Chapter II
FACE, NECK, AND EYE TRAUMA

II.1 Complex Facial Wounds

CASE PRESENTATION

A male soldier in his mid-thirties was injured by an improvised explosive device (IED) detonated close to him while he stood near a concrete barrier. He sustained multiple injuries to the face (Figs. 1 and 2), scalp (Fig. 3), and extremities. The patient was orally intubated in the field. A thorough examination that included radiographs revealed macerated facial and scalp wounds impregnated with rocks and dirt, and a partially degloved mandible (Fig. 2). Although exposed, there was no damage to the bony facial skeleton. His vision was intact. During surgery, massive irrigation and debridement of his wounds were performed. Devitalized tissue was debrided, the penetrated tissue was explored, and rocks and dirt were removed with meticulous care. The intraoral mucosa was sutured to cover the exposed mandible and to separate the oral cavity from the face. Moist wet-to-dry sterile dressings were placed on the patient's scalp and face. He was taken to the intensive care unit (ICU) for continued care. The patient was evacuated by air to a level IV medical facility for further treatment.

TEACHING POINTS

1. Note that immediate recognition and appropriate management of airway compromise are critical to survival. A survey for associated eye (proptosis, pupil size), ear (ruptured tympanum), and head trauma is imperative. Patients exposed to blasts may experience iridoplegia (paralysis of the pupil), which does not indicate secondary effect of a central nervous system mass lesion or herniation.
2. Perform wound debridement to thoroughly evaluate the extent of the injury.
3. Perform complete intraoral and extraoral examinations to rule out facial fractures.
4. Cleanse wounds thoroughly with scrub solutions and saline. Use a scrub brush to remove all dirt particles from the dermis. Copious irrigation, forceps (curette and no. 11 blade tip, among other instruments), and strong suction are keys to effective cleansing.
5. Remove foreign bodies with meticulous care in order not to provoke injury to underlying structures. The more time taken initially will improve the cosmetic outcome for the patient.
6. Treat vascular injuries using methods from direct pressure to dissection and ligation of the offending vessel. Blind clamping of bleeding areas should be avoided because critical structures, such as the facial nerve

FIGURE 1. *Multiple facial wounds impregnated with sand, rocks, and debris.*

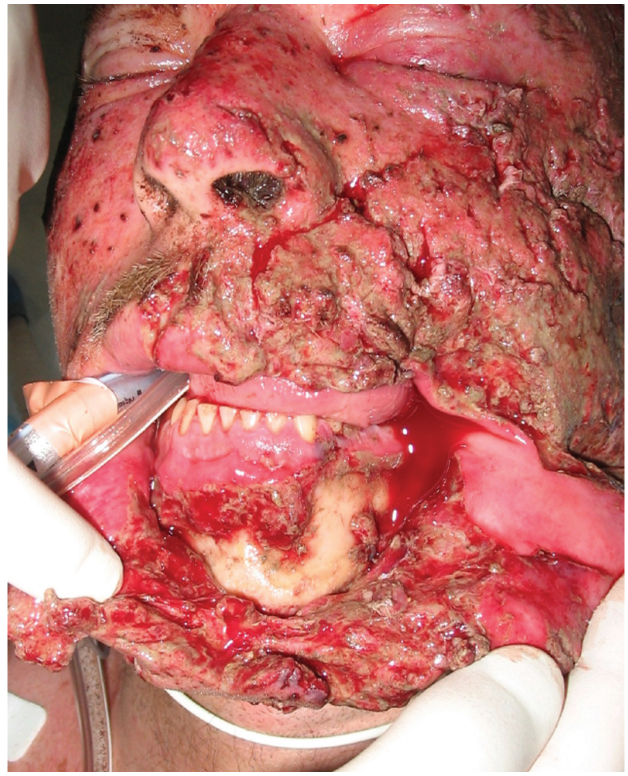

FIGURE 2. *Degloved mandible and extent of wounds.*

and parotid duct, are susceptible to injury. Use sharp debridement of wound edges that are devitalized.

7. Use antibiotics with gram-positive coverage for penetrating injuries to decrease the incidence of infection and to help promote optimal wound healing. Consider tetanus toxoid.
8. In general, in contrast to extremity wounds, primary closure is an important aspect of managing facial lacerations. When primary closure is possible, the wound should be reapproximated in proper layers to optimize an esthetic outcome for the patient (Figs. 4 and 5). In this case, the wounds were so contaminated that primary closure was delayed, and additional irrigation and debridement were required.

CLINICAL IMPLICATIONS

In contrast to similar wounds of other body regions, primary closure of small facial wounds is recommended following thorough cleansing. Closure of deep wounds involving many layers or hasty closure before adequate irrigation and debridement, however, can lead to the following adverse outcomes:

FIGURE 3. *Scalp injuries.*

Figure 4. *Scalp healing 1-year post-op.*

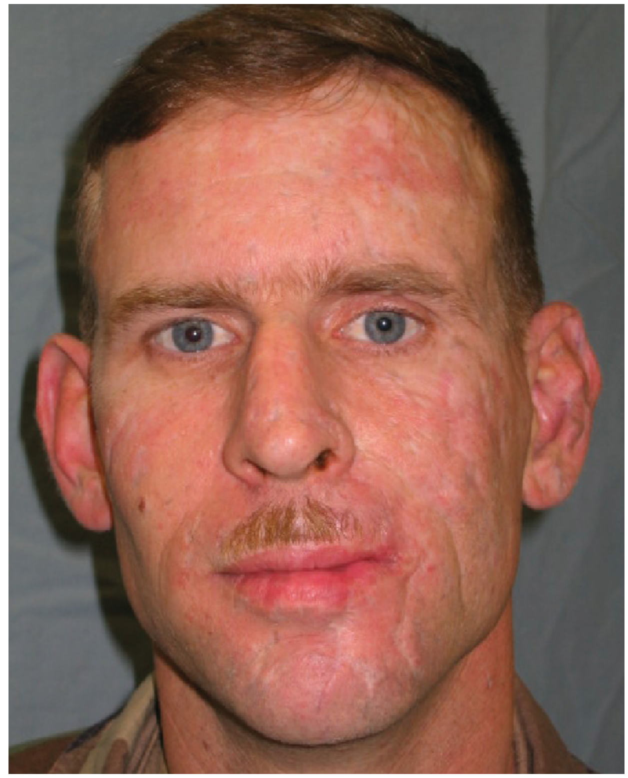

Figure 5. *Facial wound healing 1-year post-op.*

1. Infected wounds.
2. Devitalized tissues being inadvertently incorporated into the wounds.
3. Inadequate debridement of wounds with retention of foreign bodies.
4. Tattooing as a result of inadequate dirt removal.

DAMAGE CONTROL

For mild bleeding, use compression. For significant bleeding, perform ligation of the vessel. Direct visual location of the vessel is necessary before vessel ligation to prevent damaging the parotid duct or facial nerve. Meticulous irrigation and debridement of grossly contaminated wounds are vital to prevent infection.

SUMMARY

Attempt to remove all obvious debris from wounds during the first operation to facilitate a more favorable outcome for the patient. If the tissue margin looks dead or macerated beyond repair, it should be removed up to 1 to 2 mm to facilitate a more esthetic wound closure. Because of the highly vascular tissue in the face, small pedicles of tissue can survive. Native tissue will always look better than flaps and grafts. Although the face is very vascular, it is not recommended that deeply contaminated wounds be primarily closed during initial surgery. In heavily contaminated wounds, multiple rounds of irrigation and debridement are recommended with delayed primary closure, if possible. Rotational flaps and skin grafts may be necessary to obtain optimal results.

SUGGESTED READING

Chapter 13: Face and neck injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

Chapter 22: Soft-tissue injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

Fonseca R, Walker R. *Oral and Maxillofacial Trauma*. 2nd ed. Philadelphia, Pa: W. B. Saunders; 1997.

