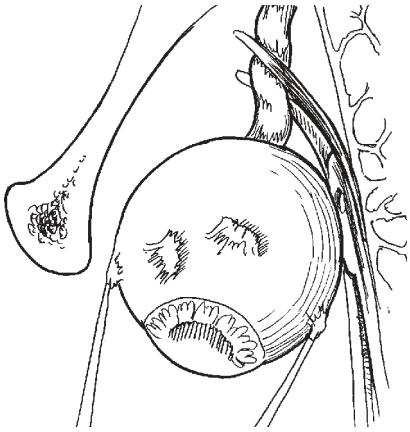

Fig. 23-14. The tips of the scissors are spread around the optic nerve. The silk traction sutures are used to distract the globe anteriorly as the enucleation scissors are slid posteriorly along the nerve. The optic nerve is transected. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

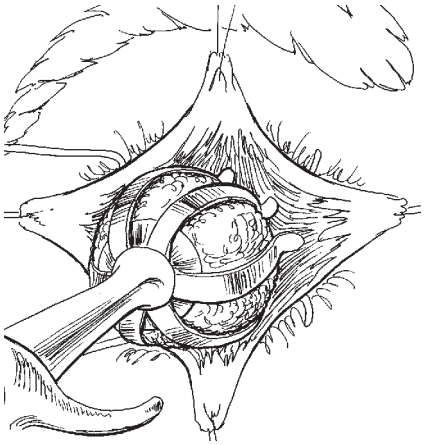

Fig. 23-16. The selected implant is placed into an inserter. The prongs of the device are placed deep into Tenon's capsule, and the plunger is depressed to eject the implant. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

of the scissors are used to locate the optic nerve by strumming it from above and below. The blades of the scissors are then spread to span the nerve (Figures 23-13 and 23-14). While applying anterior traction to the globe, the scissors are slid posteriorly and the optic nerve is transected. An attempt is made to take at least a 4-mm segment of nerve with the globe. The eye is removed from the socket, and any residual soft-tissue attachments are transected. Packing material is then placed into the socket for several minutes to control bleeding (Figure 23-15).

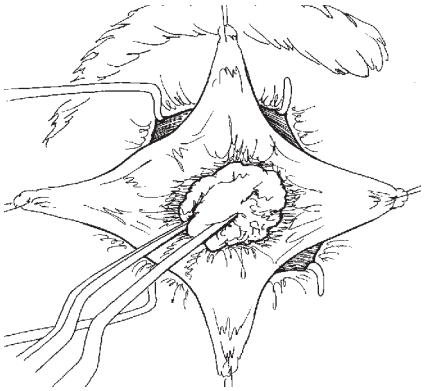

Fig. 23-15. Hemostasis is achieved by packing the socket with gauze soaked in cool normal saline solution. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

Sizing spheres may be used to determine an appropriate implant size. The implant should provide adequate volume replacement and when properly positioned should allow for a tension-free anterior closure of Tenon's capsule and conjunctiva. My own preference is the porous polyethylene sphere (Medpor, mfg by Porex Surgical Group, Newnan, Georgia) for three reasons: (1) a scleral wrap is not

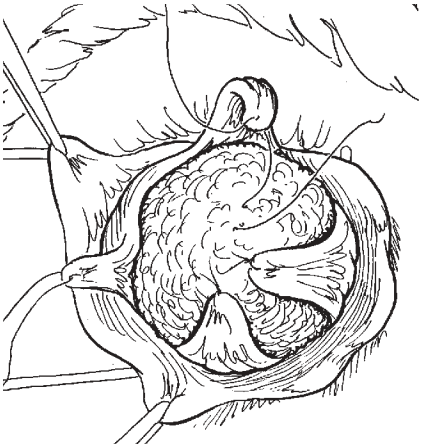

Fig. 23-17. The extraocular muscles are attached to the implant. Each needle of the double-armed suture, preplaced in the rectus muscles, is passed through the porous polyethylene implant. Anterior placement provides an additional layer of protection against implant exposure. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

