Chapter 18

EYELID AND ADNEXAL INJURIES

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INTRODUCTION

Eyelid lacerations are a common emergency room challenge. The primary repair, which should be the definitive surgery, is too often performed by medical students or physicians without ophthalmological training.[1] Whether the setting is a civilian emergency room or a battlefield, ophthalmologists should be involved as early as possible. Inadequate repair can lead to ocular irritation, pain, and even loss of the eye in cases of severe eyelid dysfunction. A complete eye examination is essential before closing the wound to confirm the extent of injury—even if the wound appears deceptively simple. Fortunately, the eyelids are endowed with excellent blood supply, which allows direct closure under tension and creation of large flaps without the threat of necrosis.[1–7] By following three main guidelines, ophthalmologists can maximize the patient's functional and cosmetic outcome:

1. Perform careful anatomic repairs.
2. Preserve the maximum possible amount of tissue.
3. Make liberal use of advancement flaps, traction sutures, and postoperative skin grafts.

On the battlefield, eyelid lacerations and adnexal injuries are not considered true emergencies, and in triage settings, life-threatening and actual sight-threatening injuries (ie, open globes) should take precedence. Eyelid lacerations can be closed up to 72 hours after the injury without a great impact on functional or aesthetic outcome. Canalicular injury can also be delayed (up to 48 hours), allowing the all-important primary closure to be performed by an experienced ophthalmologist. All tissue should be preserved, and even obviously necrotic tissue or detached tissue should be preserved until definitive closure is performed. Eyelid lacerations should be irrigated with sterile saline whenever possible and patched for transport.

Future battlefield units may have tissue adhesive, or glue, at their disposal. Closure with this tissue glue appears to be a very time-efficient technique for laceration closure.[8] When battlefield conditions prohibit access to needed equipment, many innovations are possible. A sterile safety pin can serve as a punctal dilator and probe, or 4-0 nylon can be used as a lacrimal stent. Independent of conditions, however, principles of closure and tissue preservation always apply. Irrigation, patience, and a problem-solving outlook can often transform an ominous wound into an elegant functional closure.

HISTORY, EXAMINATION, AND ANCILLARY TESTING

A complete history of the wounding incident should be sought to determine the mechanism of injury and assess whether foreign bodies (FBs) might be present. The timing is also important; injuries that occurred more than 24 hours before the examination are at increased risk for infection and poor wound healing. Fortunately, the eyelids are well vascularized and thereby defy infection even with delayed closure. Most ophthalmologists primarily close eyelid lacerations up to 72 hours old; canalicular lacerations are best repaired within 48 hours.[5] The tetanus status of the patient should be addressed and appropriate antibiotic treatment initiated immediately.

Before addressing the eyelid injuries, best-corrected visual acuity must be documented, and a complete ocular examination should be performed wherever possible. The status of the pupil should be determined; the presence of anisocoria or an afferent pupillary defect should be quantitated. A slitlamp examination of the anterior segment and an indirect examination of the peripheral retina are ideal. *If in doubt, do no harm!* Always suspect an open globe in cases of proptosis, chemosis, low intraocular pressure, and decreased vision. Repair of eyelid and adnexal injuries should be delayed if an open globe is present or suspected. (The details of management of anterior and posterior segment trauma are addressed in Chapters 8–17 in this textbook.) The lacrimal gland, canaliculi, and the lacrimal sac should be specifically inspected to determine if occult injuries have occurred.

Examination of the eyelids and ocular adnexa should include documentation of the intrapalpebral fissure dimensions, levator function, and marginal reflex distance to confirm symmetry of the eyelid appearance and function. The upper eyelid should be gently everted to rule out FBs and to allow inspection of the palpebral lobe of the lacrimal gland.

Dye disappearance time allows initial assessment of lacrimal drainage integrity. Fluorescein strips or 2% fluorescein dye solution (Fluoress) is placed in the inferior cul-de-sac of both eyes. The dye should drain into the canaliculi and then the lacrimal sac within 5 minutes. Delay in this process may indi-

cate canalicular, lacrimal sac, lacrimal duct, or nasal injuries. If the dye disappearance is delayed, further testing is indicated.

Classic Jones I and II testing is rarely performed. Instead, the puncta are inspected and gently dilated. If the patient is awake and cooperative, the nasal lacrimal system is irrigated with normal saline or Alcaine, a topical anesthetic. If a canaliculus is crushed proximal to the common canaliculus, clear irrigant will return with force from the puncta's being irrigated. If the canaliculi are blocked just distal to the level of the common canaliculus, clear irrigant will emerge from the opposite puncta. If a canalicular laceration is present, irrigation may well up in the medial wound or emerge from the site of disconnection.[9] Techniques for identifying the distal end of a canalicular laceration are discussed below in this chapter.

Further evaluation of the patient is essential if an FB, fracture, or deep orbital trauma is suspected. In ER or battlefield circumstances, plain film radiography may be used as a screening tool to identify large, metallic FBs or prominent fractures. Ultrasonography (A- and B-scans) is an effective tool for identifying intraocular or anterior orbital FBs but is not helpful for imaging the posterior orbit. Although computed tomography (CT) is excellent at identifying and localizing most FBs, magnetic resonance imaging (MRI) is superior at identifying subtle nonmetallic FBs.[10] However, if there is even a remote chance that metallic FBs are present and could be mobilized and cause damage if subjected to MRI, then CT is the study of choice.

If midfacial trauma is present in the setting of eyelid and canalicular disruption, an otolaryngologist should be involved to assess the extent of nasal injury. If the maxilla is extensively damaged, then an oral surgery consultation is also essential to allow simultaneous stabilization of the jaw. If a superior orbital fracture or cerebrospinal fluid leak is suspected, then neurosurgery consultation should be sought before any ophthalmic intervention.

SURGICAL MANAGEMENT OF EYELID LACERATIONS

The surgical approach is determined by the extent of injury. Once a complete ocular survey has confirmed that the globe is intact and that associated orbital fractures are unlikely, the eyelid laceration can be addressed. A thorough knowledge of eyelid and ocular adnexal anatomy is essential to avoid injury to vital structures and to maximize cosmetic outcome. It is important to keep in mind that tissue loss always appears more substantial because of tissue edema and contraction. Even dramatically disfigured eyelids can be repaired with careful reapproximation and knowledge of a few reconstruction options.[1–7,9]

There are four major types of eyelid lacerations:

1. superficial,
2. eyelid-margin involvement,
3. levator injury, and
4. complex tissue loss.

Anesthesia

Local infiltration anesthesia with a 50:50 mixture of 2% lidocaine (Xylocaine, mfg by AstraZeneca Pharmaceuticals LP, Wilmington, Delaware) with 1:200,000 epinephrine and 0.75% bupivacaine (Marcaine, mfg by Sanofi Winthrop Pharmaceuticals, New York, NY) and hyaluronidase (Wydase, mfg by Wyeth-Ayerst Pharmaceuticals, Philadelphia, Pa) is usually adequate for eyelid reconstruction. In more extensive injuries, regional nerve blocks may be additionally required. For regional anesthesia of lower lids, 1 mL of local anesthetic is injected into the infraorbital foramen located directly inferiorly to the supraorbital notch, 1 cm below the infraorbital rim. Blocking the supraorbital, supratrochlear, or lacrimal nerves blocks sensation to the upper eyelid.

Alternatively, the frontal and lacrimal nerve may be blocked by inserting a needle at the midpoint of the upper eyelid immediately below the orbital rim. A small amount of anesthetic (0.5 mL) is injected after the needle is advanced approximately 3 cm along the orbital roof. The medial canthus and lacrimal sac can be blocked by injecting the infratrochlear nerve, which lies immediately superior to the medial canthal tendon. In uncooperative adults or children, general anesthesia is usually necessary. If levator injury is suspected, a cooperative, lightly sedated patient enhances the prospects for postoperative symmetry.

