Like penetrating trauma to the neck or the cranial cavity, the evaluation and treatment of penetrating trauma to the face requires a thorough understanding of anatomy, physiology, and injury patterns, and several authors have addressed the management of facial injuries. All agree that a systematic approach is essential, with careful attention to injury mechanism and area involved.

**INITIAL MANAGEMENT**

As discussed in Chapter 1, all patients with penetrating trauma to the face should be initially evaluated for the ABCs of trauma—airway, breathing, and circulation—and resuscitated appropriately. Potential airway compromise should be considered in all penetrating facial trauma, and this is discussed in more detail later. Assuming that patients are initially stable, the secondary survey should include a detailed evaluation of their penetrating facial injury, including type of weapon and entry zone. We have seen that patients who do not have airway compromise, major hemorrhage, or obvious intracranial penetration are often considered “lucky” and subsequently are triaged to a lower acuity level in the emergency center. This might be appropriate in some cases, but many patients with penetrating facial trauma are at risk for delayed loss of airway, occult vascular injury, intracranial penetration, and other delayed complications, so close monitoring and continued evaluation are important.

**TYPES OF PENETRATING FACIAL TRAUMA**

It is easiest to divide penetrating trauma into the following groups: low-velocity gunshot injury, high-velocity gunshot injury, shotgun injury, and stab injury. As discussed in Chapter 20, a too-rigid division into low velocity versus high velocity can omit important information such as the type of projectile; however, it is still a useful clinical distinction. High-velocity bullets are likely to cause a larger area of cavitation injury, a larger permanent cavity, deeper penetration, higher probability of bony fracture, and in general more tissue damage and tissue loss, as compared with low-velocity bullets. Shotgun injuries have distinct injury patterns, and are best considered as a separate category. Finally, stab wounds to the face are also considered separately, as their sequelae may be easier to predict based on the angle and depth of penetration, and there is usually less adjacent or collateral damage.

**FACIAL ZONES**

The first attempt to create a staging system for penetrating facial trauma was actually described in an article by Gant and Epstein in 1979, although it was first shown pictorially in 1988 by Gussack and Jurkovich.\(^1\) This system divided the face into entry zones I, II, and III, in which zone I was superior to the supraorbital rims, zone II was from supraorbital rim to oral commissure, and zone III was below the oral commissure. The authors found that injury
patterns differed in different entry zones, which was helpful in evaluation and treatment. However, that system was potentially confusing because the entry zones of the neck also use the same nomenclature of zones I, II, and III, which could make classification and distinction of combined injuries difficult. Furthermore, because zone I was superior to the supraorbital rims, those injuries are really intracranial rather than facial.

To address those issues, a new facial zoning system was subsequently developed by Dolin et al, using entry zones A, B, and C. Injuries superior to the supraorbital rim were excluded for the reasons described above, and zone A represented the lateral face (zygomatic arch and mandibular ramus), zone B the anterior midface, and zone C the anterior mandible. Although that system had some advantages, the exact demarcation points between zones were unclear, and their data demonstrated that penetrating trauma entering zones A and B resulted in similar injury patterns.

Subsequently, Cole et al and Chen et al independently attempted to simplify facial zoning and designated two entry zones, “midface” and “mandible” (Fig. 21-1). The midface/mandible staging system has the advantage of being easy to remember, and it does not overlap with other staging systems. In the Cole series, however, no significant differences by entry site were seen; for example, gunshot wounds to the mandible zone were no more likely to have airway compromise than wounds to the maxilla zone. Those authors did find an association between vascular injury and airway compromise, but in general noted that vascular injury, intracranial penetration, bony fracture, soft tissue loss, and airway compromise were all potentially possible regardless of entry zone. Therefore, in their series they found that entry zone was not always helpful and that in penetrating facial trauma “anything was possible,” so they recommended that all patients be carefully screened for potential injuries. In contrast to those findings, other authors have found distinct differences in injury pattern by entry zone.

**Gunshot Wounds to the Face**

The midface/mandible zoning system is particularly applicable for gunshot injuries, because the two entry zones have distinct patterns of injury. We will discuss the treatment and evaluation of gunshot wounds in the same order as all trauma cases, and begin with airway and breathing.