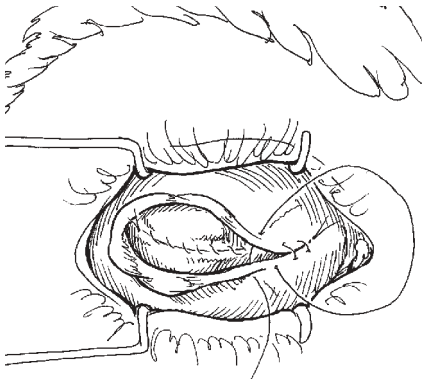

Fig. 23-18. A layered closure of Tenon's capsule and conjunctiva provides protection against implant exposure. 6-0 Vicryl is used to close Tenon's layer, and 7-0 Vicryl is used to close the conjunctiva. The tissue edges must approximate easily over the implant because wound traction increases the risk of breakdown and exposure. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

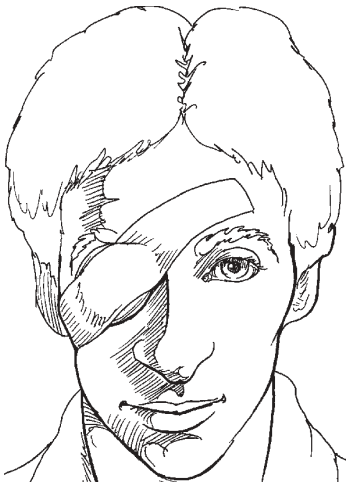

Fig. 23-19. A pressure patch is applied for 48 hours to maximize orbital hemostasis and to maintain the conformer in position. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

required, (2) the muscles may be sewn directly to the implant, and (3) future coupling-peg placement will be possible. The most frequently used implant is 20 mm in diameter. The implant is placed into the socket using a sphere introducer (Figure 23-16). If an introducer is not available, forceps are used in a hand-over-hand fashion to pull Tenon's capsule up and over the implant.

Next, the extraocular muscles are attached to the implant. Each needle of the double-armed suture, preplaced in the rectus muscles, is passed through the porous polyethylene implant (Figure 23-17). The needle tip is placed into a surface pore, and a shallow pass is made through the surface material of the implant. As these sutures are pulled tight and secured, the muscle becomes firmly attached to the implant in a position slightly anterior to the original anatomical placement. This positioning helps cover the anterior aspect of the implant and protects against its exposure. Each of the four rectus muscles is reattached in this fashion.

Tenon's capsule is draped anteriorly to ensure that it will cover the implant without tension across the wound. This layer is crucial, and several layers of interrupted 6-0 Vicryl sutures are used to close it. Care is taken to avoid trapping the conjunctiva, which will predispose to the development of inclusion cysts. Finally, a running 7-0 Vicryl suture closes the conjunctiva (Figure 23-18). The suture only approximates the conjunctival edges and does not add strength to the closure. Sterile antibiotic ointment and a plastic conformer are then placed behind the eyelids into the interpalpebral forniceal space. The largest conformer that allows for closure of the eyelids should be used. A pressure patch is applied over the closed eyelids for 48 hours (Figure 23-19).

EVISCERATION

The evisceration process removes the ocular contents but preserves the sclera and, in some cases, the cornea. The goals of evisceration and enucleation are the same (see Exhibit 23-1). Although no firm consensus exists on the indications for evisceration, most experts agree that a patient with a blind, painful eye without risk of intraocular malignancy is a good candidate. Additionally, eyes lost to endophthalmitis may be best treated with evisceration.

Evisceration is best performed under general anesthesia supplemented with a retrobulbar block but may also be performed with local retrobulbar anesthesia alone. The conjunctiva is injected with an epinephrine-containing local anesthetic mixture before the procedure. As described above for enucleation, a limbal peritomy is performed. The conjunctiva and Tenon's capsule are elevated off the sclera back to the insertions of the rectus muscle. A partial-thickness incision is made around the cor-