Preoperative Preparation

Tetracaine ophthalmic drops are placed bilaterally, and corneal shells (rigid scleral protectors) are used whenever possible. The patient is prepped and draped in the usual fashion. Irrigation is then performed with normal saline. In the case of very contaminated wounds, irrigation with an antibiotic,

such as bacitracin or cefazolin sodium (Ancef, mfg by GlaxoSmithKline, Research Triangle Park, NC), should also be performed. All visible debris or fragments should be removed manually. Traction suture placement is performed early to help with tissue retraction during the repair and left in place for postoperative traction.

Superficial Eyelid Lacerations

Even superficial eyelid lacerations should be irrigated with normal saline and the margins closed with 6-0 silk, plain gut, or nylon sutures. Sutures may be placed in a running or interrupted fashion. Care should be taken to evert skin edges to maximize the final cosmetic appearance of the wound (Figure 18-1). Horizontal or transverse lacerations should include both orbicularis and skin in the closure. The septum should never be closed. In the upper eyelid and the lateral lower eyelid, wound closure should be performed, whenever possible, parallel to horizontal skin tension lines. In the medial lower lid, horizontal defects should be closed in a vertical fashion to minimize vertical tension and subsequent development of ectropion (Figure 18-2).

When eyelid skin is missing, an advancement flap may be fashioned to allow a simple closure (Figure 18-3). Skin sutures should be removed in 3 to 5 days (plain gut sutures will dissolve within the same time). In the case of a vertical or multiple stellate laceration, the eyelid should be placed on traction for at least 7 to 10 days (Frost or reverse-Frost suture). This suture may be taped in place to allow monitoring of visual function.

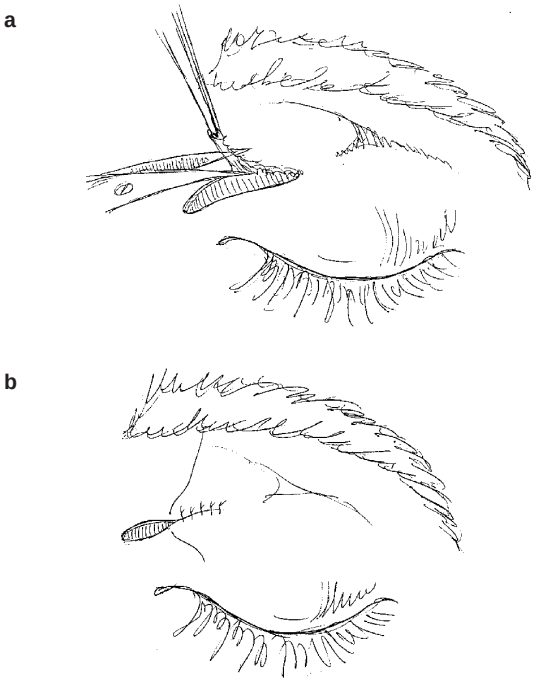

Fig. 18-1. Repair of a superficial laceration not involving the eyelid margin. (**a**) The eyelid laceration should be irrigated, carefully debrided, if necessary, and inspected to determine the depth and extent of the injury. Careful measurements of levator function should be performed. If a levator injury is suspected, exploration through an eyelid crease incision and repair is usually indicated. (**b**) Most superficial lacerations can be closed with a single-layer closure using interrupted or running 6-0 sutures (silk, plain gut, or nylon). Eyebrow lacerations, however, require a two-layer closure. The deep closure should be performed with a nonabsorbable suture such as 4-0 or 5-0 nylon and should relieve all tension on the wound edges. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

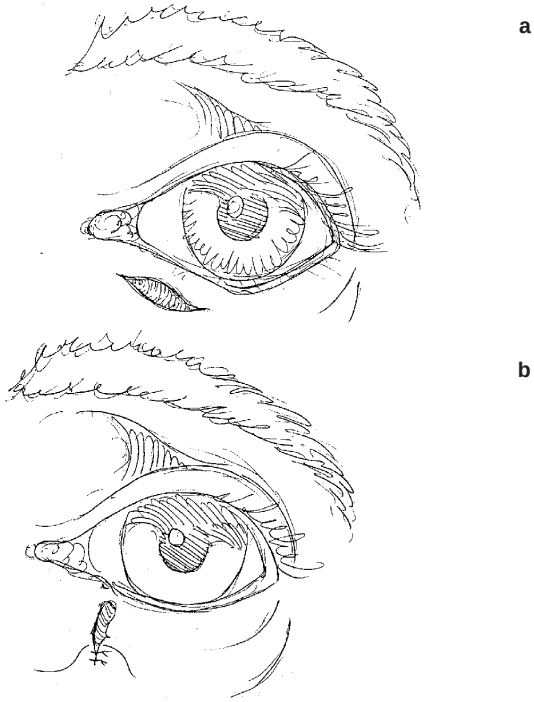

Fig. 18-2. Vertical closure of a medial horizontal defect. If the orientation of the laceration is horizontal and is located on the lower eyelid, reorientation of the wound closure to a vertical closure should be considered. (**a**) The eyelid should be placed on countertraction with a 4-0 nonabsorbable suture through the meibomian gland orifices. (**b**) Then, the laceration is closed vertically with 6-0 sutures. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

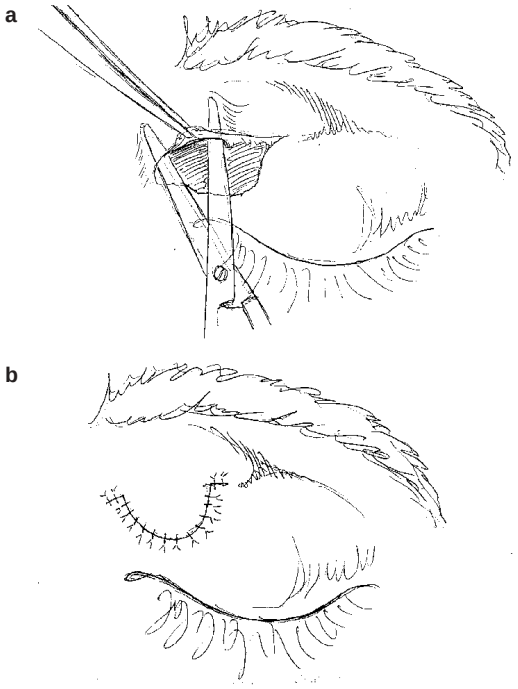

Fig. 18-3. If some tissue loss has occurred but the wound is superficial and does not involve the eyelid margin, an advancement flap can be fashioned. (**a**) The tissue that is to be advanced is generously undermined; Burrows operation to create triangles of skin may also be performed to augment the advancement. (**b**) The sutured wound is shown. If the tissue loss is greater, the remaining uncovered tissue may be allowed to granulate, or a skin graft may be performed. Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

The use of cyanoacrylate tissue glue is an expedient way to close simple lacerations. It stabilizes the tissue, has an inherent antibacterial effect, and obviates the need for suture removal. Tissue glue can also help to augment the closure of necrotic or crushed tissues that are otherwise difficult to secure with sutures.[6] After irrigating the wound, hemostasis is achieved using monopolar or bipolar cautery. The wound must be dry to allow the tissue glue to create adequate adhesion. Forceps are then used to appose the edges of the laceration, and the tissue glue is applied sparingly by means of a tuberculin syringe fitted with a small-gauge needle to facilitate accurate application. Cyanoacrylate creates a strong bond for 3 to 5 days and then disintegrates spontaneously. Antibiotic ointment should not be applied because it accelerates breakdown of the glue.

Eyelid-Margin Involvement

Lacerations involving the eyelid margin require precise closure. Failure to appropriately approximate the edges results in eyelid notching. For tissue loss less than 25% of the total horizontal dimension of the eyelid, direct closure is usually possible (Figure 18-4). Primary closure is possible if the wound edges can be brought together with forceps. The wound is closed in the same fashion as for a standard pentagonal wedge. The eyelid margin is lined up using a 6-0 silk suture through the meibomian gland orifices.