**Airway Control**

Patients with a gunshot wound to the face have a high probability of requiring airway control for several reasons, including soft tissue edema or hematoma, tissue displacement, and bleeding. Many patients require airway control in the field and arrive at the hospital intubated, and others require airway establishment at the hospital. Although some patients appear initially to have a stable airway, they can quickly decompensate and require an emergency airway. Patients with a mandible entry zone have a significantly higher chance of requiring an emergency airway than patients with a midface entry zone, although about a third of patients with midface injuries may require an emergency airway. To avoid delayed airway obstruction and emergency airway procedures, a high index of suspicion is recommended and, when indicated, early elective airway establishment. Physicians should strongly consider elective airway establishment using controlled intubation for all patients with gunshot wounds to the mandible entry zone, even if the airway appears adequate at initial presentation.

**Vascular Injury**

Vascular injury can occur with entry into any facial zone, although there is a trend toward a higher rate of injury with midface entry. If major vascular injury is suspected, the patient should have an angiogram—if possible with the capability for radiologic intravascular intervention. In facial injuries, angiogram is preferred over surgical exploration.
because surgical access and control of major vessels near the skull base is difficult, whereas an interventional radiologist can both diagnose and potentially treat a vascular injury using stenting, occlusion, or embolization. This is the same clinical rationale behind the treatment for penetrating injuries to zone III of the neck. However, even if interventional radiology is not available, diagnostic angiography should still be performed to identify and localize vascular injuries; the surgical team can then decide on techniques for approach and repair.

The best clinical indications for angiography in penetrating facial trauma are best remembered as the two “P”s: proximity to a major vascular structure, and penetration posterior to the mandibular angle plane (MAP). The MAP is an imaginary vertical coronal plane at the level of the angle of the mandible (Fig. 21-2); penetration of a projectile posterior to this plane is an indication for angiography. Regarding proximity, if the path of a projectile is near a major vascular structure, angiogram is indicated. However, this can be difficult to assess because a projectile’s path through tissue is not always predictable, and secondary projectiles that take different paths can be created. In addition, because of cavitation, the bullet may be somewhat distant from a vessel and still cause a significant injury. If the bullet is still in the patient, a lateral skull x-ray can be used to assess for penetration posterior to the MAP. If there is an entry and exit and either is posterior to the MAP, angiogram is likely indicated. Angiography is relatively safe and very sensitive, but if suspicion of vascular injury is low, patients can be observed and only undergo angiography if new symptoms develop.

In a patient with active bleeding from deep in the wound, direct pressure with some sort of packing, or an occlusive pressure dressing should be placed, and the patient should undergo immediate angiogram with possible interventional intravascular treatment. If there is active bleeding from a wound edge, again direct pressure is recommended initially, with exploration and careful ligature of bleeding vessels when appropriate. Indiscriminate clamping or suturing of tissue in the face is to be avoided because of the risk of injury to a facial nerve branch.

**Adjacent Injuries**

After airway and vascular injuries have been evaluated, the physician should consider other potential injuries associated with facial gunshot wounds. These include intracranial penetration, globe injury, bony fracture, facial nerve injury, parotid duct injury, and penetrating neck injury. Intracranial penetration is not uncommon after facial gunshot wounds, occurring in 16% of patients in one series. Bullets can reach the intracranial cavity after entry into either the midface or mandible zone. Neurosurgical consultation is obviously the next step in those cases.

Globe injury is also possible with penetrating facial trauma, and although more common in shotgun injuries, occurred in 18% of gunshot wounds in one series. Again, ophthalmology consultation is essential in cases of globe injury.