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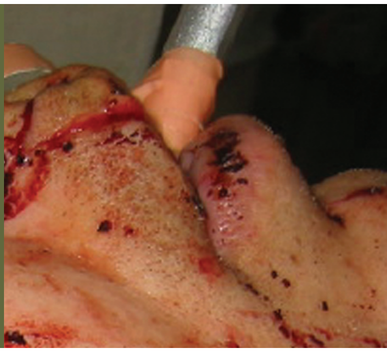

II.2 Facial Lacerations

CASE PRESENTATION

A 35-year-old male soldier sustained facial injuries from debris hurled from a car bomb explosion. Multiple soft-tissue wounds were apparent, with the most significant being a right cheek laceration (Fig. 1). Because of the location of the wounds, evaluations of the parotid duct and facial nerve were indicated. Bleeding was controlled with direct wound compression. The patient was alert and oriented. Physical and neurological examinations revealed no gross evidence of facial nerve weakness. There was no evidence of injury to the bony facial skeleton. During surgery, no evidence of damage to the parotid duct (of Stenson) was found. Manual manipulation of the gland produced an adequate flow of saliva. The duct was cannulated with lacrimal probes and catheter tubing. No disruption of the duct was seen. The patient's wound and vital structures were explored. Foreign bodies were removed, and tissues were closed in layers. He recovered without complications (Fig. 2).

TEACHING POINTS

1. Vascular injuries must be ruled out and repaired before proceeding with the laceration repair.
2. Facial bleeding should be controlled initially with compression. Ligation of the vessels may be necessary. However, direct visual location of the vessel is necessary before performing ligation to prevent damage to the facial nerve or parotid duct.
3. The importance of wound exploration needs to be stressed. There are multiple, underlying vital structures that can be damaged in a facial/cheek laceration. The wound must be carefully examined to identify and evaluate the integrity of the facial artery and nerve and its branches, the buccal fat pad, and the parotid gland and duct.
4. Although not always necessary, if sialography is performed, use a water-soluble contrast media (which is less toxic) instead of methylene blue.
5. Care should also be taken to ensure the sterility of the procedure and to prevent introduction of oral bacteria into the parotid duct.
6. Parotid duct lacerations require stent placement, with suturing of the lacerated ends (see Fig. 4, page 68). Careful monitoring of parotid gland injuries should be performed to rule out the formation of a parotid fistula or sialocele, which can be treated with antisialogogues and pressure dressings.

FIGURE 1. *Cheek, scalp, and facial lacerations.*

FIGURE 2. *Wounds immediately post-op.*

7. Repair facial nerve lacerations that occur proximal to a perpendicular line drawn from the lateral canthus of the eye.
8. Wound closure is important in managing facial lacerations. Copious irrigation, removal of foreign bodies, and antibiotics with gram-positive coverage are necessary to decrease infection and to help promote optimal wound healing. Try to maintain the buccal fat pad, if possible, to prevent cosmetic defects (eg, hollowing of the cheek). When primary closure is possible, the wound should be reapproximated in proper layers to optimize an esthetic outcome for the patient (Figs. 3 and 4).

CLINICAL IMPLICATIONS

1. Simple cheek lacerations that are superficial in depth should be managed like any other facial laceration in an esthetic zone once a neurological examination has been performed.
2. Large through-and-through lacerations are wounds that may potentially involve injury to any of the structures listed below, and injury to any of these structures may require additional procedures:

   a. Facial nerve injuries.
   b. Damage to the parotid gland and duct.
   c. Damage to the facial artery and its branches.
   d. Damage to the buccal fat pad.

DAMAGE CONTROL

Check vital structures. In a conscious patient, document the neurological examination of the facial nerve before administering local anesthesia. In an unconscious patient, a nerve stimulator can be used to assess facial nerve damage. Control bleeding: use compression for mild bleeding and use ligation of the vessel for significant bleeding. Soft tissue should be closed in multiple layers. Although talking can be uncomfortable, severe pain is not characteristic of maxillofacial injuries. Avoid oversedation.

SUMMARY

Facial lacerations should be thoroughly evaluated to rule out injury to significant underlying structures, specifically the facial nerve and parotid duct. If the clinical situation allows, immediate reconstruction of these structures is recommended. In this case, the patient did well without any significant complications. Although some patients may request scar revision after the appropriate amount of healing time, this patient declined further treatment and proudly wears his scars as a badge of courage.

FIGURE 3. *Six months post-op.*

FIGURE 4. *One year post-op.*

SIALOGRAPHY

Sialography is the radiographic examination of the salivary glands. With the patient in a supine position, it normally involves slowly injecting a nonionic water-soluble contrast medium (350 mg iodine/mL) directly into the salivary duct system. The injection is stopped when the patient feels discomfort or after 1 mL has been injected. (Note: plain films should be taken before injecting the contrast medium to identify any calculi. Also of particular benefit is placing dental film in the buccal sulcus outside the upper molars at the parotid duct orifice.) Using metal probes, the salivary duct opening is explored and dilated. Routine postcontrast X-rays should include oblique lateral and true lateral views, a posterior-anterior view of the parotid gland, or a mandibular occlusal radiograph of the submandibular duct.

SUGGESTED READING

Chapter 13: Face and neck injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

Chapter 22: Soft-tissue injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

Fonseca R, Walker R. *Oral and Maxillofacial Trauma*. 2nd ed. Philadelphia, Pa: W. B. Saunders; 1997.

Rowe N, Williams J. *Maxillofacial Injuries*. 2nd ed. New York, NY: Churchill Livingstone; 1994.

II.3
Corneal Perforation

CASE PRESENTATION

This 19-year-old male soldier sustained a femoral vessel laceration and a penetrating ocular injury from an improvised explosive device (IED). On presentation to the combat support hospital (CSH), examination of the eye revealed a small stellate perforation of his right cornea (Fig. 1). A fragment was present in the vitreous cavity, and a portion of iris and vitreous humor plugged the wound. His lens was partially dislocated, and he had a traumatic cataract. The anterior chamber had blood obscuring much of the iris details (hyphema). After the extremity hemorrhage was controlled, a Weck cell vitrectomy was performed. Because it was less than 6 hours from the time of injury, the small portion of iris was reposited into the globe. Blood was washed out of the anterior chamber. Butyl cyanoacrylate (corneal glue) was unavailable, and suturing the stellate perforation would have left such significant astigmatism that potential visual acuity would have been poor. 2-Octyl cyanoacrylate, given its similar properties to butyl cyanoacrylate, was used to close the wound.

TEACHING POINTS

1. Linear corneal lacerations are fairly straightforward to repair. However, a small stellate (or puncture wound) might pose a more difficult suture repair. Even though the wound might be small, the mechanics of closure may have a more deleterious effect on postoperative visual acuity. This situation occurs because vector forces cause irregular warpage of the cornea (astigmatism) as a result of the tension necessary to close a round or somewhat circular defect in a curved cornea.
2. Butyl cyanoacrylate (Fig. 2) is available in many countries, but it is not approved by the US Food and Drug Administration (FDA), and is unavailable in the United States. However, 2-octyl cyanoacrylate (Fig. 3) is approved by the FDA for skin use. Although they are different compounds, they have similar adhesive properties (eg, flexibility, strength, etc).
3. For glue to adhere to the cornea, the overlying epithelium must be removed. Usually, this procedure is performed easily in an injured cornea because a defect is already present in the epithelium. The process simply involves enlarging the surrounding exposed area.
4. It is important to apply the glue to a dry surface because any liquid tends to solidify the glue. Both corneal glue and skin glue will remain in liquid