A surgeon's knot is then thrown to confirm correct suture placement. If alignment is not ideal, the suture is removed and replaced to ensure approximation. If alignment is good, the knot is loosened and internal sutures of 5-0 or 6-0 chromic gut or polyglactin (Vicryl) are placed in the tarsus, sparing the conjunctiva and the skin. Care must be taken to avoid penetration of the conjunctiva to spare the cornea from irritation or even abrasion. The number of sutures placed is determined by the extent of the wound; the upper lid, with its more generous tarsus, usually requires at least three internal sutures. The skin is then closed using 6-0 silk, plain gut, or nylon. Additional 6-0 silk sutures are placed at the anterior (and in some cases, the posterior) eyelid margins, and all of the marginal sutures are left long and tethered under the anterior eyelid suture to avoid corneal contact. These sutures are then used to put tension on the wound so that healing will occur in an everted fashion to avoid lid notching and ectropion. Alternatively, an additional 4-0 suture (silk or nylon) may be placed just medial and lateral to the marginal sutures through the meibomian gland orifices, tied, and then left long to allow vertical tension (Figure 18-5). This measure is particularly helpful if the wound is under significant tension or the tissue is pulverized or necrotic.

Eyelid-margin sutures should remain in place for 7 to 10 days, whereas the skin sutures may be removed in 3 to 5 days. When irregular eyelid-margin deficits defy closure, a pentagonal wedge can be created using a scalpel, and then closed in a similar fashion (Table 18-1).

If the tissue volume loss exceeds 25%, then further measures are necessary; in the elderly, redundant skin may allow direct closure of wounds up to 50% tissue volume loss, but in younger patients a lateral canthotomy and cantholysis are necessary (Figure 18-6). If the tissue volume loss is between 25% and 50% in the upper lid (up to 75% in the

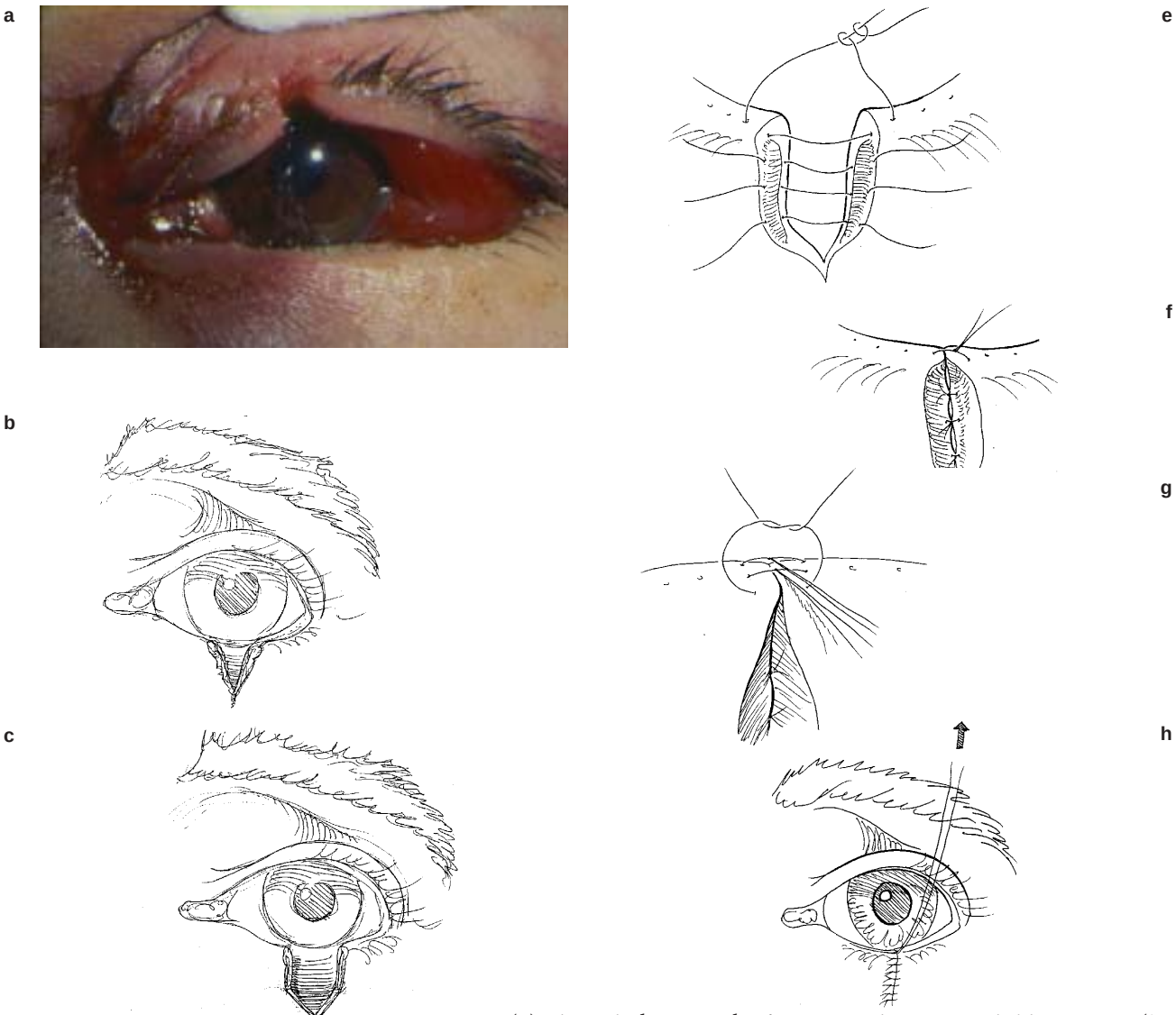

Fig. 18-4. (**a**) Clinical photograph of a marginal upper-eyelid laceration. (**b–h**) Repair of a marginal lower-eyelid laceration with less than 25% tissue loss. (**b**) An irregular laceration with tissue loss less than one fourth of the horizontal eyelid distance can usually be closed primarily. The technique is identical to the procedure used to close defects created after eyelid biopsy (pentagonal wedge closure). (**c**) The irregular traumatic laceration is freshened by creating a pentagonal wedge. (**d**) A 4-0 silk suture is placed in the eyelid margin (through the meibomian gland orifices 2 mm from the wound edges and 2 mm deep) and tied in a slipknot. Symmetrical suture placement is essential to obtain postoperative eyelid margin alignment. (**e**) The slipknot is loosened and approximately three absorbable 5-0 or 6-0 sutures are placed internally, encompassing the tarsal plate. (**f**) The skin and conjunctiva are not included in this internal closure. Anterior and posterior marginal sutures (6-0 silk) are then placed through the anterior and posterior eyelid margin. (**g**) The middle and posterior sutures are left long and tied under the anterior suture. (**h**) The skin is closed with 6-0 silk sutures, and the eyelid is placed on traction for at least 5 days. The skin sutures are removed 3 to 5 days later, and the marginal sutures are removed at 10 to 14 days postoperatively. Photograph: Courtesy of Department of Ophthalmology, Allegheny General Hospital, Pittsburgh, Pa. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

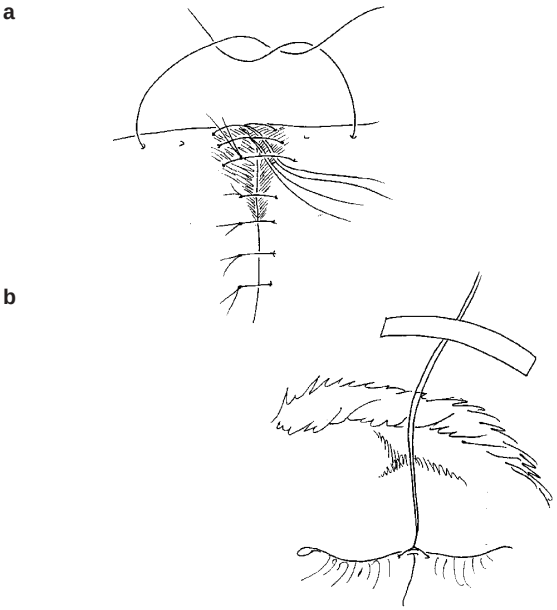

Fig. 18-5. Frost suture. (**a**) If the eyelid margin is macerated or necrotic, then an additional 4-0 nonabsorbable suture (eg, nylon) may be placed through the eyelid margin two to three meibomian gland orifices outside of the marginal silk suture placement. (**b**) The repaired laceration is placed under traction. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

