Surgical correction of severe enophthalmos caused by bullet injury

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ABSTRACT

Ballistic injuries of oral and maxillofacial region are usually fatal due to close propinquity with the vital structures. The severity of injury depends on the caliber of the weapon used and distance from which the patient is shot. The preliminary care of facial ballistic wounds strictly adheres to the basics of trauma resuscitation. Early and appropriate surgical management has proved to be influential on the final outcome and esthetic result. Treatment of facial gunshot wounds should be planned and carried out carefully to avoid esthetic complications. It takes even multiple-staged corrections to achieve the targeted functional and esthetic treatment plan. Prevention and control of infection is one of the most important goals to achieve the success of the treatment. Herewith, we present a case of facial gunshot injury with fractures in the orbital floor, medial wall maxillary sinus, and buttress of the zygomatic bone causing deficit, which was successfully managed by surgical reconstruction.

Key words: Bullet injury, enophthalmos, gunshot injury, orbital floor, titanium mesh

CASE REPORT

A 26-year-old male who worked as a soldier in the army in the Middle East reported with an accidental gunshot injury on the right side of the face and needed correction of the resultant deformity. History revealed that 20 days back, the patient was struck by a stray bullet while returning from his military camp. The bullet had entered through the nape of the neck and exited through the right orbital floor. He had been immediately hospitalized and underwent emergency surgery under general anesthesia. He reported that he underwent external carotid ligation at the level of neck and bullet extraction to control the profuse bleeding from the injury with no primary bony reconstruction except for the soft tissue redraping. The major blood vessels such as internal carotid artery and the jugular vessels were not damaged. Postsurgical history of loss of consciousness and vomiting were not observed.

On examination, a mild periorbital swelling and scars were evident near the right nasolabial fold and lower eyelid skin. The right eye had no alteration in vision. He had diplopia, enophthalmos, and hypoglobus with orbital dystopia. On palpation, there was paresthesia of the right infraorbital nerve dermatome. There was deficiency of bone...
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palpable in the right inferior orbital rim and anterior wall of maxilla. Further, computed tomography imaging studies revealed fracture with bony deficit in the orbital floor, medial wall maxillary sinus, and buttress of the zygomatic bone. An arteriogram done on his carotid system revealed no abnormality. An angiography was done to detect any dormant aneurysm [Figures 1-4].

Path of the bullet
The bullet entered through the nape of the neck damaging the trapezius, semispinalis capitis, and splenius capitis muscles. The bullet would have supposedly traversed across the neck through the infratemporal fossa exiting through the infraorbital region damaging the floor of the orbit, infraorbital rim, and maxillary sinus buttress. The entrance wound may be characterized by the “keyhole” effect. Such a wound results from a bullet striking the skull at an angle [Figure 5]. This effect may be in accordance with Berryman who stated that “as the bullet advances, fragments produced by radiating fractures become elevated, and connecting fractures form perpendicular to the radiating fractures. Bone fragments delimited by these fractures are propelled outward as the bullet passes through.” The end result is a wound resembling a keyhole. The bullet narrowly missed the brainstem and skull base including major blood vessels such as the internal carotid artery and the jugular vessels. The cause of profuse uncontrolled bleeding could be from the highly vascular region of infratemporal fossa-pterigoid venous plexus and maxillary artery. [2]

Surgical procedure
Under general anesthesia, through a preexisting scar in the right infraorbital rim, the infraorbital region was explored. The orbital floor was shattered with multiple small fracture fragments as evident beyond fixation. The potentially vascular fracture fragments were removed to avoid infection. A soft tissue pocket was created inferior to the globe for the placement of a graft to reconstruct the orbital floor. A titanium mesh was contoured, positioned, and adapted

Figure 1: (a) Immediate postoperative view after primary management, bullet extraction, and wound closure. (b) Entry wound appearing as a beveled oval wound. (c) Preoperative computed tomography showing comminuted fracture and bony deficit involving the right orbital floor, infraorbital rim, and zygomaticomaxillary butress. (d) Preoperative three-dimensional computed tomography