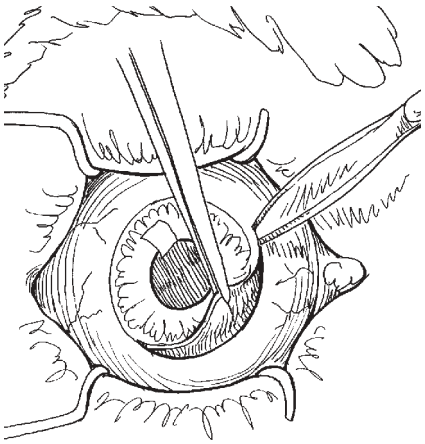

Fig. 23-20. The surgical limbus is incised with a surgical blade, and then corneal scleral scissors are used to remove the corneal button. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

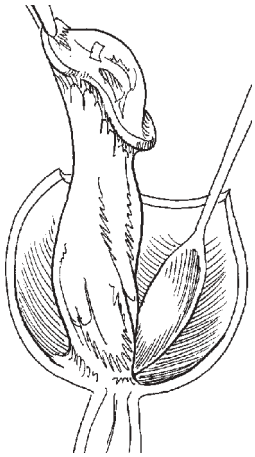

Fig. 23-22. The ciliary body is disinserted, and a plane deep to the choroid is dissected. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

neal limbus, and scissors are used to excise the corneal button (Figure 23-20). A cornea-sparing technique has also been described[16] but is not recommended by this author. An evisceration spoon is placed into the eye to scoop out the intraocular contents (Figure 23-21). The dissection plane is just internal to the sclera, and the entire uveal tract, vitreous, lens, and anterior ocular structures are removed (Figure 23-22).

Sterile, cotton-tipped applicators soaked with absolute alcohol solution are used to treat the internal aspect of the sclera, minimizing the potential for viable uveal tissue remnants (Figure 23-23). Small, radial incisions are made in the oblique quadrants of the sclera so that sizing spheres can be placed into the scleral shell. Care is taken to select an implant that will minimize any anterior traction on the scleral closure. An insertion device can be used to place the implant into the scleral shell, and forceps can be used to further position the implant and ensure that it is adequately seated. If the sclera does not easily close over the implant, then poste-

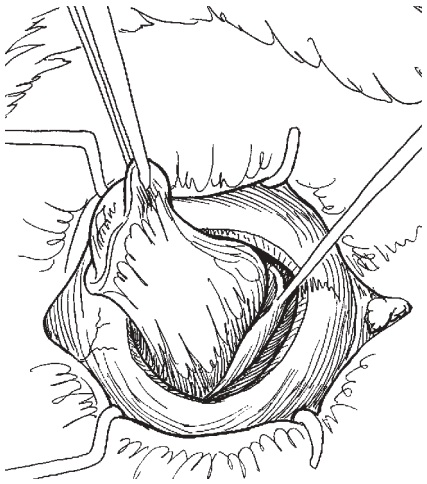

Fig. 23-21. An evisceration spoon is used to remove the ocular contents. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

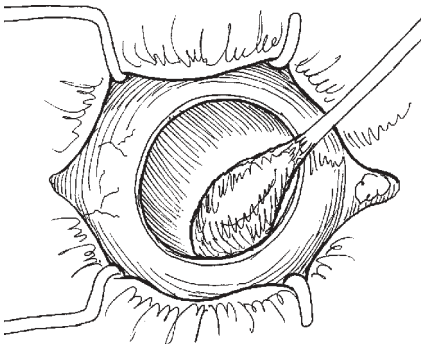

Fig. 23-23. A cotton-tipped swab soaked in absolute alcohol is used to clean the inside of the scleral shell. This step minimizes the survivability of uveal tissue and may reduce the risk of sympathetic ophthalmia. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

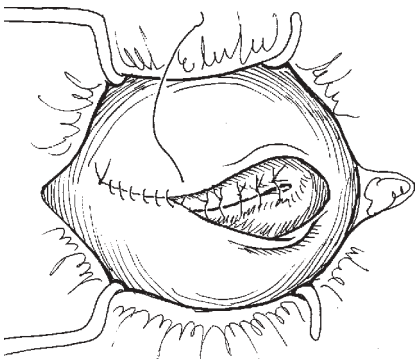

Fig. 23-24. A permanent suture (eg, Mersilene) is used to close the sclera over the implant. A tension-free, layered closure of Tenon's capsule minimizes the risk of implant exposure or extrusion. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

rior radial incisions may be made in the scleral shell to allow the implant to be placed deeper. A 4-0 nonabsorbable suture (eg, Mersilene) is then used to close the sclera over the implant. Tenon's capsule and the conjunctiva are now closed in separate overlying layers (Figure 23-24). A conformer is placed behind the eyelids, and a pressure patch is applied for 48 hours.