TABLE 18-1

SUTURE RECOMMENDATIONS

Nature of Injury	Recommended Materials for Closure
Superficial Skin Laceration	6-0 plain gut, silk, nylon, or tissue glue
Eyelid Skin	
Margin	Three 6-0 silk in the margin
Tarsus	Two or three 5-0 or 6-0 Vicryl
Skin	6-0 silk or nylon
Eyebrow Injury	
Deep	Vertical mattress: 4-0 or 5-0 nylon or Vicryl
Skin	5-0 silk or nylon; tissue glue
Canalicular Injury	
Deep	8-0 or 9-0 nylon in tissue surrounding canaliculus
Skin	6-0 nylon
Medial Canthal Tendon Injury	
Medial resuspension to periorbita	4-0 nylon, Prolene, or wire
Skin	6-0 silk, nylon, or plain gut; tissue glue
Lateral Canthal Injury	
Lateral resuspension to periorbita	5-0 chromic gut, 4-0 Mersilene
Reconstruction of canthal angle	6-0 Vicryl internally; 6-0 silk externally
Skin	6-0 silk, nylon, or plain gut; tissue glue

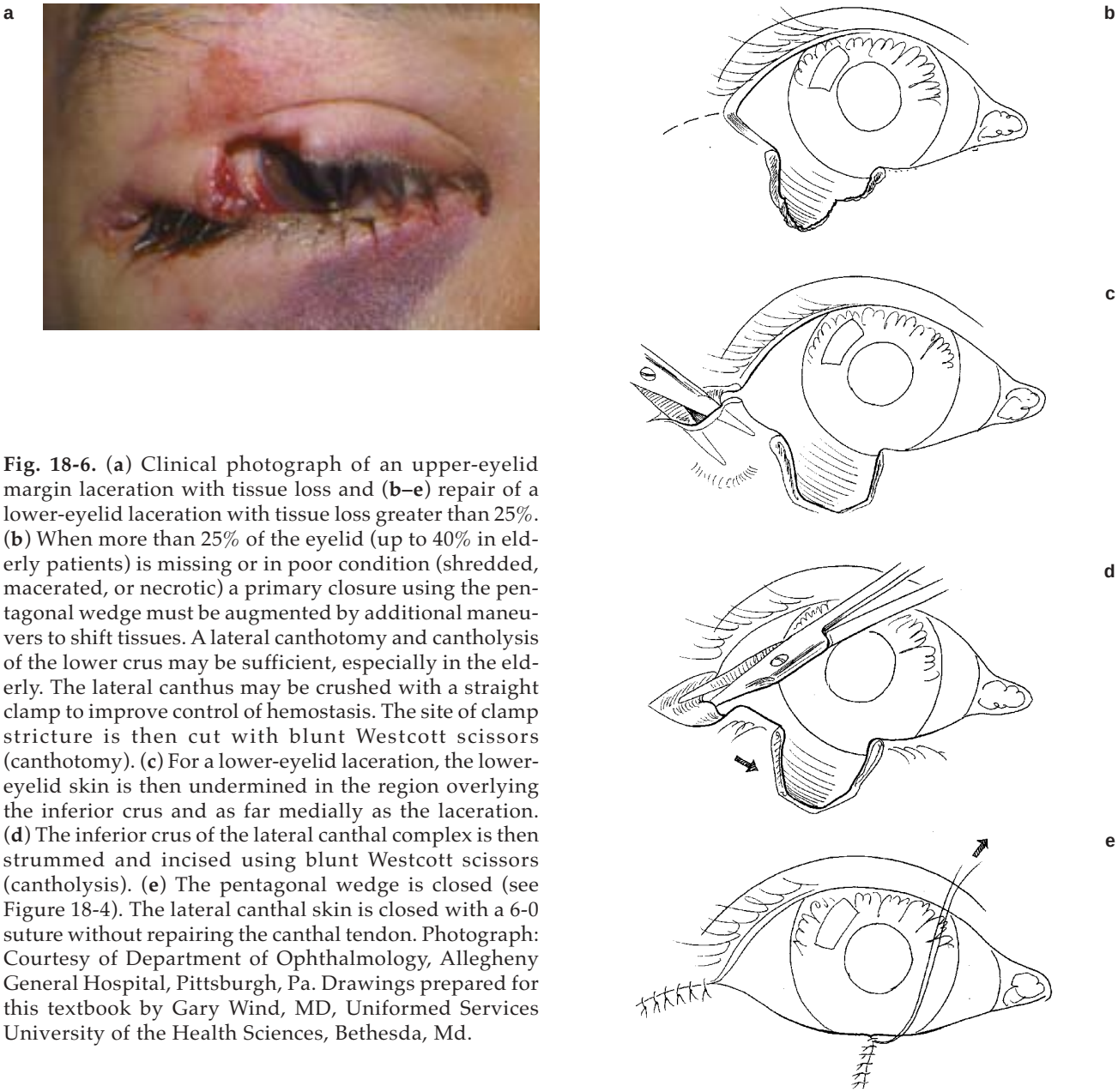

Fig. 18-6. (**a**) Clinical photograph of an upper-eyelid margin laceration with tissue loss and (**b–e**) repair of a lower-eyelid laceration with tissue loss greater than 25%. (**b**) When more than 25% of the eyelid (up to 40% in elderly patients) is missing or in poor condition (shredded, macerated, or necrotic) a primary closure using the pentagonal wedge must be augmented by additional maneuvers to shift tissues. A lateral canthotomy and cantholysis of the lower crus may be sufficient, especially in the elderly. The lateral canthus may be crushed with a straight clamp to improve control of hemostasis. The site of clamp stricture is then cut with blunt Westcott scissors (canthotomy). (**c**) For a lower-eyelid laceration, the lower-eyelid skin is then undermined in the region overlying the inferior crus and as far medially as the laceration. (**d**) The inferior crus of the lateral canthal complex is then strummed and incised using blunt Westcott scissors (cantholysis). (**e**) The pentagonal wedge is closed (see Figure 18-4). The lateral canthal skin is closed with a 6-0 suture without repairing the canthal tendon. Photograph: Courtesy of Department of Ophthalmology, Allegheny General Hospital, Pittsburgh, Pa. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

lower eyelid), then a Tenzel flap is necessary (Figure 18-7). The flap diameter should be twice the diameter of the defect, up to a flap size of 20 mm. Larger defects also require inferior crus cantholysis and release of the lateral septum and retractors. Both of these techniques mobilize lateral skin medially to allow closure of the wound under acceptable tension. If more than 50% of the upper eyelid or 75% of the lower eyelid is severely damaged or missing, then a larger flap or lid-sharing maneuver is required.[2,3]

If more than 50% of full-thickness lower eyelid is lost, a Hughes lid-sharing procedure is an excellent technique to provide the necessary posterior lamella support (Figure 18-8). The upper-lid conjunctiva and tarsus are mobilized from the upper eyelid and brought inferiorly to replace the posterior aspect of the lower eyelid. The anterior lamella (skin and orbicularis) may be provided as a free graft from the opposite upper eyelid, postauricular, or supraclavicular regions. The graft should be oversized by approximately 1 mm and secured with 6-0 silk.