Figure 2: (a and b) Preoperative view showing enophthalmus, hypoglobus, dystopia, and a scar in the right infraorbital region

Figure 3: (a) Orbital approach through the preexisting scar. Note the titanium mesh used for orbital floor reconstruction. (b) Orbital floor reconstructed with titanium mesh. (c and d) Harvesting of rib graft

Figure 4: (a) Infraorbital rim reconstructed using rib graft. (b) Postoperative view showing corrected enophthalmos and hypoglobus. (c) Preoperative worm’s eye view. (d) Postoperative worm’s eye view showing enophthalmos and hypoglobus
to the floor and rim fixing the mesh at the lateral orbital rim. A costochondral graft was harvested and contoured according to the need. The graft was used to reconstruct the infraorbital rim and the orbital floor. The defect was thus reconstructed, and the globe of the eye was elevated to the level of the contralateral eye. The wound was closed in layers after excising the scar.

DISCUSSION

The most common types of firearm used are handguns, rifles, and shotguns. Handguns fire low-caliber projectiles (lead or lead alloy) at a low velocity (<2000 feet/s). Rifles fire low-to-high-caliber projectiles at a high velocity (>2000 feet/s). A shotgun is a long gun that may fire a single pellet or hundreds of pellets at a low velocity. Bullets crush structures along its track, causing temporary cavitation, shearing, and compression, sometimes tears the structures (as with solid abdominal viscera) or stretches inelastic tissue (the brain). As tissues recoil and hot gases dissipate, soft tissue collapses inward, and hence a permanent cavity is formed. In addition, kinetic energy transfer occurs during retardation of the velocity of the bullet and this may cause damage outside the tract. Factors influencing the efficiency of kinetic energy transfer include the kinetic energy of a body, proportional to mass and velocity, projectile’s deformation and fragmentation, entrance profile and path travelled through the body, and biological characteristics of the tissues.

The maxillofacial gunshot injuries are associated with a high mortality rate. The severity of these injuries varies depending on the caliber of the weapon used, distance, and the mass and velocity of bullet (low velocity, <1000 feet/s and high velocity, >2000 feet/s). High-velocity injuries have traditionally been assumed to cause more damage than low-velocity ones have, an assumption that is still under dispute. A close-range, high-velocity gunshot wound can result in devastating facial disfigurement and disability in those who survive.

Shape of the wound of entrance (WOE) may be circular or oval. The WOE is circular when the bullet strikes the body surface perpendicularly. When the bullet strikes the body at an angle, the WOE is oval. WOE is everted with protrusion of fatty tissue through the wound. The margin is irregular. In shorter distance, wound of exit is larger than the wound of entry, whereas at a longer distance, the wound of exit is slightly smaller than the WOE. In our case, the oval entry wound with more destruction in the exit wound suggests that the bullet enters at an angle from short distance.

Beveling may occur indicating the direction of fire. Symmetrical beveling at the entrance wound suggests that the shot was made at a 90° angle. Whereas asymmetrical beveling indicates a shot made at an angle. Certain parts of the skull, such as the temporal and facial bones, are thin and therefore do not bevel. Bullet rotation may also help create external beveling at the entrance site although this explanation seems unlikely, given that a bullet does not spin much as it perforates the skull.

As the projectile enters the victim, the different layers of tissue react according to their specific properties. Injuries to the dermis include abrasion, impaction of particulate matter, and contusion. At closer ranges, burning and implantation of powder and residue may occur and may result in a tattoo. After the projectile passes through the skin, it next encounters muscle tissue, which is very elastic and may sustain deformation of as much as four times the diameter of the projectile. On a cellular level, the muscle along the pathway of the projectile becomes devitalized and necrotic.