IMPLANTS

The history of implant development is fascinating but beyond the scope of this chapter. However, excellent reviews are available elsewhere (eg, in the Enucleation chapter in *Ophthalmic Plastic and Reconstructive Surgery*[17]). The most suitable options at present include (*a*) solid spheres, (*b*) autogenous dermis fat grafts, and (*c*) porous implants.

The solid spherical implants, either acrylic (polymethylmethacrylate) or silicone, are well tolerated, have low extrusion rates, and are inexpensive. Their disadvantages include a tendency to migrate within the orbit and decreased motility.[18] However, by wrapping the implant in donor sclera and reattaching the extraocular muscles, it may be possible to minimize both of these complications.

The autogenous dermis fat graft is readily available in all settings, and the implanted tissue can augment the lining of a contracted socket.[19] Disadvantages include decreased motility, unpredictable resorption, and increased operative time. Although it may not be the primary implant of choice, harvesting and implanting the dermis fat graft are procedures that battlefield ophthalmologists should be prepared to perform.

The graft is harvested from an area midway between the anterior superior iliac spine and the ipsilateral buttock. The area is injected with local anesthetic. A 20-mm circle is drawn and incised to a depth of approximately 20 mm or just above the underlying muscular fascia. Before removing this cylindrical core of tissue, the epidermis is sharply excised or abraded from the dermis and discarded. The dermis-covered fat plug is then separated from its deep attachments and transferred to the recipient orbit. The donor site is converted into an ellipse and closed primarily.

The dermis fat graft is inserted into the orbit. The tagged extraocular muscles are drawn up and sutured in correct anatomical position to the edge of the dermis cap. Tenon's capsule and the conjunctiva can now be positioned over the edge of the dermis graft and sutured into position. By minimizing the overlap at this junction, maximal socket surface area is maintained. The bare dermis will epithelialize under the conformer.

The porous implants are the ones most commonly used today. Both hydroxyapatite and porous polyethylene have interconnecting pores that provide a passive latticework for fibrovascular ingrowth. This ingrowth helps stabilize the implant position within the muscle cone and provides the implant with access to the patient's immune system. After fibrovascular ingrowth is complete, an optional pegging procedure may be considered, in which the prosthesis is directly coupled to the implant, allowing complete translation of socket motility (Figure 23-25). Many patients, however, are satisfied with the motility of the uncoupled prosthesis and decline to risk the potential complications associated with the pegging procedure. These complications include chronic discharge, peg extrusion, and implant exposure.[20]

Hydroxyapatite implants must be wrapped prior to placement. Donor sclera, readily available from eye banks, is commonly used for this purpose. The wrap covers the abrasive surface of the implant, decreasing the risk of conjunctival breakdown and providing a scaffold to which the extraocular muscles are reattached. Four small windows are cut