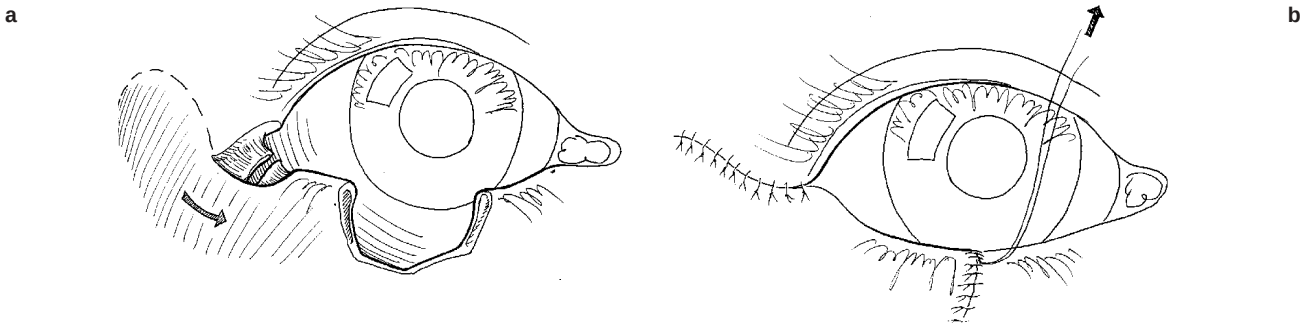

Fig. 18-7. Repair of a lower-eyelid laceration with tissue loss exceeding 50%. (**a**) If sufficient laxity is not present with the lateral canthotomy and cantholysis, then a Tenzel rotational flap is created, mobilizing tissue from the lateral upper lid for lower-lid laceration. (**b**) The final result after placement of skin sutures is shown. If primary closure of the eyelid margin is still not possible after these two procedures, then more-complex procedures—beyond the scope of most general ophthalmologists—are required. A Mustarde flap can be used to mobilize facial laxity to help with eyelid closure, or an eyelid-sharing technique from the opposite lid may be performed. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

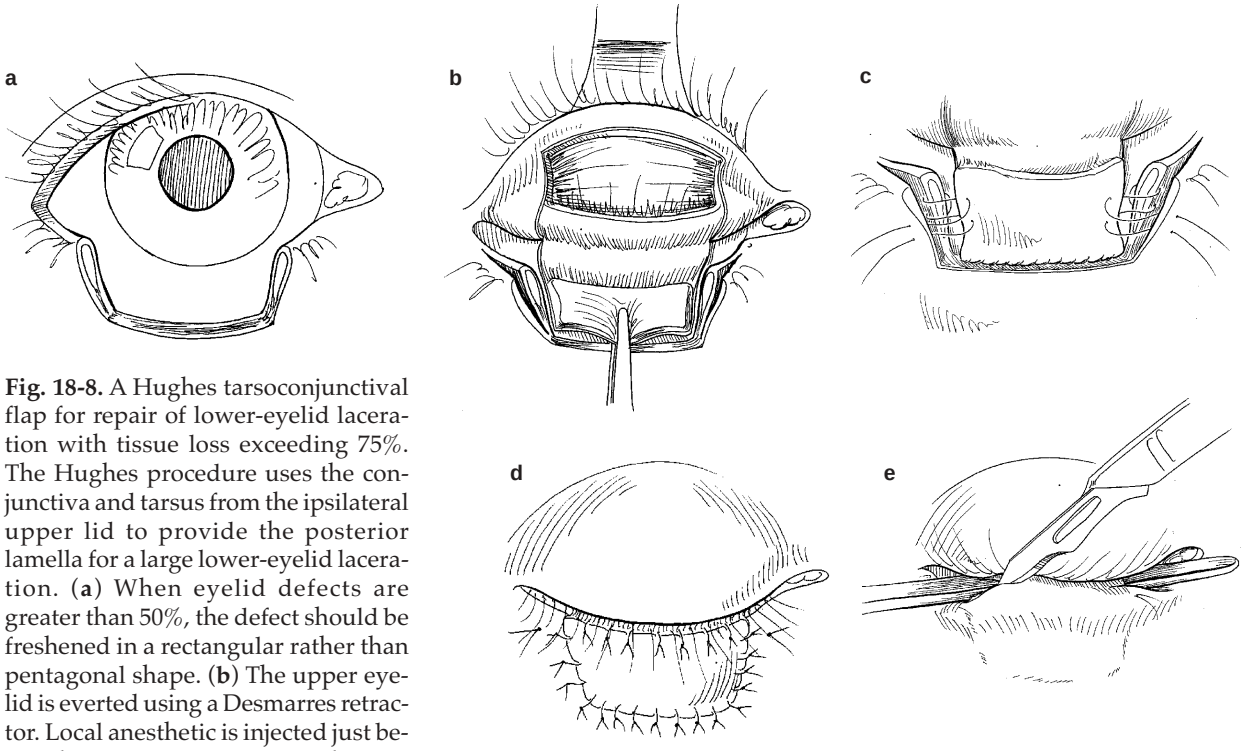

Fig. 18-8. A Hughes tarsoconjunctival flap for repair of lower-eyelid laceration with tissue loss exceeding 75%. The Hughes procedure uses the conjunctiva and tarsus from the ipsilateral upper lid to provide the posterior lamella for a large lower-eyelid laceration. (**a**) When eyelid defects are greater than 50%, the defect should be freshened in a rectangular rather than pentagonal shape. (**b**) The upper eyelid is everted using a Desmarres retractor. Local anesthetic is injected just below the conjunctival surface. The conjunctiva is incised 3 mm from and parallel to the eyelid border as the first step in the formation of a tarsoconjunctival flap. The conjunctiva and tarsus are then incised perpendicular to the original incision, creating a fornix-based flap. Sharp and blunt dissection are used to free the Müller's muscle from the flap. (**c**) The tarsus of the upper lid is sutured to the lower lid in a tongue-in-groove fashion using a 4-0 silk suture nasally and temporally. 7-0 Vicryl is then used to secure the tarsus to the conjunctiva inferiorly. (**d**) A skin graft from the contralateral upper eyelid, inferior advancement flap or a Tenzel flap may be used to replace the anterior lamella (skin and orbicularis). The skin graft pictured is best obtained from the contralateral—never the ipsilateral—upper eyelid and is secured with interrupted 6-0 silk sutures. If insufficient upper-eyelid skin is present, retroauricular or supraclavicular skin may be used as an alternative. (**e**) Six to 8 weeks after primary repair, the second-stage procedure should be performed. The tarsoconjunctival flap is incised approximately 1 mm above the intended upper-eyelid level. The globe should be protected with a malleable retractor or knife handle and the incision performed using a no. 15 Bard-Parker blade. This second-stage procedure should be performed 6 to 8 weeks after the primary repair. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

A bolster composed of cotton or a Telfa pad should be secured over the skin graft, using sutures that are left long for this purpose. The bolster and a pressure patch should be left in place for 5 days to minimize shrinkage or hypertrophic healing. Alternatively, a flap mobilized from excess lateral skin (Tenzel flap) may be used. If the defect is in the upper eyelid, the posterior lamella may be obtained from the contralateral upper-eyelid tarsus, or ear cartilage as a free graft. Other materials, such as donor sclera or preserved pericardium, have also been used with success.

If the posterior lamella is replaced with a graft, then the anterior lamella must be constructed from a medial- or lateral-based flap. The Cutler-Beard technique uses a full-thickness flap of lower-eyelid skin passed behind an intact bridge of lower-lid margin. Two grafts overlying one another are likely to fail because of inadequate blood supply. In the case of very large defects, a Mustarde flap, which mobilizes tissue from the cheek and lateral skin, should be performed (*a*) only by ophthalmologists with extensive experience or (*b*) with the help of a plastic surgeon. Inappropriate flap development can result in facial paralysis or flap necrosis (Exhibit 18-1).[2–7]

EXHIBIT 18-1

OPTIONS FOR REPAIR

- Anterior Lamella (Skin, Orbicularis, Subcutaneous Tissue)
  - Granulation < 5 mm (< 10 mm in medial canthal region)
  - Primary closure: simple
  - Advancement flap (with burrows triangles)
  - Free skin graft: upper eyelid, retroauricular, and supraclavicular
  - Tenzel semicircular flap
  - Cutler-Beard tunnel flap (upper-eyelid reconstruction)
  - Mustarde flap
- Posterior Lamella (Conjunctiva, Tarsus)
  - Free tarsal graft
  - Hughes tarsoconjunctival graft (lower-eyelid reconstruction)
  - Hard palate (lower eyelid only)
  - Donor sclera
  - Preserved pericardium
  - Ear cartilage
  - Nasal septum

Levator Injury

If posttraumatic ptosis is noted or if orbital fat is present in the wound, then a deeper laceration should be suspected. Ptosis may due to a levator laceration or penetration, edema, hemorrhage, or nerve injury. Careful exploration allows inspection of the levator muscle and can rule out deeply imbedded FBs (Figure 18-9). If the levator aponeurosis is injured, then primary repair should be performed whenever possible.

