Facial Gunshot Wounds: Trends in Management

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ABSTRACT

Facial gunshot wounds, often comprising significant soft and bone tissue defects, pose a significant challenge for reconstructive surgeons. Whether resulting from assault, accident, or suicide attempt, a thorough assessment of the defects is essential for devising an appropriate tissue repair and replacement with a likely secondary revision. Immediately after injury, management is centered on advanced trauma life support with patient stabilization as the primary goal. Thorough examination along with appropriate imaging is critical for identifying any existing defects. Whereas past surgical management advocated delayed definitive treatment using serial debridement, today's management favors use of more immediate reconstruction. Recent advances in microsurgical technique have shifted favor from local tissue advancement to distant free flap transfers, which improve cosmesis and function. This has resulted in a lower number of surgeries required to achieve reconstruction. Because of the diversity of injury and the complexity of facial gunshot injuries, a systematic algorithm is essential to help manage the different stages of healing and to ensure that the best outcome is achieved.

KEYWORDS: Facial gunshot wounds, management, reconstruction

Facial gunshot wounds frequently represent a complex set of challenges for the plastic surgeon. Often a result of assault, accident, or suicide attempt, facial gunshot injuries cause significant soft tissue and bone defects.^{1,2} The extent of soft tissue damage, immediately after injury, is typically not wholly apparent (Fig. 1). High rates of significant tissue necrosis, ischemia, and infection further complicate reconstructive efforts. For optimal recovery, an appropriate reconstructive approach should involve three stages, composed of the initial stabilization, definitive reconstruction, and potential secondary refinement. Whereas past management favored delayed reconstruction, contemporary efforts more frequently use immediate, definitive reconstruction.³⁻⁷ In an effort to update the current

algorithm on facial gunshot wound management, we present a review of both past and modern approaches to these challenging injuries and discuss relevant aspects of management.

EPIDEMIOLOGY

The actual incidence of facial gunshot injuries remains illusive. A retrospective review of nearly 4100 gunshot wounds observed that ~6% involved the face.⁸ Male patients, comprising greater than 80% of the gunshot wound patient population, are most frequently involved.⁵ Approximately two-thirds of gunshot victims suffered a single gunshot wound, resulting in nearly 11% mortality within the first 24 hours posttrauma.

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Figure 1 On initial evaluation, missile injury may be misleading and cover the severe underlying skeletal injury (arrowhead, entrance wound; arrow, exit wound).

ETIOLOGY

The etiology of missile injuries accounts for a combination of the projectile's structural character, kinetic energy, and its interaction with tissue. A majority of projectiles remain a single unit after penetration. However, some bullet structures are specifically designed to fragment within the body and create multiple individual tracks, which disperses the extent of the injury (Fig. 2). The wounding capacity of a projectile is directly related to the amount of kinetic energy transferred to the tissue.⁷⁻⁹ Both mass and velocity of the missile affect the kinetic energy (KE) as described by the equation $KE = \frac{1}{2} \text{ mass} \times \text{velocity}^2$. This equation demonstrates that missile velocity has the greatest impact on ballistic energy. Whereas *doubling* bullet mass only doubles energy, doubling projectile velocity *quadruples* available kinetic energy. Elasticity, density, and anatomic relationships within penetrated tissue strongly affect wound character as well. Viscoelastic tissue qualities contribute to the overall damage. Unlike rigid bone, which tends to fragment, the elasticity of muscle and other superficial soft tissues is more accommodating.^{5,8,9}

Ballistics are classified according to low (< 1200 ft/s), medium (1200 to 2000 ft/s), and high (> 2000 ft/s) velocities.^{6,9-11} Handgun and shotgun wounds result

Figure 2 Some bullets are designed to fragment within the body. This produces multiple individual tracks, which extend the injury well beyond the site of penetration.

from low- to medium-velocity projectiles.^{1,9} Shotguns are a frequent choice for suicide attempts and tend to cause massive tissue destruction at close range. When at distances of up to 20 feet, the pellets disperse in a conical trajectory, which results in a wide, although less intense, area of destruction.^{1,9,12} Low-velocity projectiles have minimal correlation between their entrance and exit due to their tendency to deflect off of tissue, resulting in more bone than soft tissue damage.¹²⁻¹⁴ Bone fragments may acquire some of the energy from the ballistics and behave like secondary projectiles, resulting in additional injuries.^{12,13} This is particularly concerning in the face due to the proximity of the mandible, teeth, dentures, and maxilla, which may dislodge and become secondary projectiles.¹⁵ High velocities of greater than 2000 ft/s and greater tissue destruction are typical of rifles. Emergency room presentation of high-velocity gunshot wounds to the face and cranium is rare due in part to the fact that most people do not survive these types of injuries.