**Bone Fractures**

Bone fracture is a common sequela of facial gunshot wounds. Although almost all fractures caused by gunshot wounds require some debridement and local care, not all fractures require open reduction and plate fixation. Although gunshot wounds may cause loss of bone, if the buttresses that provide midface stability are spared, then reduction and fixation may be unnecessary. Similarly, mandible injuries might involve damage only to an edge of the mandible, with sufficient stable bone above or below the injury. In that case, no reduction or fixation is necessary. Computed tomography (CT) scan with axial and coronal views is the preferred imaging study to evaluate the extent of bony injuries. In most cases, the wound should be explored, irrigated, and cleansed, and devitalized tissue, particularly bone separated from periosteum, debrided. As in all
gunshot wounds, the amount of damaged tissue that might survive can be surprising, so debridement should be fairly conservative. Gunshot entry and exit wounds are usually not closed, as bullets are not sterile, but are dressed and allowed to heal by secondary intention. Large or gaping soft tissue wounds can be partially approximated to facilitate healing. Local flap coverage, or even microvascular tissue transfer may eventually be necessary to close some tissue defects.

Unstable fractures should be repaired using the same plate-and-screw techniques of fracture repair as described in other chapters. If large pieces of bone are missing, consideration should be given to bone grafting, however the timing is important. If the wound is relatively clean and there is adequate surrounding blood supply, some recommend immediate bone grafting. Within 48 hours, after debridement and irrigation, the wound may be ready for a bone graft, even if it does not look “clean.” When there is obviously contaminated tissue, the wound should undergo progressive debridement and cleaning and the bone graft placed in a delayed fashion. However, if bone grafting must be delayed, then in all mandible fractures and most midface fractures the distance relationships between bone edges should be maintained by plating, generally using heavier plates than would normally be used for fracture repair. In the mandible, reconstruction plates are ideal for that purpose. Then, at a later date the bone graft can be affixed into the gap bridged by the plate. Because the bone graft never acquires the same strength as the original bone, the heavier plates help assume the load of the missing bone. In the mandible, in particular, if there has been tissue loss or damage in the oral cavity, the soft tissue around the mandible may be insufficient to support an immediate or early bone graft. In that case, soft tissue should be closed and placement of the bone graft delayed. Some have discussed using free tissue transfer, for example, omentum, to create a vascularized recipient bed for later bone grafting. If free bone grafting is not possible, then free tissue transfer of vascularized bone, such as fibula or scapula, is another option for eventual reconstruction of a bony mandible or midface deficit.

Bone grafts placed early can heal surprisingly well, and can help maintain the position of the soft tissue overlying the bone. One problem with delaying bone grafts is that the overlying soft tissue can contract, and then when the surgeon attempts to place the bone graft, the tissue cannot be expanded back to its original size, and even if it can, it may have an unnaturally tense and stretched appearance. This can be avoided by placing bone grafts as soon as practical, particularly in protruding visible areas like the nose, malar eminence, and orbital rim. Even if some revision is required later, the soft tissue healing is usually improved when the underlying bony projection was restored soon after injury.

The CT scan with its multiplanar images has significantly changed the management of penetrating facial injuries, and facilitates assessment of tissue damage and bullet path. Fig. 21-3 is an example of a facial scan after penetrating trauma, and demonstrates the value of CT scan in assessing the extent of injury as well as the location of bullet fragments and secondary projectiles. This assists in planning debridement as well as repair. Finally, the surgeon should keep in mind that bullets can be deflected into the tissues of the neck, particularly in mandible gunshot wounds because of the thick bone.

**Bullet Removal**

In general, bullets should be removed from the wound, because they are a foreign body. However, that is occasionally not practical if the bullet is lodged deep in the tissues near vital structures, such that the surgical exploration necessary to expose and remove the bullet might potentially cause more injury than leaving the bullet in place. Many bullets have been left in tissues and have not caused any later problems. However, we have seen several patients with recurrent or persistent pain, infection, or foreign-body sensation from retained bullets, and after surgical removal the symptoms have resolved.

![Computed tomography scan showing damage from a gunshot wound to the face.](image-url)
**Shotgun Wounds to the Face**

As discussed in Chapter 20, shotguns have a high muzzle velocity, and close-range shotgun injuries may impart significant energy to tissue, with resultant massive tissue destruction. Most patients with shotgun wounds to the face have pellet penetration of both the midface and mandible entry zones, so the zoning system is not helpful. I recommend considering shotgun wounds as a separate category of penetrating facial trauma, and the patient should be evaluated as if both zones were entered.