Figure 5: (a) Three-dimensional computed tomography showing presumed path of bullet shown in red arrow - first hitting the zygomaticomaxillary buttress producing radiating fractures extending till the orbital floor and the infraorbital rim. (b) Presumed path of bullet - keyhole effect

Figure 6: Shape of entry wound depending on the angle of bullet entry
As the projectile travels, it may also encounter other surrounding vital structures such as nerves and blood vessels. The injuries to neurovascular tissue are similar to injuries to muscle. Vessels may be ruptured, crushed, or sheared, and spasm may occur. These injuries may result in hemorrhage and in the formation of thrombi and hematoma. On a cellular level, damage occurs to all the three layers of the vessel wall.[3] Sensory and motor nerves may be damaged. When sensory nerves stretch, anesthesia and paraesthesia result; when motor nerves stretch, there is a result of conduction deficit and loss of function.

Injury to bony tissue differs from injury to soft tissues. The minimal projectile velocity required for bone fracture is 65 m/s. Bone is very inelastic; therefore, the type of injury that occurs depends on the type of bone encountered by the projectile. Injury to cancellous bone usually results in a defect of the drill-hole type. Injury to cortical bone or teeth usually results in shattering. The resulting fragments may act as secondary projectiles and may pose an aspiration risk.[5]

Bullet injuries are most severe in friable solid organs (e.g., liver and brain) where damage may be caused by temporary cavitation (tissue stretch) remote from the actual bullet track.[2] Dense tissue (e.g., bone) and loose tissue (e.g., subcutaneous fat) are more resistant to bullet injury. Bone modifies the behavior of bullets markedly by altering their course, creating a tumbling effect, slowing them down, and increasing deformity and fragmentation.[7,8] Evaluation of bone injuries and the distribution of bone and bullet fragments on radiographs can be helpful in determining the direction of travel, which is important not only for clinical assessment but also for forensic evaluation of the incident.[6]

The presence of a full or partial metal jacket has a major effect on deformity. Bullets with full metal jackets often remain in one piece and usually do not deform much. These projectiles typically do not leave a trial of lead fragments along their path. On the other hand, semi jacketed, hollow point, nonjacketed soft point bullets tend to deform on impact or break apart, leaving a telltale trail of metal fragments through the soft tissue.[10]

The first procedure in definitive maxillofacial management of a gunshot injury is to irrigate the wound with normal saline. Irrigation debrides any necrotic tissue, removes foreign bodies, and brings the contaminants to nonpathogenic concentrations. Simple cutaneous wounds may be cleansed and dressed with bacitracin or sulfadiazine cream 1%. Shattered bone and teeth along with debris should be removed under copious irrigation. Injuries resulting in active hemorrhage should be explored and repaired at the earliest. At the time of hemorrhage control, obvious nerve damage should also be repaired.

Orbital injuries should be managed with attention to form and function. The spectrum of eye injuries may possibly vary from very mild to extremely serious, resulting in blindness. Early attention should be paid to vision and ocular motility. When an eye is severely damaged, it may be necessary to remove it surgically. The most common procedures are evisceration (removal of the contents of the eye except the sclera and extraocular muscles) or enucleation (removal of the eye itself) and exenteration, which is the most radical of the three procedures and involves removal of the eye, adnexa, and part of the bony orbit.

Nerve damage, particularly to the facial and trigeminal nerves, can be expected after severe gunshot wounds to the face. The damage caused by either the direct injury or the blast effect generally prevents immediate reconstruction.[11]

In the present case, the patient was shot from the back in the occipital region and the bullet exit wound is in the orbit. The fractured floor was reconstructed successfully by titanium mesh plate. The patient escaped from injury to any vital structure which provided him a very good prognosis with functional and esthetic rehabilitation.

CONCLUSION

Firearm injuries have become very common with the increasing availability and use of ammunitions by individuals in domestic violence and homicide. Gunshot wounds in oral and maxillofacial region often present with frightful deformity. The type of injury is dependent on the type of the projectile and the energy of the impact. Prevention and control of infection is important in the outcome of the treatment success. Knowledge about the primary management of the cases is very important as it could be lifesaving as well as facilitates secondary correction by surgical or prosthetic means. Most of the patients require secondary correction of the facial deformities or replacement of lost body parts, most often the eye. The basic principles of surgery followed logically can effectively rehabilitate the unfortunate victims of war and domestic violence.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.
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