Familiarity with the layers of the eyelid is essential; the levator lies deep to the preaponeurotic fat, orbital septum, orbicularis, and skin. Therefore, if fat presents in the wound, then the orbital septum has been violated and a levator injury is very likely. The technique of reapproximating the levator is similar to the techniques utilized in levator aponeurosis resection for ptosis. If the laceration size limits visualization of the levator, then a skin-crease incision can be performed to improve exposure. The overlying orbicularis is excised, and the septum is identified and incised, allowing visualization of the preaponeurotic fat. The fat is carefully elevated from the levator aponeurosis, and any defects or regions of dehiscence are identified.

Two complementary techniques may aid in the assessment of eyelid anatomy, especially in the challenging traumatized wound. The surgeon may grasp the levator and have the patient look up and down; these eye movements create tension and confirm that the levator is the tissue being grasped. Alternatively, the surgeon may grasp and pull downward on the presumed septum; resistance should be noted because the septum is attached to the superior orbital rim. If lacerated, the levator can be repaired utilizing 6-0 silk or Vicryl. If completely disinserted, it can be reattached utilizing two or three double-armed sutures allowing approximation to the tarsus. Be careful to avoid inclusion of the septum in wound closure; the septum should not be closed. Surgical repair of ptosis should be performed in an awake patient, if possible, to allow matching of the eyelid level to the normal side.[7,9]

Complex Eyelid Injuries

More-complex eyelid lacerations require problem-solving techniques similar to those required by a jigsaw puzzle. Although initially, tissue loss may appear to be extensive, when the corners are

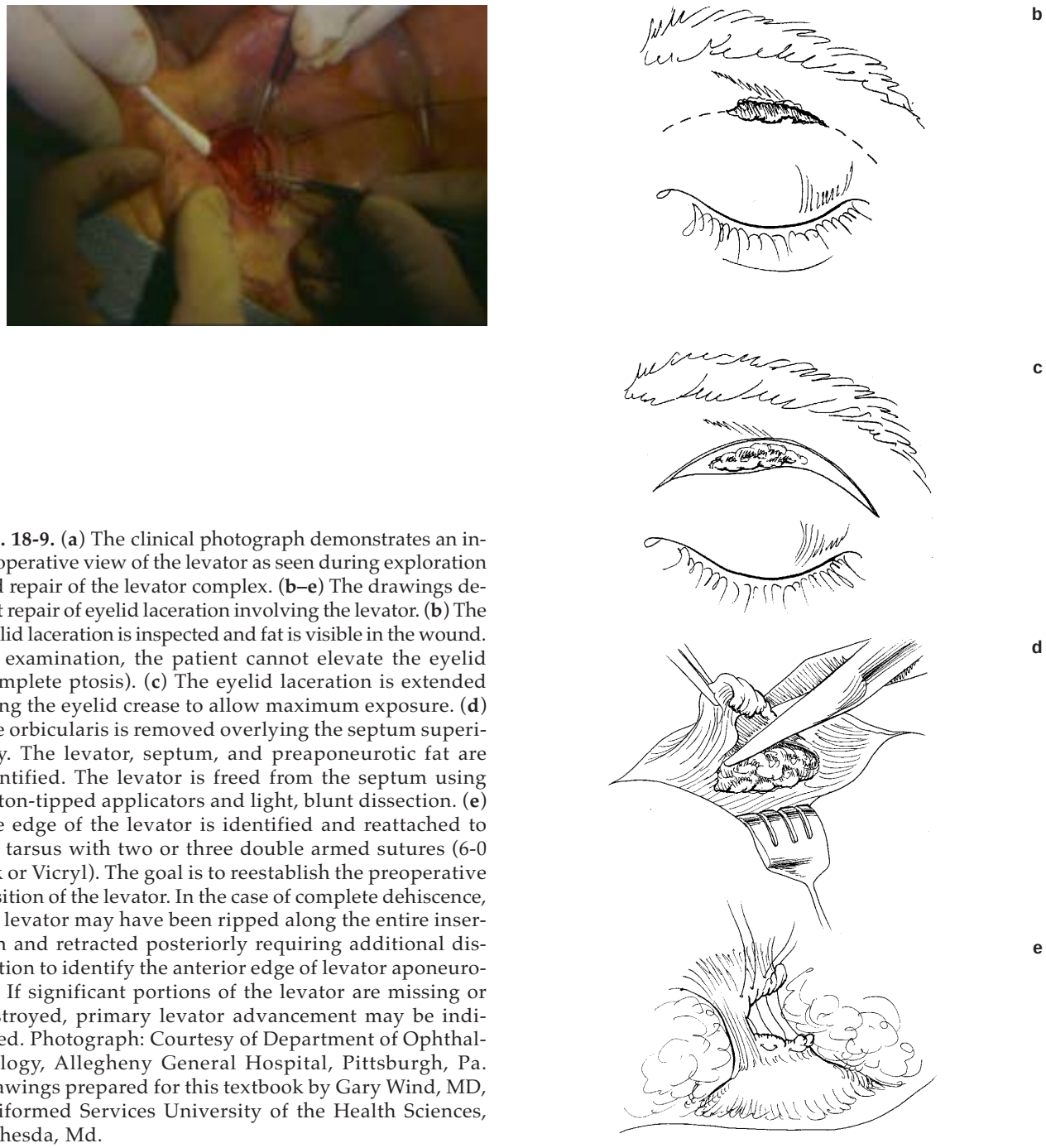

Fig. 18-9. (**a**) The clinical photograph demonstrates an intraoperative view of the levator as seen during exploration and repair of the levator complex. (**b–e**) The drawings depict repair of eyelid laceration involving the levator. (**b**) The eyelid laceration is inspected and fat is visible in the wound. On examination, the patient cannot elevate the eyelid (complete ptosis). (**c**) The eyelid laceration is extended along the eyelid crease to allow maximum exposure. (**d**) The orbicularis is removed overlying the septum superiorly. The levator, septum, and preaponeurotic fat are identified. The levator is freed from the septum using cotton-tipped applicators and light, blunt dissection. (**e**) The edge of the levator is identified and reattached to the tarsus with two or three double armed sutures (6-0 silk or Vicryl). The goal is to reestablish the preoperative position of the levator. In the case of complete dehiscence, the levator may have been ripped along the entire insertion and retracted posteriorly requiring additional dissection to identify the anterior edge of levator aponeurosis. If significant portions of the levator are missing or destroyed, primary levator advancement may be indicated. Photograph: Courtesy of Department of Ophthalmology, Allegheny General Hospital, Pittsburgh, Pa. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

reapproximated, the true extent of tissue loss may be much less. Every attempt should be made to accomplish complete closure; 6-0 silk, plain gut, or nylon sutures are placed in an interrupted fashion and should remain for 3 to 5 days. Certain suture techniques, such as the far-near–near-far technique, help relieve superficial wound tension.

Allowing small, superficial defects to heal by secondary intention can result in acceptable cosmesis if they are very small (< 5 mm) or located in the medial canthal region and less than 1 cm in diameter. Eyelid-margin involvement or extensive tissue loss, however, mandate primary repair.[3,5,7] Skin grafting or large flap advancements should be performed in the acute setting only when severe corneal exposure is present. Complex cases are best delayed if possible so that the primary repair can be performed by experienced, subspecialty-trained ophthalmologists.