The need for emergency airway establishment is uncommon in shotgun injuries to the face, although with close-range injuries involving the mandible or with significant oral cavity bleeding, the airway can be compromised. Two of 15 patients with shotgun wounds to the face required an emergency airway in one series. Shotgun wounds to the face have been reported to achieve intracranial penetration as well as penetration posterior to the MAP, so careful evaluation of anterior-posterior and lateral skull x-rays is a mandatory part of evaluation. Shotgun wounds have a very high prevalence of globe injury, so all patients should undergo a careful ophthalmologic assessment. Facial bony fractures requiring reduction and fixation are unusual, even in close-range shotgun injuries. However, bony fragmentation can occur; this usually occurs along with soft tissue injury, and the bony fragments can be debrided at the same time as the soft tissue is addressed. As discussed previously, irrigation, cleansing, debridement of devitalized tissue, and removal of foreign bodies and pellets are important aspects of the early management of shotgun injuries.

**Stab Wounds to the Face**

Stab wounds to the face can result in globe injury, vascular injury, unstable fracture, and even intracranial penetration. The overall management of stab wounds to the face uses the same principles of management of stab wounds elsewhere, as detailed in Chapter 20: if the weapon is still in place, assess depth of penetration using x-rays and do not attempt early removal; gently probe other wounds to assess depth; consider movement of the blade under the skin; and consider angiography to assess vascular injury. If the blade of a weapon is still impaled and there is concern about vascular injury, then diagnostic angiography can be performed prior to blade manipulation, with establishment of proximal vascular control using an inflatable balloon; in some cases distal control can also be established. Then, with the balloon in place, the blade can be removed and if significant bleeding ensues, the balloon could be quickly inflated to stop or slow the bleeding—either as a definitive measure or to allow time for surgical exposure and an alternative means of vascular control. If interventional radiology is not available, then the surgeon could establish exposure and potential vascular control in the neck prior to blade manipulation.

Intracranial penetration and globe injury due to stab wounds require consultation with appropriate specialists. Management of facial fractures is the same as for other penetrating injuries, except that in stab wounds there is usually not a large amount of missing bone, so open reduction with internal fixation is usually adequate. Similar to bullets, the blades of penetrating weapons are not considered sterile, so stab wounds should not be closed primarily. However, there is usually little tissue loss with stab injuries, so irrigation and removal of foreign debris are usually sufficient treatment of the soft tissue injury. Other specific injuries are possible with facial stab wounds, and those are discussed in the next section.

**Management of Specific Injuries**

**Facial Nerve Injury**

Patients with penetrating facial trauma and immediate paralysis of one or more branches of the facial nerve are likely to have transection of the nerve. If the wound is posterior to a vertical line drawn at the lateral canthus, these patients should undergo local exploration with primary nerve repair or nerve grafting—if their overall condition permits. Nerve injuries anterior to the lateral canthus are typically not explored because spontaneous nerve regeneration is usually adequate in that location. Although as a general principle, all patients with facial paralysis secondary to penetrating trauma should be explored and repaired; some of those injuries will recover adequate function even if completely transected because of substantial cross-innervation. The areas with richest cross-innervation are the midface and zygomatic regions. In contrast, forehead and ramus mandibularis branches have poor cross-innervation, so injuries to these areas should be explored and repaired whenever possible. Gunshot wounds with immediate facial paralysis have a high probability of nerve damage beyond what is visible to the eye, so additional debridement of nerve ends and even nerve grafting should be strongly considered in gunshot injuries. Although surgical repair is the appropriate treatment, long-term functional
outcomes after gunshot wounds are usually disappointing—no better than House-Brackman grade 4. This is probably due to the force and energy from the bullet that is transmitted to the facial nerve.

Severed distal facial nerve branches will retain their electrical excitability for ~48 hours, and a nerve stimulator can be used intraoperatively to identify the severed ends of nerve branches. The preferred neurorrhaphy technique is to trim back the perineurium away from the anastomosis and perform epineurial repair with 9-0 or 10-0 monofilament suture.7 Facial nerve injuries that progress from partial to total paralysis following injury, or paresis that develops several hours after injury, are usually secondary to edema and may be treated expectantly with expected eventual resolution, similar to facial weakness following blunt trauma.