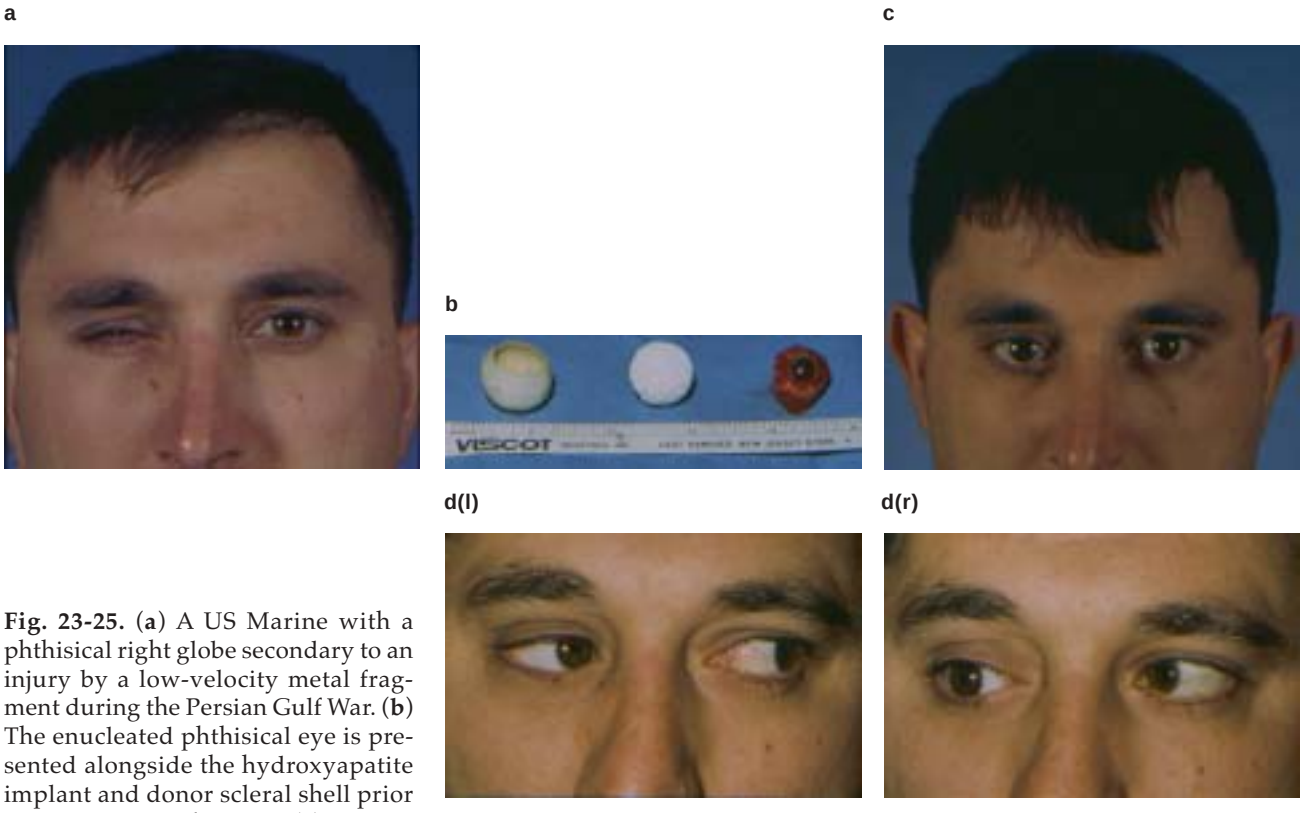

Fig. 23-25. (**a**) A US Marine with a phthisical right globe secondary to an injury by a low-velocity metal fragment during the Persian Gulf War. (**b**) The enucleated phthisical eye is presented alongside the hydroxyapatite implant and donor scleral shell prior to placement in the orbit. (**c**) Postoperatively, the patient was pleased by his orbital symmetry but elected implant pegging to increase the motility of the prosthesis. (**d**) Following a successful pegging procedure, the patient enjoyed excellent left and right lateral gaze. Photographs: Courtesy of William Bigham, Captain, Medical Corps, US Navy; Naval Medical Center San Diego, San Diego, Calif.

in the sclera to accept each of the four rectus muscles. The windows are positioned to approximate the anatomical insertion of the extraocular muscles. Each of the double-armed Vicryl suture needles is passed through the anterior edge of the scleral window. Securing these sutures pulls the muscle into the window and into contact with the hydroxyapatite implant. This provides the anterior implant with a source for fibrovascularization. Several windows may be cut in the posterior aspect of the implant wrap to accelerate the ingrowth there.

Porous polyethylene implants have a smooth surface and may be placed without a wrap. The material is also softer, and the suture needles used to attach the extraocular muscles can be passed through the surface of the implant. The curved needle engages the implant in a surface pore at a shallow angle. With steady force, the needle is passed forward and the natural curve of the needle returns it to the implant surface.