ACUTE NONSURGICAL MANAGEMENT

Facial gunshot wound patients must be initially managed in accordance with the algorithmic advanced trauma life support (ATLS) protocol. Initially, primary concern is devoted to maintaining airway patency, which may be compromised by direct laryngeal injury, aspirated teeth or bone fragments, and excessive bleeding. Airway compromise can also occur when the floor of the mouth and tongue lose critical underlying support and swell substantially. The trauma team should have a low threshold for airway protection via endotracheal intubation or tracheostomy. Treatment of the compromised airway is complicated by a 10% incidence of cervical spine injuries in this patient population.⁸ Cervical spine clearance is critical prior to further management.

The dense vascularity of the head and neck can cause significant blood loss from soft tissue injuries, representing 10 to 50% of facial gunshot wounds.^{8,10} Accurate and directed control of bleeding vessels is essential to avoid clamping critical structures. Bleeding that cannot be controlled with direct pressure should be packed. Frequently, the bleeding source is a branch of the external carotid system, and angiographic embolization by a radiologist should be done to definitively control the bleed.^{5,7,8} Surgical ligation of the external carotid artery is often ineffective for bleeding control due to its robust collateral vessels.

A critical part of initial management consists of a thorough neurologic evaluation. Approximately 17% of patients with facial gunshot wounds demonstrate some degree of altered mental status secondary to direct brain injury.^{6,8} The Glasgow Coma Scale (GCS) is the most widely accepted method for expressing the

degree of neurologic injury, evaluating motor, verbal, and eye-opening responses of the patient at presentation. Demetriades et al found that 8% of facial gunshot victims experience concomitant spinal injury.⁸ Cervical spine stabilization is paramount until cleared both clinically and radiographically.

Physical Examination

Although it is easy to be distracted by more impressive injuries and significant swelling during initial assessment of the patient's condition, overlooking less obvious but potentially significant problems can be detrimental to the patient. In addition to assessing facial soft tissue status, a careful assessment of sensory disturbances in the forehead, cheek, and lower lip should be well documented along with any facial nerve deficits.^{5,6,13} Any surgical intervention in the postoperative period may be erroneously attributed to undocumented preoperative nerve injuries.

Much of the long-term morbidity of facial trauma is associated with ocular and orbital injury. Although there should be a low threshold to involve the ophthalmologist, the physician treating facial trauma should be well versed in the ocular examination. A complete ocular examination should consist of an evaluation of general acuity, light and red light perception, ocular motility, pupillary reactivity, and examination of the conjunctiva and eyelids.^{1,5,12}

Oral cavity examination is crucial, especially in the obtunded patient who may have bone fragments, loose teeth, or foreign bodies. For proper evaluation, identification and removal of prosthetics such as dentures is essential.^{1,2} Occlusion and intercuspation should be carefully evaluated, as both mandibular and maxillary injuries may cause malocclusion. Even a slight change in occlusion can be sensed by the patient.^{3,4} Although compromised mental status may not allow the patient to report on occlusion character, careful analysis of wear facets may enable the surgeon to determine if malocclusion is present.

Imaging

Computed tomography (CT) is the gold standard for determining the nature of complex head and neck injury. One-millimeter axial views, from the top of the cranium through the bottom of the mandible, should be obtained.³⁻⁵ Both coronal and sagittal views are necessary. For more complex fractures, visualization of the extent of injury is enhanced using a three-dimensional reconstruction of the facial skeleton. Although 100% sensitive and specific for facial bone injury, CT does not give sufficient detail of dental structures, root damage, or tooth position, which require panoramic radiographs for appropriate assessment.