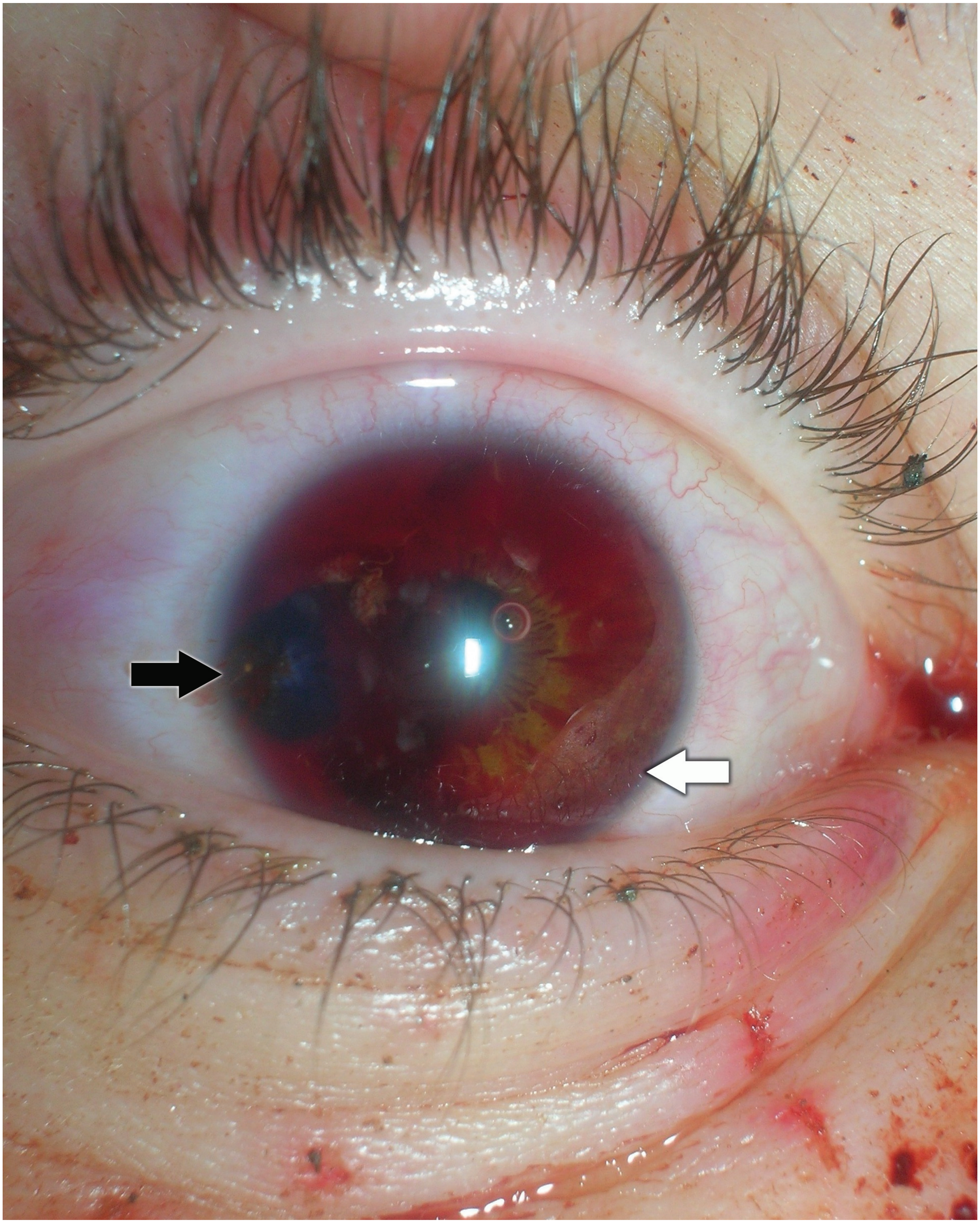

Figure 1. *Right globe with perforation at 9 o'clock accompanied by the loss of at least two clock hours of iris* (black arrow). *A portion of the iris and vitreous humor appears as a fine brownish halo at the edge of the cornea protruding from the anterior chamber* (white arrow), *which is filled with blood and an air bubble at 2 o'clock*.

form until contact with fluid or moisture. In this case, the surgeon squeezed the skin glue onto the plastic cover of a specimen cup. He used a 30-gauge needle on a tuberculin syringe to draw up a small amount of it. A Weck cell sponge was used to dry the corneal surface at the perforation. The drop of glue gently touched the surface of the defect, which caused a slight spreading. The aqueous humor quickly began to solidify the glue from the inside. [Note: Add a drop of saline solution to solidify the outer portion of the glue if the tear film does not already do this. The defect may require several drops (as in this case presentation) to cover the defect completely. Be sure that no intraocular contents (eg, iris, vitreous humor, lens material, etc) are protruding through the defect, or it will adhere to the glue.]

5. Dried glue presents a rather hard and irregular surface that is painful to lid movement. Even if the glue dried to a fairly smooth surface, the lid movement can dislodge the glue before sufficient healing has occurred. Therefore, always use a bandage contact lens for protection and comfort (Fig. 4). The best option is use of a specific therapeutic lens that has no refractive power and is larger in diameter (18–24 mm). However, low-power, standard contact lenses can also be used (generally between 13–15 mm) as a bandage. As long as the patient is treated with a broad-spectrum antibiotic (ie, fluoroquinolone or polymyxin/neomycin) 2 to 4 times a day, the contact lens can remain in place.
6. As the defect heals and the epithelium covers the area, the glue will be automatically dislodged. Generally, this process requires 4 to 6 weeks, depending on the size of the defect. This approach is best for corneal defects less than 2 mm, but it might be possible to place sutures to act as a scaffold rather than as a tension-inducing closure. The glue is then placed on this scaffold of smaller defects.

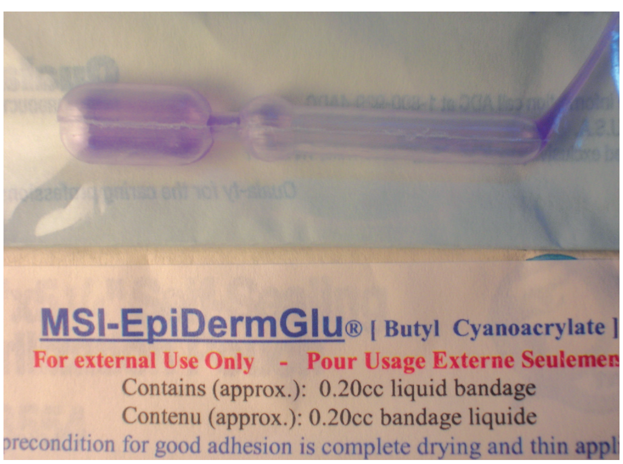

Figure 2. *Butyl cyanoacrylate or corneal glue (MSI-EpiDermGlu, Medisav Services, Inc, Markham, Ontario, Canada).*

DERMABOND

This topical skin adhesive is a sterile, liquid wound adhesive designed to repair lacerations and to close surgical incisions. It reacts with moisture on the skin's surface to form a strong, flexible bond. DERMABOND is used topically to hold closed easily approximated skin edges of wounds from surgical incisions, including punctures from minimally invasive surgery, and simple, thoroughly cleansed, trauma-induced lacerations. *(See full Prescribing Information for use.)*

Figure 3. *2-Octyl cyanoacrylate or skin glue. Photograph: Courtesy of Ethicon, Inc, Somerville, New Jersey.*

CLINICAL IMPLICATIONS

Unfortunately, penetrating injuries to the eye continue to be common in theater. Injury to the eye is found historically in 5% to 10% of all combat casualties. Treatment of these injuries requires specialized ophthalmic procedures within 24 to 48 hours. Medical personnel who provide initial treatment should note the following principles:

FIGURE 4. *Therapeutic contact lens* (left; *Kontur Kontac Lens Company, Richmond, California*) *and standard contact lens* (right; *Bausch & Lomb, Rochester, New York*).

1. Supply eye protection in the combat zone. This is mandatory and must be emphasized to soldiers and commanders by all medical personnel at all levels of care.
2. Determine the severity of ocular wounds. Personnel at level I and level II medical treatment facilities should evacuate all patients with penetrating globe injuries to a medical treatment facility with an ophthalmologist.
3. Note that loss of vision—manifested by the inability to read normal print, compared with the other eye—is suggestive of serious injury.
4. Do not apply a pressure dressing if penetrating injury is suspected. Apply a rigid eye shield instead.
5. Do not apply topical medications.
6. Start ciprofloxacin 500 mg orally or intravenously.
7. Retrieval of intraocular foreign bodies is not recommended in the forward surgical setting.
8. Prevent emesis.
9. Administer tetanus toxoid if indicated and evacuate the patient.
10. Triage patients with eye injuries and attend to the A–B–Cs and the life-threatening injuries first. Then treat eyesight and limb injuries.
11. Distinguish major ocular injuries from minor injuries. (This can be a difficult process.)
12. Avoid nonsteroidal antiinflammatory drugs with intraocular injuries. If evaluation to an ophthalmologist is delayed for more than 24 hours, consider treatment with a topical beta-blocker (timolol, levobunolol, etc) twice a day to help prevent intraocular pressure elevation.