**Parotid Duct Injury**

Penetrating wounds to the cheek inferior to the zygomatic arch that injure the buccal branch of the facial nerve are also likely to injure the parotid duct, because that nerve branch and the duct are usually immediately adjacent. So buccal branch weakness should raise a high level of suspicion for parotid duct injury. Parotid duct injuries do not usually heal spontaneously or recanalize, so exploration and surgical repair are almost invariably required. If there is no buccal branch facial injury, but parotid duct injury is still suspected (i.e., clear saliva draining from a penetrating cheek wound, or sialocele formation), the wound should be explored. If injured, the duct should be primarily repaired over a hollow stent to allow saliva to continue to flow from the gland. Small monofilament suture is used for duct repair, and the stent can be fashioned from the tubing of a butterfly-type phlebotomy needle or a neonatal pediatric feeding tube. The stent is brought out through Stensen’s duct into the lateral aspect of the mouth, and can be sutured to the buccal mucosa. The stent is usually removed after a few weeks.

**Delayed Complications of Penetrating Facial Trauma**

Even after successful initial stabilization and treatment, there are several potential delayed sequelae of penetrating facial injuries, which can occur in up to 35% of patients.3,4 These include blindness, visual loss, diplopia, facial nerve weakness or paralysis, cerebrospinal fluid leak, soft tissue loss, bony malunion, malocclusion, trismus, orbital or periocular cellulitis, sinusitis, oral-antral fistula, nasal obstruction or stenosis, and choanal stenosis. Although some of these complications can be directly caused by the injury and therefore cannot be avoided, many complications are potentially preventable with early recognition and aggressive management. In particular, nasal obstruction and stenosis, sinusitis, and choanal stenosis can be prevented or minimized with intranasal debridement and irrigation, placement of nasal stents, and using the techniques of functional endoscopic sinus surgery to restore adequate sinus drainage.

In addition, ophthalmologic complications such as diplopia and orbital infections may be prevented with careful reconstruction of the orbital floor to restore orbital anatomy and isolate the maxillary sinus from the orbit. Of course, when an orbital wall fracture causes globe displacement and diplopia, then surgical reconstruction is needed. However, even in cases of near-blindness or enucleation (where diplopia or globe position are not an issue), reconstruction of the orbital floor is still important to prevent communication between the maxillary sinus and orbit. We have seen cases of serious orbital infection, requiring removal of an orbital prosthesis, that were due to maxillary sinusitis and inadequate repair of the orbital floor, which allowed communication between the sinus and orbit.

Trismus and temporomandibular joint fibrosis can be prevented with early mobilization and stretching of the temporomandibular joint. Having the patient stack tongue depressors and place progressively larger stacks between the incisors to stretch the mouth open is a useful maneuver to prevent trismus. Malocclusion is usually caused by inadequate open reduction and internal fixation of mandible or midface fractures, or by inadequate use of intermaxillary fixation at the time of fracture repair. That complication, therefore, is best avoided by careful attention to occlusion during fracture repair.

**Pearls: Penetrating Facial Trauma**

- Patients with penetrating trauma to the face should be evaluated using the trauma ABCs, followed by the secondary survey for associated injuries.
- The face is divided into two zones of entry: midface zone and mandible zone.
- Gunshot wounds to the mandible zone have a high chance of requiring emergency airway establishment.
• Gunshot wounds to the midface may cause injury to the globe or major vascular structures, or achieve intracranial penetration.
• The indications for arteriogram in penetrating facial wounds are proximity to a major vascular structure, or penetration posterior to the mandibular angle plane.
• Shotgun wounds to the face have a high prevalence of globe injury.
• Shotgun wounds can achieve intracranial penetration or cause deep vascular injury.
• When bone is missing after a gunshot wound, bone grafts should be placed relatively early if possible.
• Stab wounds can achieve significant depth of penetration.
• Facial nerve weakness after penetrating trauma is usually due to nerve transection; the wound should be explored and the nerve ends reapproximated.

REFERENCES