Total Avulsion

In the case of total avulsion, the amputated tissue should be retrieved from the injury scene, wrapped in moistened Telfa padding, and carefully preserved on ice during transport. The avulsed tissue should be soaked in a diluted antibiotic prior to reattachment. If necrosis is present, debridement should be minimal and not prohibit wound closure. The avulsed tissue should be secured in an anatomically correct location using a layered closure. If the tarsus is involved, it should be closed in a fashion analogous to the pentagonal wedge described above. Avulsed eyelid tissue that is carefully handled and reattached appropriately has a good chance of surviving and providing adequate function and cosmesis.[3,5,7,9,10]

SURGICAL MANAGEMENT OF ADNEXAL INJURIES

Eyebrow and canalicular injuries commonly occur in association with eyelid lacerations. Injury to the medial canthal ligament frequently accompanies medial lacerations. Lateral canthal lacerations and lacrimal gland and sac injuries are more unusual.

Eyebrow Injuries

The eyebrow may be lacerated in isolation or in continuation with an eyelid injury. The skin in the eyebrow region is thicker than in the eyelid and requires at least a two-layer closure. The deep closure should result in skin approximation. A gap before skin closure will result in an unacceptable postoperative incisional width. Sutures such as 4-0 or 5-0 nylon or Vicryl are often used in a buried, interrupted fashion (eg, vertical mattress technique). The skin is then closed with interrupted or running 6-0 gut, silk, or nylon sutures or with tissue glue.[3]

Canalicular Injuries

Although direct injuries to the lacrimal gland and lacrimal sac are rare because each lies within its own fossa, injuries to the canaliculi are common. Blunt injuries can result in contusions or posttraumatic stenosis of these tiny structures. More commonly, however, a laceration of the medial aspect of the upper or lower eyelid disrupts the continuity of one of the canaliculi (Figure 18-10). Dog bites are a common cause of such injuries, especially in children.[11] A fist striking the cheek can also disrupt the canaliculi. In such cases, the temporal swelling can mislead even the most prudent examiner. Finally, on occasion, a well-intentioned surgeon can cause injury to these delicate structures while repairing an adjacent injury. To avoid this kind of inadvertent iatrogenic injury, the canaliculus should be dilated and a probe placed while adjacent lacerations are repaired. Suspicion and inspection are keys to the identification and early repair of canalicular injuries. Although most ophthalmologists feel comfortable repairing a wide variety of eyelid lacerations, repair of the canaliculi prompts concern in even the most skilled retinal or anterior segment surgeon.[5,7,8,11–15]

The management of canalicular lacerations is controversial. Recommendations in the literature range from observation (if only one canaliculus is injured) to canalicular repair with intubation of the upper and lower systems. Although epiphora is not a guaranteed outcome if an injured canaliculus goes unaddressed, repair should be attempted if possible. Repair can be delayed for 48 hours without affecting the outcome.

Surgical repair begins with identification and dilation of the puncta and probing of the proximal aspect of the injured canaliculus. Magnification is essential, although repair is possible using loupes; a microscope is often necessary. Using magnification, inspection of the correct region (posterior to the medial eyelid stump, adjacent to the caruncle)

Fig. 18-10. A medial laceration with suspected canalicular injury. All lacerations that extend medial to the puncta should be explored to determine the status of the canaliculi and the medial canthal tendon. Photograph: Courtesy of Department of Ophthalmology, Allegheny General Hospital, Pittsburgh, Pa.

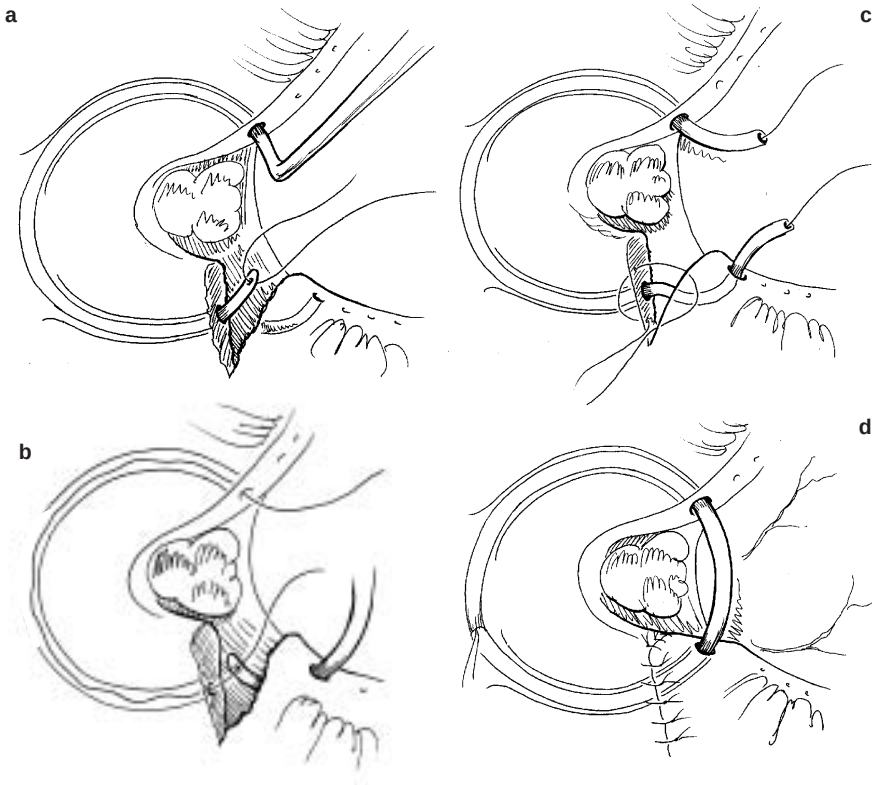

Fig. 18-11. Pigtail probe technique for distal canalicular identification. (**a**) The pigtail is inserted through the uninvolved upper punctum and then passed through the common canaliculus and out the medial end of the lower canalicular laceration. 6-0 nylon suture is then threaded through the eyelet on the end of the pigtail probe so the probe can be carefully pulled back through the common canaliculus and out the intact canalicular system. (**b**) The pigtail probe is then inserted through the proximal canalicular edge so that it passes from the punctum into the wound. The eyelet is threaded with the same 6-0 suture and pulled through the punctum. The 6-0 suture now traverses the entire canalicular system. Silicone tubing is then threaded over the 6-0 suture, completing the intubation of the canalicular system (15–20 mm of silicone tubing is necessary). (**c**) The canalicular laceration is then repaired. A single-suture technique is a good alternative to the multiple-suture technique. The single 7-0 Vicryl suture is placed in a horizontal mattress fashion. The goal is to align the tissues surrounding the canaliculus; direct repair of the canaliculus is not necessary. (**d**) Following the laceration repair, the 6-0 suture is tied such that the ends of the silicone tube are approximated and the section of silicone tube containing the knot positioned in the common canaliculus. The silicone tube should not be long enough to contact the cornea or short enough to "cheesewire," or cut, through the puncta. Drawings prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md. NOTE: the normal angulations of the canaliculi have been simplified for these illustrations.

may reveal the white, round, rolled edges of the cut medial end. Additional measures are frequently required to identify the cut end amid the tissue edema and distortion. Normal saline, with or without 2% fluorescein, may be irrigated from the uninjured puncta and visualized as it exits the detached distal end of the injured canaliculus. Methylene blue is not recommended because once applied, it stains the entire field.

If the distal end of the canaliculus cannot be located, a pigtail probe may be used (Figure 18-11). The occasional lacrimal surgeon should be very careful; if used in the wrong way, the pigtail probe can damage the lacrimal sac and uninvolved canaliculus. The pigtail probe should be used with a very delicate touch and abandoned immediately if smooth passage does not occur the first time. Once the pigtail probe is appropriately inserted, silicone tubing can be cannulated over a 6-0 polypropylene suture and the knot rotated so that it lies within the lacrimal sac. The soft tissues surrounding the injured canaliculus are approximated using 8-0 or 9-0 nylon suture. Nonreactive suture (eg, nylon) is preferred to avoid inflammation and potential secondary stricture of the canaliculus, which are associated with dissolution of absorbable sutures.