Plain films or CT must be obtained to rule out an intraocular or intraorbital foreign body prior to performing any MRI.

DAMAGE CONTROL

With suspected ocular injury, place a rigid dressing over the eye, start antibiotics, and evacuate to the nearest military treatment facility that has an ophthalmologist.

SUMMARY

Because of the nature of high-velocity projectiles and explosive fragmentation devices, multiple facial and ocular injuries are quite common on the battlefield. Primary fragmentation from IEDs or secondary projectiles (eg, rocks, dirt, glass, or metallic fragments) can be responsible for penetrating globe injuries, including a direct perforation of the cornea. Medical personnel must be ever vigilant about patients with eye injuries, particularly patients with suspected penetrating globe injuries. This case provides tips on the repair of a nonlinear corneal perforation.

SUGGESTED READING

Chapter 14: Ocular injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

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II.4
Maxillofacial Reconstruction

CASE PRESENTATION

This host nation male sustained gunshot wounds to the right side of his face. He had comminuted maxillary and mandibular fractures. Additionally, there were multiple missing and shattered teeth, fragments penetrating neck zones I to III, a shredded parotid gland, a severed Stenson's duct, and facial nerve transection. He had significant soft-tissue trauma to the right side of the face (Fig. 1). At the combat support hospital (CSH), he underwent angiography, neck and face exploration, and a tracheotomy. The ends of the parotid duct were identified and ligated. The wound was loosely approximated and dressed. Later, he was transferred to another hospital for more definitive treatment. Prior to reconstruction of the rami and arch, arch bars were placed on the patient's dentition after debridement of tooth particles and fragments. The maxilla was broken into four pieces. The patient received maxillomandibular fixation that ensured good, reproducible occlusion (Fig. 2). Titanium plates and screws were used to stabilize as many bone fragments as possible, with careful reapproximation at the Le Fort I level. Working together, the oral and maxillofacial surgeon and the cardiothoracic surgeon harvested two ribs (nos. 4 and 6) from the patient's right side. The patient's condylar head was removed, because it was completely fractured from the rest of the comminuted mandible. The zygomatic arch was extremely comminuted, with multiple fragments only several millimeters in length. One rib was used to reconstruct the patient's right mandibular condyle and ramus, and the other rib was used to reconstruct the right zygomatic arch. Titaninum plates and screws were used to secure the bone grafts to stable bones. The inferior alveolar nerve could not be repaired, because too much destruction had occurred (future reconstruction would involve a microsurgical graft repair). A parotidectomy was also perfomed. No ends of the facial nerve could be identified. The patient was released from fixation to check the occlusion, rinse and suction the oral cavity, and remove the throat pack. He was then placed back into fixation to stabilize the segmented maxilla because no palatal stent was available. Meticulous reapproximation of the soft tissues was accomplished in layers. A Penrose drain was placed. The patient was given intravenous (IV) antibiotics, and wound care was provided. Wire cutters were with the patient at all times. Maxillomandibular fixation was planned for 6 weeks to let the maxilla heal. He was extubated within the week and transferred from the CSH. Good facial symmetry was achieved (Fig.

FIGURE 1. *Intraoperative exploration of wounds. Note neck wounds and soft-tissue avulsion of the face.*

3). Long-term follow-up was not available. Further microsurgical reconstruction would have been beneficial, but the overall esthetics and basic function were preserved using this technique.

TEACHING POINTS

1. This case is an example of a patient who required extensive reconstruction within the limitations of a level III medical treatment facility.
2. Facial reconstruction is tedious and time consuming. The primary goal in treating US patients is stabilization and evacuation. On the other hand, non-US patients require definitive treatment in theater. This treatment requires equipment that is not standard issue in the deployed level III medical facility. By necessity, level III facilities have acquired additional specialized equipment to handle these difficult patients.
3. Alternative approaches could have been utilized in the facial reconstruction of this patient. External fixation of reconstruction bars could also have been used. The degree of comminution and the condylar head remnant indicated that bone grafting was the logical choice to reconstruct the mandible. Costochondral grafting is a definitive treatment to replace a mandibular condylar head, whereas a reconstruction bar would be temporary. The rib graft also provided excellent contour for the reconstruction of the zygomatic arch, thus restoring the projection of the midface.
4. This case also demonstrates the need for subspecialties within the level III medical treatment facility. Neurosurgeons, oral and maxillofacial surgeons, and ophthalmologists who are available in theater greatly enhance the capabilities of the level III medical facility. These medical pro-

Figure 2. *Final closure obtained and patient placed back into maxillomandibular fixation.*

fessionals provide a higher level of expertise and patient care beyond basic stability when evacuation is not an option or when evacuation could present a greater risk of morbidity.

CLINICAL IMPLICATIONS

1. Autologous bone grafts are a useful and accepted way to reconstruct facial injuries definitively. Costochondral grafts can be used to reconstruct the mandibular ramus and the zygomatic arch. Iliac crest bone grafts or cranial bone grafts can be used to reconstruct the orbital floor.
2. Multiple surgeon teamwork expedites tedious, time-intensive reconstruction. Mission and operational tempo often mandate limiting operating time to as close to 2 hours as possible. Usually, definitive reconstruction cannot be accomplished that quickly. If teams are not available, staging of reconstruction is done.
3. A tracheotomy is an ideal airway for patients with extensive facial trauma. These patients have extensive edema and may undergo several operations for reconstruction. The tracheotomy is a definitive airway that is more easily secured and maintained.
4. Repair of Stenson's duct (not done in this case) is accomplished by cannulation with a small gauge angiocath. The duct is then reapproximated with fine absorbable sutures over the cannula to maintain patency (Fig. 4).
5. Suspected facial nerve injuries should be explored and primarily repaired if possible. Facial nerve branches that are lacerated at a site anterior to a vertical line drawn down from the lateral canthus of the eye do not need to be surgically reapproximated because these branches are very small and will spontaneously regenerate with good return of facial function (Fig. 5). If the wound

FIGURE 3. *Note symmetry obtained at mandibular ramus and zygomatic arch. Bone screws and plates are radiopaque.*

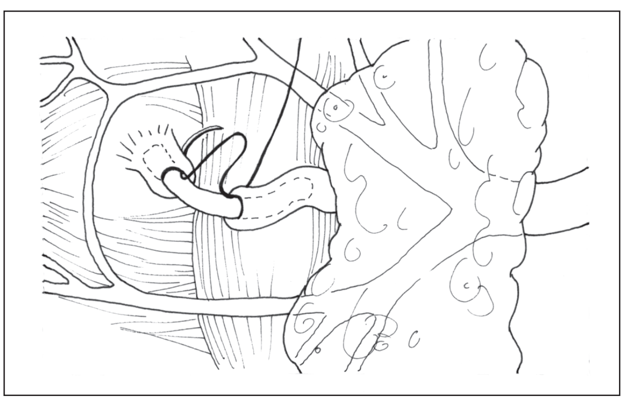


FIGURE 4. *Repair of parotid duct.*

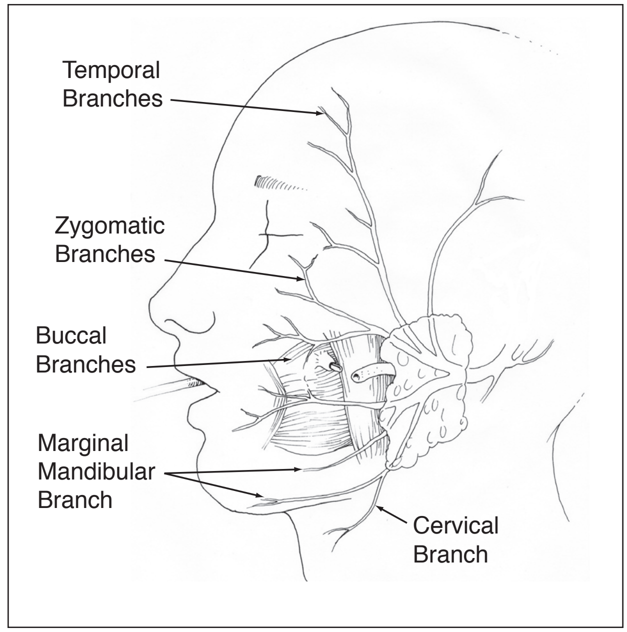


FIGURE 5. *Branches of the facial nerve, parotid duct injury.*

is heavily contaminated and cannot be closed primarily, the severed ends of the nerve should be located and tagged for identification and repair at the time of wound closure.