POSTOPERATIVE CARE

The use of systemic antibiotics should be dictated by the potential for infection. If endophthalmitis is present preoperatively, then an antibiotic that is appropriate for the cultured pathogen should be used. In cases of trauma specifically involving organic matter (ie, tree-branch perforation of the eye), a broad-spectrum antibiotic is appropriate. Routine enucleation or evisceration with minimal risk of infection need not be covered with antibiotics.

The pressure patch is applied following surgery to preclude orbital hematoma formation. It also serves to maintain the conformer in position under the eyelids, ensuring the preservation of deep superior and inferior fornices. The patch is removed 48 hours after surgery unless discharge or patient complaints of increasing orbital pain warrant earlier removal to allow inspection of the socket. Following removal of the pressure patch, the patient

is instructed to instill an ophthalmic antibacterial ointment into the interpalpebral fissure twice daily for 7 days.

The conformer is first removed 1 week following surgery, and a careful inspection of the socket is performed. The conjunctival suture line is surveyed for breakdown and areas of implant exposure. Any indication of infection warrants aggressive management, including culture and appropriate antibiotics.

The patient is next seen 5 to 6 weeks following surgery. At that time, the conjunctiva should be pink and free of edema. The superior and inferior forniceal spaces should be deep and there should be no evidence of implant exposure. The patient is now ready for referral to the ocularist for socket evaluation and prosthesis fitting.

Most patients who receive porous implants are satisfied with the translation of socket movement to the prosthesis without pursuing direct coupling. The ocularist should be consulted before the option of implant pegging is entertained. Changes to the posterior prosthesis—in addition to overall size modifications—may provide satisfactory improvement in motility. If the patient still desires increased motility and a disparity between socket and prosthesis movement can be seen, then pegging can be considered 6 to 12 months after implant placement. The time delay is necessary to ensure adequate implant vascularization. Magnetic resonance imaging with gadolinium contrast medium may be useful in assessing vascularity of the implant.[21]

Pegging systems exist for both the hydroxyapatite and the porous polyethylene implants. Each system involves the placement of a post (ie, a peg) into the central implant along a line paralleling what would be the visual axis. A template prepared by the ocularist can assist the surgeon in achieving proper centration. A small portion of the post protrudes above the conjunctival tissues and engages a corresponding indentation on the posterior surface of the prosthesis. In addition to the potential for improved motility, such coupling may serve to distribute a portion of the weight of the prosthetic to the implant, effectively unweighting the lower eyelid. This may, over time, minimize lower-eyelid sag.

Although impressive results are possible following prosthesis–implant coupling (see Figure 23-25), the patient must be prepared to accept the potential complications of the procedure. Long-term effects of pegging are not known, but early problems include exposure, extrusion, and socket discharge.[12]

COMPLICATIONS

Blepharoptosis

Either true or pseudoblepharoptosis may follow eye removal. True blepharoptosis can be a result of aponeurotic dehiscence, levator palpebrae muscle injury, or damage to the innervation of the levator palpebrae. These complications may result from the initial trauma or the surgical procedure used to remove the eye. Careful preoperative assessment is necessary to document a preexisting problem. Enucleation surgery, by virtue of visitation to the retrobulbar space, has higher potential for damage to the levator palpebrae muscle or the orbital branches of the third cranial nerve.

Pseudoblepharoptosis can be associated with inadequate volume replacement or the shape of the prosthetic. An ideal implant replaces most of the globe volume, leaving only enough room for an adequately sized prosthesis. Too small an implant can create enophthalmos, and the lack of anterior projection changes the geometry of the levator palpebrae complex. The ocularist can increase the vertical height of the prosthesis or build up its superior margin—within the limits of acceptable weight and volume—to help correct eyelid position. Too large a prosthesis, though, can decrease motility and create lower-eyelid malposition.

Lower-Eyelid Malposition and Laxity

Both minimizing prosthetic size and coupling the implant to the prosthesis decrease the amount of weight that the lower eyelid must support. Over time, though, it is not uncommon for the lower eyelid to yield to gravitational forces, and a lower-eyelid-tightening procedure might be necessary. If recurrences of lower-eyelid malposition secondary to a large prosthetic occur, it may be necessary to replace the orbital implant with one of greater volume. The increased volume of the implant allows the ocularist to fit a smaller prosthesis.