The canaliculus itself does *not* require repair. A variety of monocanalicular stents are available but have not been found to be superior to stenting the entire system with standard silicone tubes (ie, Crawford, Donahue, or Jackson tubes). Although monocanalicular stents are often easier to place, the proximal end is secured to the skin or inferior culde-sac, which promotes premature tube dislocation (Figure 18-12). Table 18-2 lists an array of equipment for canalicular diagnosis repair and suggests some field-expedient substitutes.

Recanalization of mucosal surfaces is rapid, yet how long the tubes should remain in place is debated (2 wk[2,3] to 6 mo[10,12]). If the patient is not both-

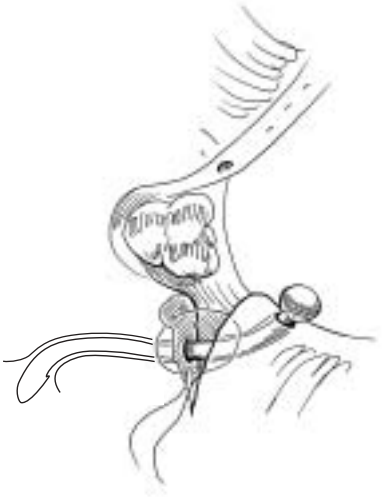

Fig. 18-12. Monocanalicular stent placement. If the distal end of the canalicular laceration is easily identified, a monocanalicular stent can be slipped in place, and then the canalicular laceration can be repaired (see Figure 18-11). Drawing prepared for this textbook by Gary Wind, MD, Uniformed Services University of the Health Sciences, Bethesda, Md.

TABLE 18-2

EQUIPMENT REQUIRED FOR CANALICULAR REPAIR

Traditional	Improvisations
Punctal Dilator	Safety pin
Lacrimal Probes (Bowman no. 00, 1, 2)	Paper clip
Canalicular Irrigation Cannula	25-gauge needle with the tip filed flat
Canalicular Stents	4-0 nylon suture
Veirs Rod (Ethicon, Inc*)	—
Johnson Wire Stent (Karl Storz Industrial Endoscopy*)	—
Silicone Tubing (Dow Corning Corp*)	—
Mini Monoka (FCI, Inc*)	—

*Distributor

ered by the tubes, a 6-month course is ideal in severely traumatized cases.

Medial Canthal Injuries

Medial canthal disruption or significant medial skin defects can occur in isolation or in conjunction with canalicular lacerations. If the posterior limb of the medial canthus is disrupted, rounding occurs and telecanthus typically develops. Reapproximation of the canthal tendon to the periosteum overlying the posterior lacrimal crest may be accomplished with 4-0 monofilament suture (eg, nylon) on a small, reverse-cutting needle but more often requires screws or plates for definitive repair.

Overcorrection is the goal in the immediate postoperative period; the medial punctum should be pulled 1 to 2 mm medial to its normal position and be markedly inverted. Care must be taken to maintain the natural position of the medial canthus 2 mm lower than the lateral canthus. Tissue loss in the region of the medial canthus can be managed effectively with granulation, a graft, or a glabellar flap. In the case of medial canthal injury, the canaliculus should be repaired first, the tendon should then be reattached (with special attention to its posterior aspect), and, finally, skin or eyelid-margin lacerations should be addressed. The conjunctiva does not require repair, but the plica semilunaris and caruncle should be reconstructed with buried, interrupted, 6-0 plain gut sutures to achieve better cosmesis.[2,3,5]

Lateral Canthal Injuries

Lateral canthal injuries require deep repair to preserve the shape and position of the eyelid. If the lateral canthus has been entirely disrupted, care should be taken to identify the superior and inferior crus, resuspend the inferior crus to the periorbita, and reform the lateral canthal angle. The suspension is very similar to a lateral tarsal strip procedure. The inferior crus is resuspended to the periorbita using a 4-0 polyester or 5-0 chromic suture. If no periorbita remains, a miniplate may be placed along the lateral orbital margin and 4-0 or 5-0 nylon sutures used to attach the lateral canthus.

The superior and inferior crus should be internally (6-0 Vicryl) and externally (6-0 silk or nylon) secured to one another to recreate the normal sharp angle of the lateral canthus. The skin can be closed in an interrupted or running fashion with 6-0 silk, nylon, gut, or tissue glue. If inferior eyelid trauma is also present, a temporary lateral tarsorrhaphy or a Frost suture should be placed for upward traction and prevention of postoperative ectropion or eyelid retraction.

Lacrimal Sac and Lacrimal Gland Injuries

Lacrimal sac and duct injuries tend to accompany midfacial injuries that fracture the lacrimal or ethmoid bones or both. These injuries are very difficult to identify in the acute setting, and primary repair is not typically an issue. Dacryocystorhinostomy (DCR) or conjunctivo-dacryocystorhinostomy (C-DCR) with Pyrex (Jones) tube placement may be necessary at a later time.[7,9]

Injury to the lacrimal gland may be confused with fat presenting in the wound. In any lateral eyelid injury, fat prolapse should be assumed to be lacrimal gland tissue until proven otherwise. The levator aponeurosis provides the anatomical separation between the palpebral and orbital lobes of the lacrimal gland. Orbital fat tends to have a yellow-white appearance, whereas lacrimal gland is more flesh- or pink-colored. In traumatic wounds, these color distinctions may be blurred because of contamination, edema, and blood. Suspected lacrimal gland tissue should be replaced into its fossa and the overlying skin defect closed, as described above in the Superficial Eyelid Lacerations section.[4,7]

POSTOPERATIVE WOUND CARE

Postoperative wound care should include daily cleaning of crusting with cotton-tipped applicators and hydrogen peroxide whenever possible. Topical antibiotic ointment (erythromycin or bacitracin) should be applied at least daily. In the case of delayed closure, an oral antibiotic with broad-spectrum coverage should be prescribed. The eyelids are very well vascularized and heal well despite delayed closure or even complete avulsion.

Minimizing contraction during the healing of the wound is very important. Countertraction with a suture (Frost or reverse Frost) through the eyelid margin (preferably using 4-0 nylon or silk) should be placed in all traumatic eyelid injuries. The more significant the eyelid deficit, the longer the eyelid should be left on traction. Skin grafts should be pressure-patched for at least 5 days, and longer for larger defects. Plastic tape can be used to exert upward traction on the malar fat pad and minimize the effects of gravity. Frost sutures, pressure patching, and unweighting of the cheek should be combined in complex eyelid injuries.

SUMMARY

Injuries to the eyelids and ocular adnexa are very common in civilian and battlefield settings. These injuries are often accompanied by intracranial or facial injuries, so stabilization of the patient and attention to the classic ABCs (airway, breathing, and circulation) of trauma care are crucial. If midfacial injuries are present, relying on a team of expert otolaryngologists, oromaxillofacial surgeons, and, occasionally, neurosurgeons maximizes the patient's functional and cosmetic outcome.

Eyelid and ocular adnexal injuries are also commonly associated with injury to other aspects of the globe and orbit. A complete history and ophthalmic examination are always indicated prior to intervention. CT scans should be performed if FBs or fractures are suspected. All wounds should be carefully irrigated and all but very severely necrotic tissue preserved.

Primary closure of the eyelid defect should be performed within 72 hours; canalicular laceration repair should be performed within 48 hours. Completely avulsed tissue should be soaked in antibiotic solution and used for repair whenever possible. If primary closure is not possible, then a combination of skin grafts, lid-sharing techniques, and flaps is necessary. The types of suture or canalicular stenting material are far less important than a meticulous primary closure that respects eyelid and adnexal anatomy. Finally, liberal use of traction sutures, pressure patches, and taping minimizes the effects of gravity and maximizes the cosmetic outcome.

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