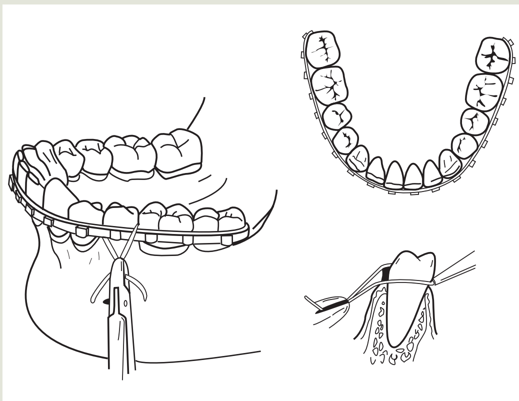
6. Patients placed into maxillomandibular fixation must have wire cutters with them at all times in case they need to be cut loose because of airway compromise. Use umbilical tape to fashion a necklace so that the wire cutters are around the patient's neck during transport. If MEDEVAC crews are reluctant to transport a patient in wire maxillomandibular fixation, small elastics can be used to achieve maxillofacial fixation until the patient arrives at a stable location.

DAMAGE CONTROL

Damage control of oromaxillofacial injuries will center around airway and hemorrhage control. Emergency cricothyroidotomy may be necessary with unstable facial fractures where a definitive airway cannot be rapidly established. Approximation of large bony fragments with loose closure of overlying soft tissue may allow adequate hemorrhage control to get the patient out of the operating room for further resuscitation.

ERICH ARCH BAR

The Erich arch bar (also known as the Erich dental bar or the Erich arch bar meter coil)—a metal arch bar secured with soft, stainless wires—is an arch bar commonly used in the repair of mandibular fractures. The Erich arch bar is an important tool in occlusal restoration, particularly in cases of comminuted and oblique fractures and the loss of continuity of the mandible.



Advantages

- Rigidity.
- Maxillomandibular fixation easily applied.
- Easily adaptable to elastic traction.
- May be prefabricated or adapted.
- Continuous occlusal (superior tension band) control.

SUMMARY

This case demonstrates a method of definitive facial reconstruction and highlights the need for diverse specialties within a level III medical treatment facility. It also provides some practical advice for dealing with extensive facial trauma.

SUGGESTED READING

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Chapter 5: Airway/breathing. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

Chapter 13: Face and neck injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

II.5 Mandible Gunshot Wound

CASE PRESENTATION

A host nation male suffered a gunshot wound to his left mandible (Fig. 1). His airway was intact, and his vital signs were stable on presentation to the emergency department. He underwent operative debridement and washout of the wound. There was no oral and maxillofacial surgeon (OMFS) nor ear, nose, and throat (ENT) surgeon assigned to the level III facility at the time. In addition, an oromaxillofacial surgery/microplate set was not available. After several days, the wound appeared clean and free of devitalized tissue and contamination (Fig. 2). After consulting with a remotely assigned OMFS, a team of general and orthopaedic surgeons took the patient to the operating room for definitive repair (Fig. 3). Using an orthopaedic handset, the major fragments were reduced and reapproximated with a single plate (Fig. 4). Other fragments were lag screwed into position. After further debridement and irrigation, the soft tissue was closed (Fig. 5). Arch bars were placed to maintain the reduction and stabilize the mandible (Fig. 6). The wounds healed well. After 5 weeks, the arch bars were removed, and the patient demonstrated normal occlusion and function.

TEACHING POINTS

1. Initial treatment of high-velocity missile injuries involves the basic principles of wound debridement and liberal irrigation to remove devitalized tissue and foreign debris, regardless of the anatomical site of injury.
2. Fixation and stabilization of fractures with soft-tissue closure (when possible) should be accomplished once the wound is cleared of dead tissue and debris. This can be accomplished within several days of wounding, dependent on the extent of soft-tissue injury and the degree of wound contamination.
3. Because this patient could not be transferred to a higher level of care, definitive repair had to be accomplished on-site. Using a multidisciplinary team of general surgeons (who deal with soft-tissue wounds regularly) and orthopaedic surgeons (who deal with plate-and-screw technology daily), after researching the surgical options and consulting with an OMFS, the patient underwent definitive reconstruction with an excellent outcome.
4. Arch bars are placed to help reduce the fracture and provide a tension band. The mandible may be reduced and internally fixed prior to

FIGURE 1. *Gunshot wound to left mandible.*

placement of the arch bars if the fracture is easily anatomically reduced. However, correct sequencing should be arch bar placement to help reduce the fracture, then internal fixation after a good reduction.

CLINICAL IMPLICATIONS

Often, in the deployed setting, surgeons may encounter clinical situations unfamiliar to them. In an emergency situation—by following Advanced Trauma Life Support (ATLS) guidelines—a patient can often be stabilized enough for transport to a higher level of care. For patients who must remain for definitive care (typically enemy prisoners of war or host nation civilians), consider the following:

1. Follow the basic principles of surgical care:
    a. Wound debridement and washout.
    b. Antibiotics as appropriate.
    c. Stabilization of fractures.
    d. Wounds left open until clean enough for closure (with either wound VACs or wet-to-dry dressings).
    e. Nutritional support.
2. Consult other surgeons/physicians if in unfamiliar territory.
    a. Often, general surgeons have widely different surgical experience.
    b. Other surgery specialists may have additional expertise that could be synergistic in a patient's care.
    c. Available specialists can be consulted remotely either by telephone or e-mail.

FIGURE 2. (Top) *Wound several days postinjury.*

FIGURE 3. (Bottom) *Operative repair. Sterile gloves are used to cover operating room light handles.*