Enophthalmos

As noted above, enophthalmos is usually related to inadequate volume replacement at the time of enucleation or evisceration. In cases of trauma, with concurrent damage to the bony orbital walls, spherical implants alone may be insufficient for volume

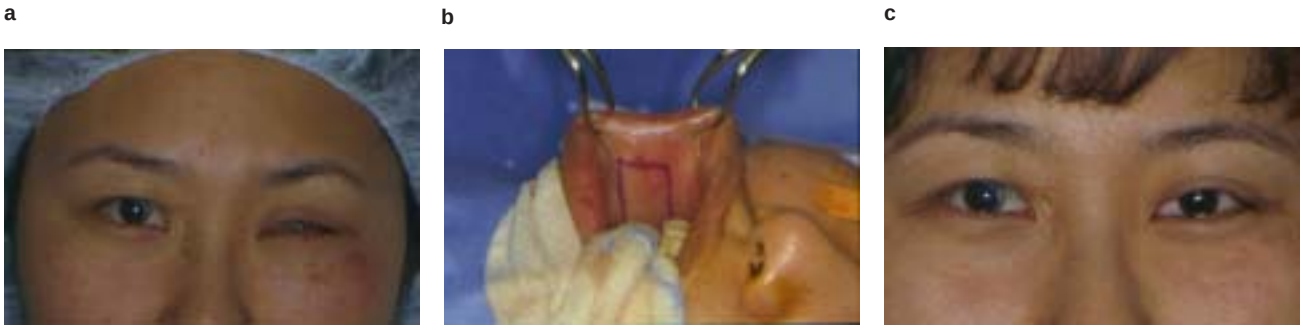

Fig. 23-26. (**a**) A severely contracted socket precluded the patient from wearing an ocular prosthesis. (**b**) Buccal mucosa grafts were harvested and used to expand the surface area of the socket. (**c**) Postoperatively, the prosthesis is maintained in the expanded socket.

replacement. Orbital fracture repair may be necessary to achieve satisfactory results.

Socket Contracture

One of the more difficult complications to manage is contracture of the socket and the associated foreshortening of the fornices. Depending on the degree of contracture, the patient may be unable to wear a prosthesis, and surgical expansion often requires tissue grafting to the mucosa-lined socket (Figure 23-26). In removing the eye, every effort should be made to preserve Tenon's capsule and the conjunctiva. Preserving these structures can be challenging in serious ocular injuries and may necessitate primary dermis fat grafting if insufficient tissue is available.

Following either enucleation or evisceration, a conformer of the largest possible size should be placed into the palpebral fornices as a socket maintainer. Patients should be instructed on how to replace the conformer should it dislodge and the potential consequences of not wearing one for prolonged periods.

Implant Exposure

Tension on the closure of Tenon's capsule and conjunctiva may predispose to wound breakdown and exposure of the implant (Figure 23-27). A rough implant surface (eg, uncovered hydroxyapatite spheres) has also been associated with anterior implant exposure and extrusion.

Small, stable defects of the conjunctiva may be observed. Progressive areas of exposure or those

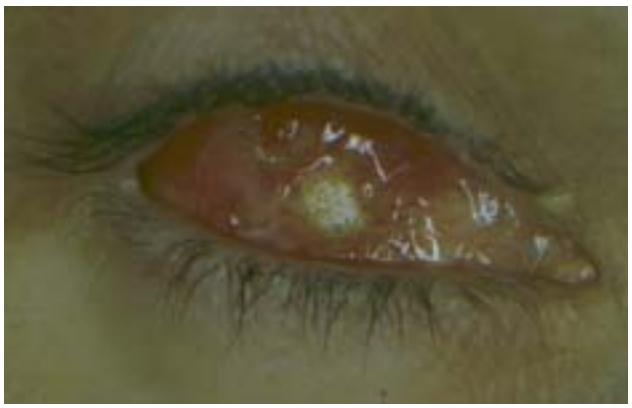

Fig. 23-27. Central area of breakdown exposes the surface of the porous implant.