TIMING OF SURGICAL MANAGEMENT

Once the patient is stabilized, attention may be devoted to the facial wounds if injuries involving globe penetration, extraocular muscle entrapment, or exposed intracranial contents have been addressed acutely.⁵ After skeletal fixation, soft tissue coverage is crucial. In the acute and subacute setting, tissue coverage depends upon (1) wound character and dimension, (2) overall patient status, and (3) surgeon prerogative. Shortly after injury, it is generally preferred to attain more conservative wound coverage. Whereas some advocate emergent free flaps, we prefer "temporary" coverage and defer lengthy definite procedures to a time when the patient has stabilized. Examples of this coverage include use of galeal flaps and scalp flaps, backgrafting any defects created temporarily with xenograft or allograft (Fig. 3).^{10,16} Timing of definitive reconstruction, however, remains an area of continuing debate.¹⁷ Whereas traditional approaches advised delayed reconstruction, the contemporary paradigm demonstrates success with more immediate definitive reconstruction within 24 to 48 hours.

Proponents of delayed reconstruction have typically maintained that the prolonged period decreased infection rates, reduced necrotic debris, and allowed the surgeon to obtain a better idea of the extent of irreversible injury (Fig. 4). Additionally, by allowing adequate time for edema resolution, the decrease in inflammation provides for a better assessment of the pretraumatic facial structure. However, in a review of 33 facial reconstructions, Vasconez et al observed similar infection rates between delayed and immediate post-gunshot wound reconstruction.¹⁸ The delayed group also demonstrated an increased incidence of wound contracture, which resulted in significantly more structural and functional deformity. In two other comparative reviews, Gruss et al¹⁴ and Vayvada et al¹³ also present improved results over traditional delayed approaches. These authors proposed that by immediately reducing local dead space: (1) immunoreactivity is improved, (2) more robust biologic coverage is provided, and (3) delivery of hematogenous

Figure 3 Scalp flaps can provide temporary coverage of facial defects. Backgrafting of the resulting defect can be achieved using xenograft or allografts, deferring definitive coverage to a later date.

Figure 4 With delayed reconstruction, severe swelling is allowed to dissipate, revealing the extent of irreversible injury.

nutrients essential for wound healing is enhanced. Furthermore, fewer and less complex revisionary procedures are necessary for patients who underwent immediate definitive reconstruction.^{13,14}

SURGICAL MANAGEMENT

Early Debridement

Facial gunshot wounds frequently consist of contaminated and profoundly injured local tissue. Initial soft tissue management involves decontamination and debridement of the wounds to prevent dead space formation, minimize wound tension, and evert the wound edges. Prior to closure, all foreign debris must be removed from the wound. Only clearly nonviable tissue should be debrided. When tissue viability is questionable, it should be allowed to heal naturally with ensuing necrotic areas debrided every 48 hours.^{1,5,10–12} Irrigation with a pulsed lavage system is recommended for more extensive wounds or those with a great deal of contamination. Prophylactic antibiotics with broad coverage specific for oral and skin flora should be administered at this time.^{1,3,5} Coronoidectomy at the time of debridement should be considered, given the propensity of facial gunshot wounds to result in trismus and ankylosis.⁵

Skeletal Fixation

Correction and stabilization of skeletal dimension should be attempted after debridement and irrigation are completed. Restoration of anteroposterior projection and width of the face should be the primary goal of skeletal reconstruction. Although the order in which the craniofacial skeleton is addressed is somewhat controversial, it is helpful to use the zygomatic arch as a guide by plating it early in the sequence.^{5–7} Correct positioning of the arch helps establish the proper facial width and frames the face. Improper reconstruction of the arch may result in incorrect framing for the remainder of the

Figure 5 For extensive bone comminution with minimal soft tissue damage, external fixation stabilizes the fragments, providing scaffolding for osteogenic regeneration.