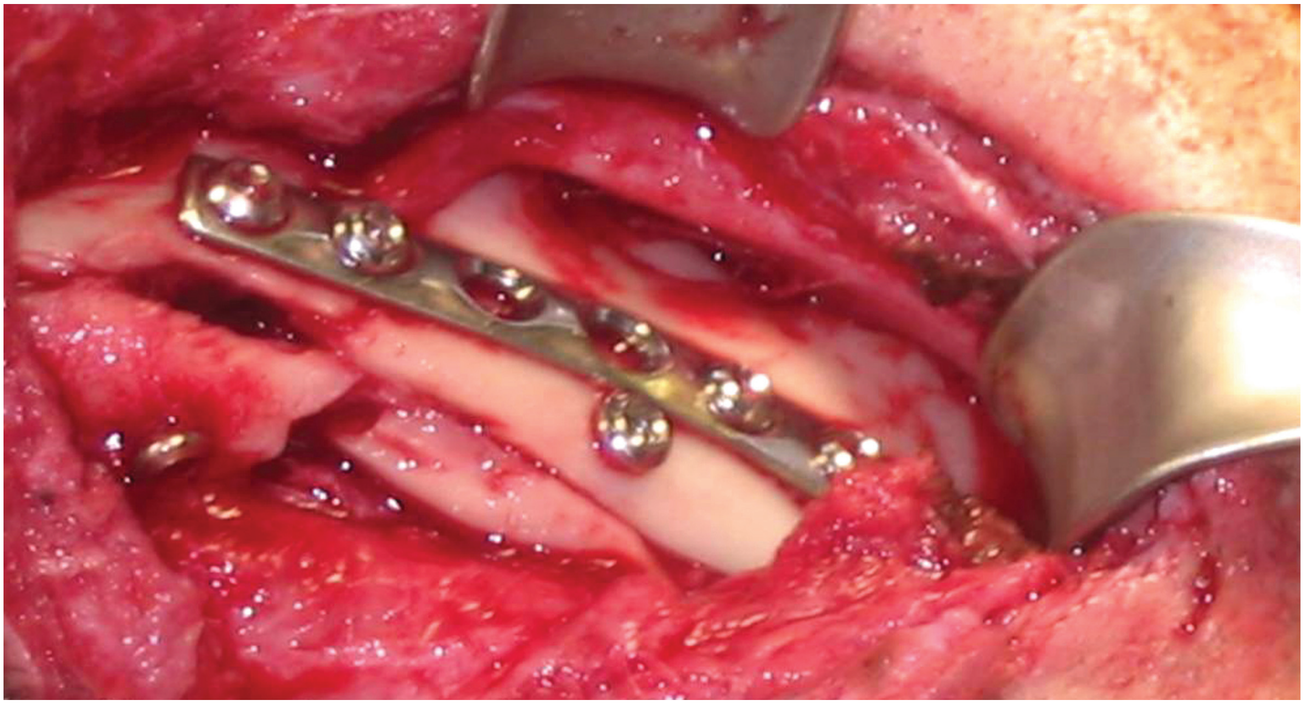


FIGURE 4. (Top) *Approximation of mandible fragments with plate.*

FIGURE 5. (Bottom Left) *Wound closure.*

FIGURE 6. (Bottom Right) *Arch bar stabilization.*

3. Consult available references and the Internet.
4. Do not try something that has little chance of success.

DAMAGE CONTROL

With extensive jaw or facial injuries, emergency cricothyroidotomy may be necessary at the outset of the resuscitation phase.

SUMMARY

Combat surgery can often challenge the most experienced surgeons to the limits of their capabilities. Nonetheless, by following basic surgical principles, by thoroughly researching surgical options, and by seeking assistance from locally available—as well as remotely assigned—specialists, a successful outcome is more probable.

SUGGESTED READING

Chapter 13: Face and neck injuries. In: *Emergency War Surgery, Third United States Revision*. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2004.

COMMENTARY

High-Energy Facial Injuries

by COL Karen M. Keith, DDS

Since 2003, in the most recent conflicts of Iraq and Afghanistan, approximately one third of combat injuries involve the head and neck. Today's soldier wears more effective personal protective equipment into combat than at any other time in history. Modern body armor protects the torso, and the Kevlar helmet provides excellent protection to the head and brain. As the conflict has progressed, ballistic eyewear protection has been enforced. Consequently, nonlethal but extremely morbid wounds of exposed limbs and the facial area have increased disproportionately in the overall distribution of injuries. The oral and maxillofacial (OMF) surgeon has necessarily played a significant role in the management of these patients. The unique training of OMF surgery makes the surgeon a force multiplier in times of crisis. The OMF surgeon can provide anesthesia; perform tracheotomies; elevate cranial flaps; harvest bone grafts from the calvarium, iliac crest, tibia, and rib; and elevate the temporalis, pectoralis, and other myocutaneous flaps.

Unlike previous conflicts, a soldier can now be evacuated from theater to the United States in as little as 4 days. Thus, resuscitation and stabilization are the acute management goals for these soldiers. However, the morbidity of coalition and host nation troops not evacuated to higher echelons of care is also improved by the skills and ingenuity of the combat surgeons. Forward Surgical Teams (FSTs) provide immediate treatment, with rapid evacuation to level III echelon care at the combat support hospital (CSH). The OMF surgeon is assigned to the CSH or to a Head and Neck Team. Only in very recent years (2003) has an extensive OMF surgery set been fielded, which includes the full range of craniofacial plating sets and external fixation equipment. This greatly expands the capability of the OMF surgeon. The basic needs for stabilization and fixation, however, remain arch bars and wire, and any deploying surgeon needs to understand their proper application.

Many lessons learned regarding current injury patterns and etiologies resulted in modification of treatment protocols for injuries of the head and neck. Improvised explosive devices (IEDs) currently account for 40% to 60% of injuries to soldiers and civilians. These devices cause wounds grossly contaminated with dirt, plastic, gravel, material, and flesh. Other high-velocity projectile wounds result from gunshots and mortar blasts. Globe rupture or penetration, otological blast damage, burns, punctures, and avulsive soft-tissue wounds with extensive hard-tissue comminution represent the injury patterns that present many challenges and considerations (Figs. 1 and 2).

In any head and neck trauma, the first consideration should always be the airway. Often, the patient is intubated in the field or soon after presentation to the emergency room. Most often, patients are intubated orally because it is easier and safer in a trauma setting than placing a nasal tube. If there are no concomitant midface injuries, the patient can be extubated and reintubated nasally before addressing OMF surgery repair. If a patient has midface fractures, caution must be exercised when placing a nasal tube to avoid inadvertent entrance through a cranial base fracture, potentially causing cerebral injury. Another approach to securing an endotracheal tube is to pull an orally placed tube out through a submental incision. This provides a secure airway without hampering the surgeon's ability to wire the teeth and jaws closed. In cases of severe facial trauma, in which evacuation or prolonged intubation (oral or nasal) are anticipated because of edema, ventilator weaning difficulty, or multiple returns to the operating room, a tracheotomy is strongly advocated. Patients should also have cricothyroidotomies converted to tracheotomies prior to evacuation to the next echelon of care. This will guarantee a secure airway for transport and for the next phase of treatment.

FIGURE 1. *Example of destructive, avulsive combat injuries.*

Once the airway is secured, a thorough examination must be performed to determine the extent and severity of the injury. OMF injuries are not life-threatening once the airway and bleeding are controlled. Bleeding is controlled with packing, judicious cautery, or suture ligation. Prophylactic antibiotics and tetanus prophylaxis are administered. After initial stabilization, a thorough assessment of the extent of injury and reconstructive needs are performed.

History and a focused physical examination guide the imaging. In an immature theater, plain films and clinical acumen can successfully guide surgical treatment. Clinical examination can be hampered by intubation and by the cervical collar. Fine-cut (1–3 mm) axial CT images, when available, of the patient's face help delineate the injuries and are more useful than plain radiography. If the patient's cervical spine is cleared, coronal CT images offer additional information. Three-dimensional reconstructions are particularly useful when planning the repair of complex OMF surgery injuries (Fig. 3). The surgeon evaluates all the studies and makes the diagnosis and treatment plan. The surgeon must consider the extent of comminution, avulsion, and contamination of the hard- and soft-tissue structures. Avulsive or penetrating trauma in this region can involve damage to salivary ducts, branches of the facial or trigeminal nerve, and vascular structures. The physical examination should include identifying such damage and tagging structures that cannot be handled at the current echelon of care, thereby affording a greater chance for future successful repair at the next echelon of care.

Consideration must be given to the overall condition of the patient. Definitive repair is time-consuming and can involve multiple, lengthy procedures. If the patient cannot tolerate prolonged surgeries, the surgeon can consider washouts and shorter staged procedures based on patient progress and stability. For US soldiers, definitive reconstruction will not usually be performed at the level III echelon of care.

Copious irrigation and careful, serial debridement are essential to minimize the potential for infection and future esthetic concerns of OMF wounds. It is important not to overlook seemingly inconsequential puncture wounds. Careful exploration of wound cavities can reveal an extensive radius of damage and foreign debris, such as plastic, dirt and small glass particles, and occult fractures secondary to the impact of the fragmentation. Pulse lavage is an excellent adjunct when available. Copious irrigation with a surgical scrub assists in overall cleansing. Small