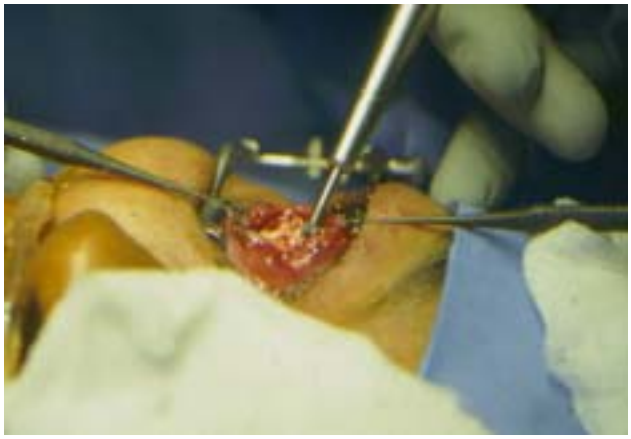

Fig. 23-28. An electric burr is used to reduce the anterior projection of the implant that underlies the area of exposure. This volume reduction may facilitate primary closure of the defect and provide a more vascular bed to support the overlying tissue.

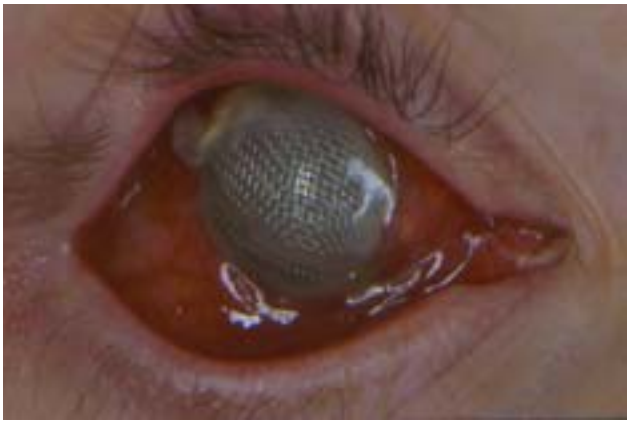

Fig. 23-29. An older, metallic-mesh implant is exposed to its equator and complete extrusion is impending. The implant was exchanged with a porous sphere, and the patient did well.

associated with infection require intervention. In some cases, the anterior projection of the porous implant may be reduced, allowing for a tension-free closure of Tenon's capsule and conjunctiva. An electric burr is used to remove portions of the anterior implant both to reduce its projection and to expose deeper vascularized areas (Figure 23-28). If the wound is sufficiently large to preclude primary closure, a small dermis fat graft can be used to span the defect. It may be necessary to replace the implant with a smaller one in cases of profound infection or impending extrusion (Figure 23-29).[22]

SUMMARY

Proportionally, the eyes receive more battlefield injuries than any other area of the body. Early care must be definitive, with every possible attempt made to preserve vision. In the event that this is not possible, the military ophthalmologist must be prepared to remove the traumatized eye.

Given the tools of modern warfare, ocular injuries with significant uveal exposure and increased risk of sympathetic ophthalmia can reasonably be expected. It is, therefore, most likely that enucleation will be the procedure of choice for those eyes deemed unsalvageable. In planning, the battle-ready ophthalmic surgeon must identify those essential supplies necessary to provide optimum care. Space and weight allowances will limit gear selection.

A single implant that is suitable for both enucleation and evisceration is ideal. Additionally, an implant that allows direct attachment of the extraocular muscles will save on the necessity to stock a wrapping material such as donor sclera. A selection of 18-mm, 20-mm, and 22-mm implants should be adequate. The advantages of stabilization and access to the immune system warrant consideration of porous implants (I prefer porous polyethylene implants). The military ophthalmologist should also ensure that an adequate supply of socket conformers is available, as the freshly operated socket will contract without one.

Eye removal surgery runs contrary to ophthalmologists' investment in preservation of vision. When circumstances necessitate, the military ophthalmic surgeon must be prepared to intervene and provide the best result possible. It is the initial surgery that defines a successful outcome or, conversely, commits the patient to future surgical management of complications arising from an inadequate repair. Finally, ophthalmologists must be prepared to recognize the psychosocial issues associated with eye removal and to treat or refer for treatment when necessary.

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