reconstruction. When a mandibular fracture is a component of gunshot wounds, reestablishing mandibular continuity and occlusion first is advisable.^{5,7,19} This aids restoration of the remaining facial skeleton by creating a useful anatomic platform.^{19,20} External fixation may be prudent in the event of extensive bone comminution with minimal soft tissue damage (Fig. 5).^{21–24} While maintaining vital soft tissue coverage, external fixation allows bone regeneration and advancement without devascularizing the underlying bone stock. This also stabilizes the severely comminuted bone fragments and tends to promote the fragments' osteogenic character, facilitating bone healing and restoration of bone structure.^{21,22} Internal plating should be used in the majority of the remaining instances in which bone fragments are large enough to accept screws. Whereas miniplates typically suffice for the cranium and midface, large (2.4 mm) locking plates are typically used on the mandible.^{5,21}

Midface and mandibular bone defects larger than 5 mm should be bone grafted.^{21,22,24} Iliac crest bone graft is preferred for the mandible, as grafts similar in height and thickness to natural mandible can be easily harvested. Typically, midface bone defects are more limited and load bearing is not as much of an issue. Depending on the nature of these defects, iliac crest, cranium, and rib are all reasonable options. In most cases, vascularized bone is not critical for reconstruction. Unlike skeletal defects after cancer resection, radiation-induced graft resorption is not an issue as long as healthy vascularized soft tissue is used to repair the defect.^{5,14}

Definitive Closure

Optimally, simple reapproximation of adjacent tissue can achieve definitive closure. Surprisingly, seemingly massive injuries can sometimes be closed primarily once tissues are evaluated in the operating room (Fig. 6).^{1–3,14} However, it is critical to avoid placing undue tension on local tissues. Undermining of skin edges, usually a

Figure 6 Reapproximation in the operating room may be achieved even when on initial evaluation the injuries appear too severe for primary closure.

significant facilitator of primary closure, should be approached very conservatively.

Many massive soft tissue defects secondary to gunshot wounds require free tissue transfer. Over the past decade, advances in microvascular technique have established free flap transfer as the gold standard in the reconstruction of severe facial trauma (Fig. 7).^{1-3,7,10} Inherently thin, fasciocutaneous flaps are highly pliable and most accurately re-create cheek contour. The anterolateral thigh flap is the most commonly applied free flap in our practice. The ability to harvest simultaneous with a second team performing procedures on the face, a long pedicle, this anterolateral thigh flap tissue, and primary donor-site closure make this an excellent choice for most reconstruction.

Regarding osteocutaneous flaps, many surgeons discourage their use despite significant composite defects.^{19,21} However, much of this literature on which these opinions are based is derived from experience with tumor extirpation and local radiotherapy.^{16,19,21} In our experience though, soft tissue-only reconstructions tend to droop. Without underlying structural support, it is best to replace like with like and incorporate bone and soft tissue in composite defect reconstruction if at all possible.

Secondary Revisions

The final stage of reconstruction attempts to achieve optimal functional and aesthetic results. For secondary revisions, flap debulking, dental implant placement, and scar revisions are important components.^{1,5,6,10} Although recent reports link early definitive reconstruction with a decreased need for revisional surgery, a majority of our patients still request some form of revision. As with all facial trauma patients, the most common problems include enophthalmos, lid retraction,

Figure 7 A combination of both microvascular and local flap techniques may be necessary for the repair of severe defects.

and trismus, which are treated in the standard fashion.^{3,4} Unique to this group of patients, however, is postoperative issues with “skeletonization” of the reconstruction and soft tissue atrophy. We have had success with temporalis muscle flap turndowns to the cheek for added bulk in this region and with temporoparietal facial flaps for coverage of periorbital wounds.

CONCLUSION

Facial gunshot wounds pose a significant challenge for reconstructive surgeons who are faced with a mixture of significant soft tissue and bone defects. A thorough assessment, calculated tissue repair and replacement, and likely secondary revision are necessary regardless of injury mechanism. Initial management centers on ATLS with the primary goal of patient stabilization. Thorough examination and appropriate imaging are critical in identification of existing defects. Today, surgeons are in favor of more immediate reconstruction, as opposed to past delayed definitive treatment using serial debridement. Whereas local tissue advancement has been historically preferred, recent advances in microsurgical technique have permitted distant free flap transfers, which improve cosmesis and function. This has resulted in a reduced number of surgeries necessary to achieve reconstruction. Given the complexity and diversity of injury associated with facial gunshot wounds, a systematic algorithm is essential to help manage the different stages of healing and to ensure that the best outcome is achieved.

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