FIGURE 2. *Example of destructive, avulsive combat injuries in another patient.*

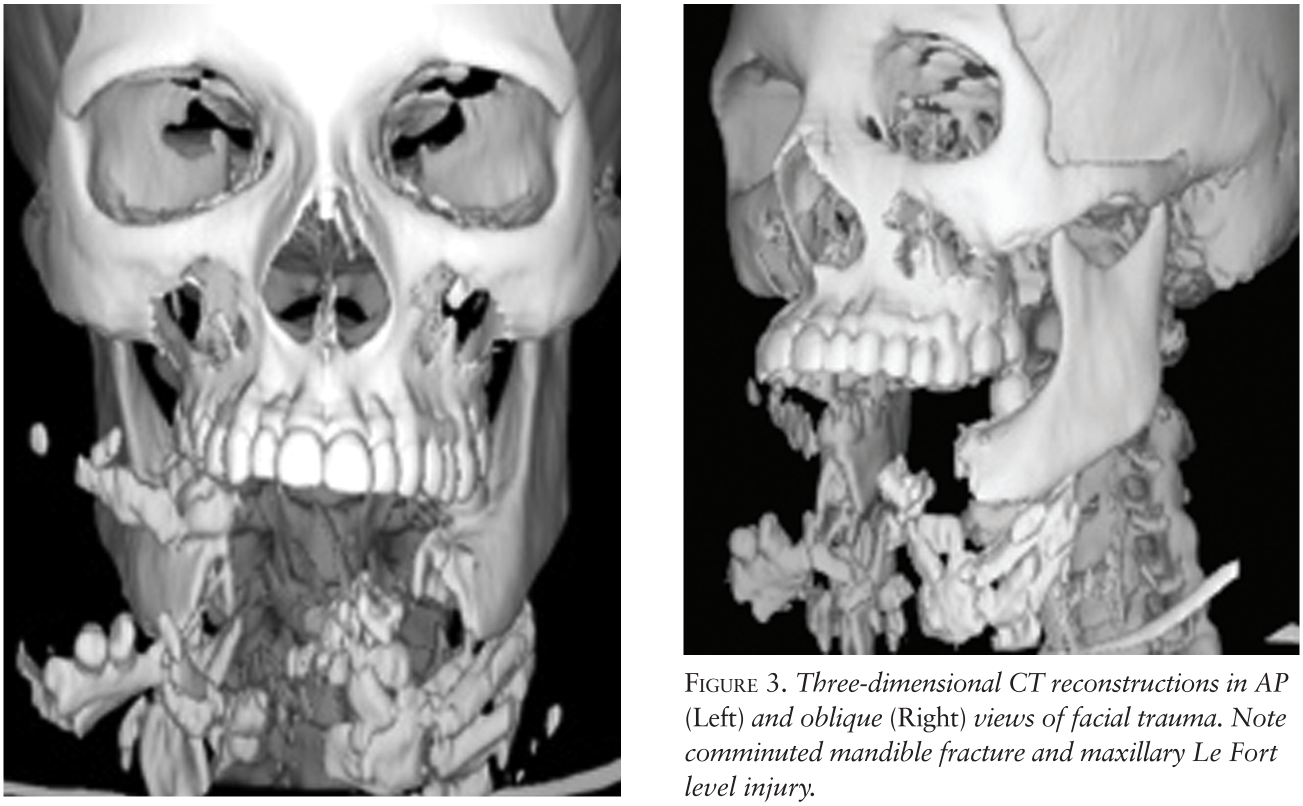


FIGURE 3. *Three-dimensional CT reconstructions in AP* (Left) *and oblique* (Right) *views of facial trauma. Note comminuted mandible fracture and maxillary Le Fort level injury.*

punctate wounds on the face that are easily debrided should be closed primarily for esthetic concerns rather than allowed to heal by secondary intention.

With fractures that involve the midface or mandible, arch bars and maxillomandibular fixation (MMF; Fig. 4) need to be placed prior to reduction and fixation. Immediate reduction of the fracture and improvement of occlusion can be obtained with a bridle wire (24 or 25 gauge) placed around at least two teeth on either side of the fracture. If the patient has a nondisplaced subcondylar fracture and normal occlusion, he can be treated with a soft diet and proscriptions on wearing a helmet and protective (“gas”) mask. Occlusion is something that the OMF surgeon remains particularly attentive to because it can guide final reapproximation and fixation of hard tissue. Wiring the patient’s teeth closed establishes the correct occlusion, which may be especially problematic with avulsion of bony fragments. Note that teeth in the line of fracture can be maintained if stable and not interfering with establishing the occlusion. If fractured with exposed pulp, or very loose, teeth should be removed. Only using an anatomical reduction, without MMF, to reduce fractures can risk giving the patient a postoperative malocclusion that can then necessitate additional extensive surgery to rectify. Once the fracture is fixated, the MMF is released. The arch bars usually remain in place until the fracture is healed (6 weeks) in case elastics or additional manipulation is required.

Any patient who will remain in MMF (closed reduction) should have wire cutters available at all times. Umbilical tape is used to hang them around the neck. Wire cutters are for the provider assisting the patient to release the MMF if necessary for airway issues. This is a very rare occurrence. Emesis is not usually itself an indication for release. If the patient is evacuated, elastics (6-ounce

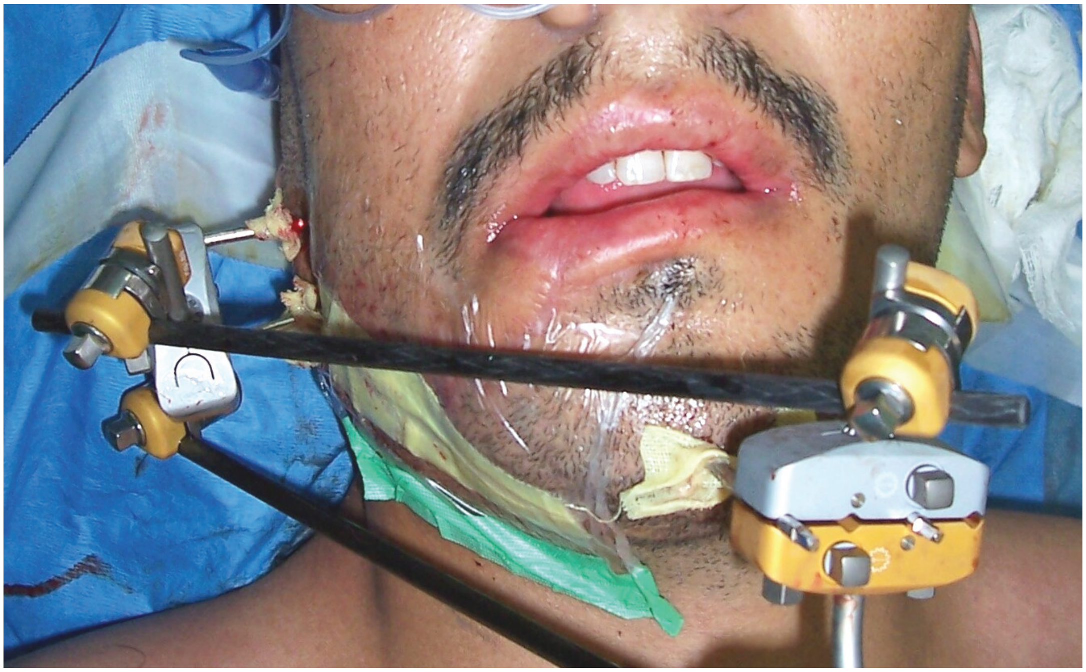
FIGURE 4. *Clinical example of maxillomandibular fixation with arch bars and wire loops.*

Figure 5. *Joe Hall Morris appliance system.*

JOE HALL MORRIS DEVICE

The Joe Hall Morris device (or the biphasic system) is an example of an external-pin fixation appliance. It allows fixation of a mandibular fracture with no major incisions. This technique is ideal for areas with significant soft-tissue loss or infection. This biphasic device serves as the patient's mandible until the fracture site has completely healed. The Joe Hall Morris device was used extensively in World War II, but it is not used so widely any more. Surgeons, however, should be familiar with this technique and include it as part of their surgical armamentarium. It is particularly useful in edentulous patients with comminuted fractures.

Figure 6. *Wrist external pin fixation system.*



orthodontic elastics) can be used instead of wire for closed reduction. This minimizes patient discomfort until the next echelon of care is reached, but is more suitable for patient management during evacuation. Remember to discuss fixation with the evacuation team.

Comminuted, avulsed, and contaminated fractures are often best treated initially with external fixation rather than with open reduction and internal fixation. The biphasic system, known as the Joe Hall Morris device (Fig. 5), is the most common and familiar device to the OMF surgeon. However, the orthopaedic hand and wrist external fixation device works effectively and is a simpler system that requires less time to place (Fig. 6). This is ideal in areas of significant soft-tissue loss or infection (Fig. 7). It is also particularly beneficial in an edentulous mandible with comminuted fractures (Fig. 8). The surgeon can also elect to place a reconstruction plate across a comminuted mandible fracture (Figs. 9 and 10). The site must be thoroughly irrigated and debrided, and the plate must be covered with soft tissue (Fig. 11). If there is an inadequate soft-tissue envelope, a soft-tissue flap can be rotated to cover the defect (Figs. 12 and 13), or the surgeon can choose to convert to external pin fixation.

Burns need to be evaluated for airway concerns with fiberoptic intubation or early tracheotomy if edema or inhalation injury causes respiratory distress. Associated tracheal or laryngeal injury needs to be assessed. Orbital compartment syndrome requires lateral canthotomy and cantholysis. Silvadene should be avoided on the face because of its caustic nature.

In combat, the OMF surgeon can be confronted with many challenging and complex injury patterns in a less than optimal environment. The goals of facial bone fracture repair are realignment and fixation of the fragments in the correct anatomical position with the proper occlusion. MMF (closed reduction with wire) is inferior, but often easier and most readily available. Plates and screws, reconstruction plates, and external pin fixation are also part of the armamentarium. Depending on the extent of injury, several staged procedures will be required to definitively reconstruct a patient. Planning should be done after three-dimensional reconstruction of CT scans and stereolithography model fabrication. The ability to preserve soft tissue enhances the esthetics, psychological recovery, and function of the overall reconstruction. Flaps, bone grafts, and alloplastic materials can be used to provide the best reconstructive efforts to improve the patient's quality of life. Training in myocutaneous flaps and adjunctive procedures with other surgeons has resulted in many creative and versatile reconstruction techniques. Therefore, the surgeon must consider the patient's status, support systems, available technology in theater, and the long-term goals for reconstruction and develop the best course of action for all assessed patients.

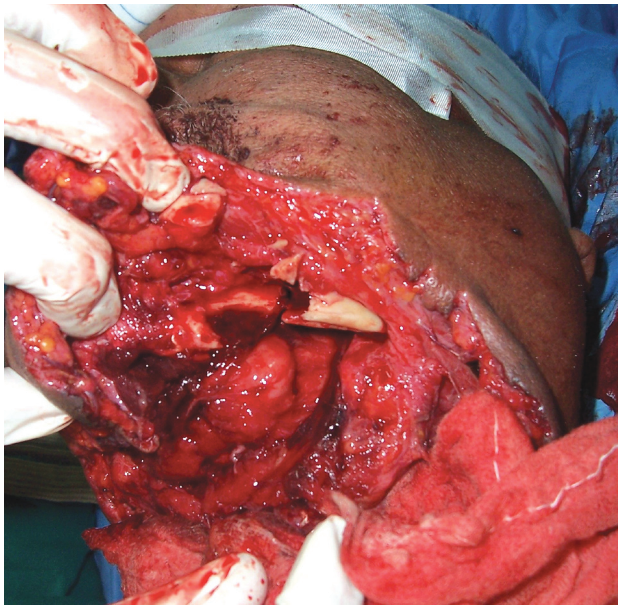


Figure 7. *Comminuted mandible fractures with avulsion of hard and soft tissues.*

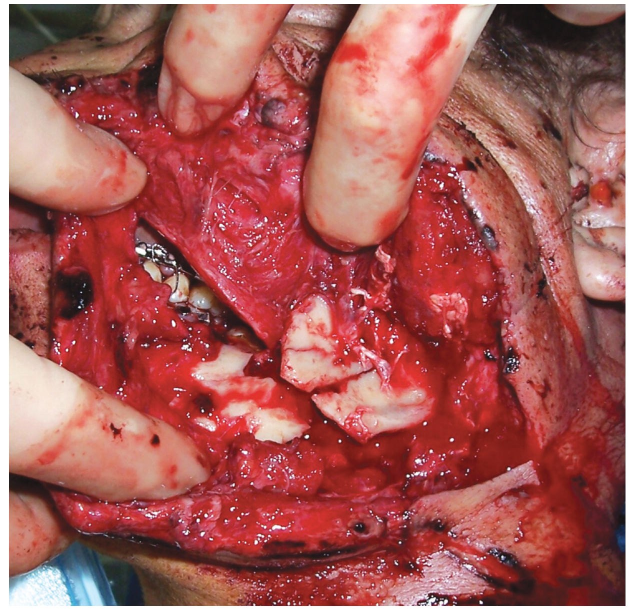


Figure 8. *Comminuted mandible fractures with avulsion of hard and soft tissues in another patient.*

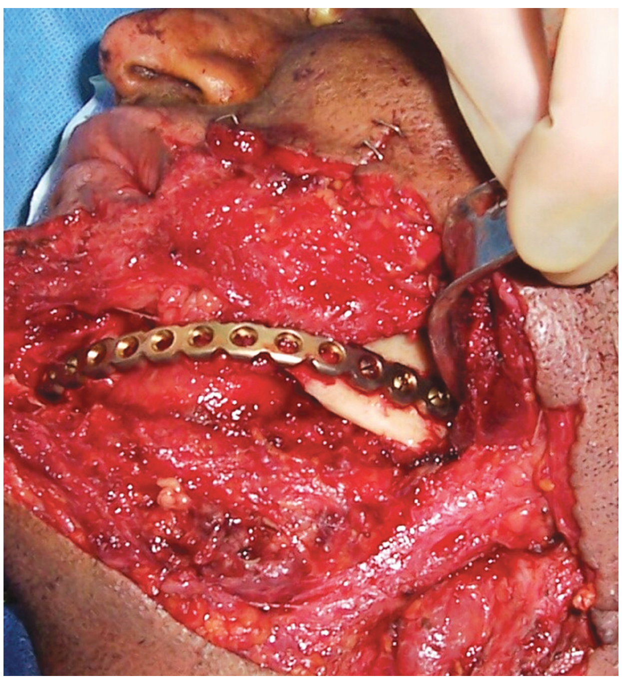


Figure 9. *Clinical example of an open reduction with internal fixation during initial surgery.*

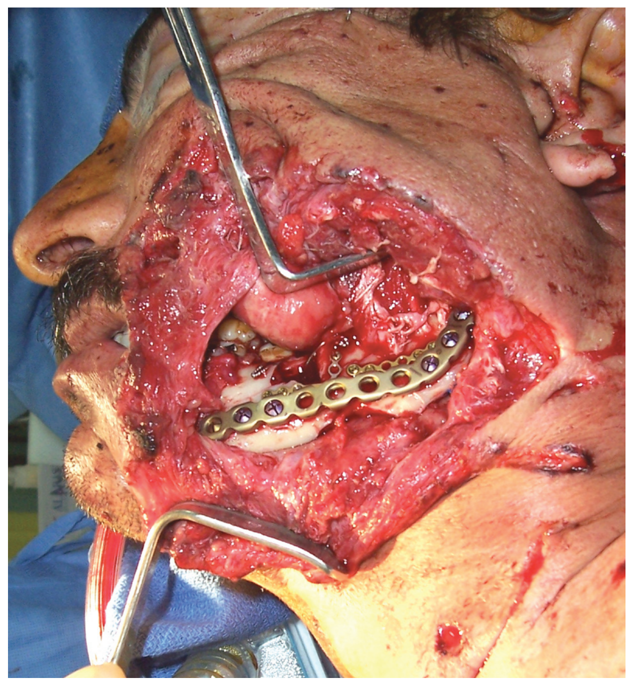


Figure 10. *Open reduction with internal fixation during initial surgery in another patient.*

FIGURE 11. *Primary closure established over hardware using available local soft tissue.*

FIGURE 12. *Pectoralis major flap is used to cover defect.*

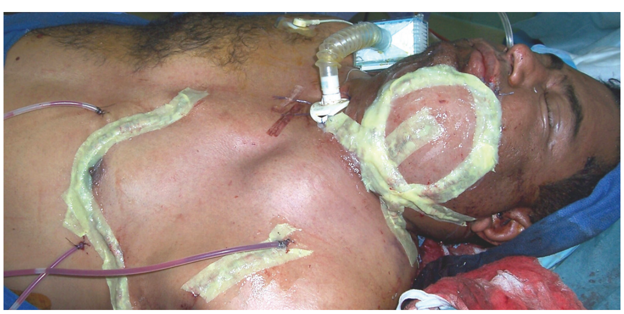


FIGURE 13. *Pectoralis major musculocutaneous flap.*

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