

Chapter 25

MIDFACE FRACTURES

GEORGE COPPIT, MD, FACS*

INTRODUCTION

ANATOMY

PATHOPHYSIOLOGY

EVALUATION

TREATMENT

SUMMARY

CASE PRESENTATIONS

Case Study 25-1

Case Study 25-2

Case Study 25-3

**Colonel, Medical Corps, US Army; Chief, Otolaryngology/Head & Neck Surgery, Walter Reed National Military Medical Center, 8901 Rockville Pike, Bethesda, Maryland 20889; Assistant Professor of Surgery, Uniformed Services University of the Health Sciences*

INTRODUCTION

During Operation Iraqi Freedom and Operation Enduring Freedom, more than 7,200 US service members sustained head and neck injuries, including 11,689 facial fractures.¹⁻³ The most common mechanism of injury has been the improvised explosive device (IED), resulting in devastating high-velocity injuries.⁴ According to the Joint Theater Trauma Registry, the most common site of facial soft-tissue injury was the face/cheek (48% of cases), with the most common fracture site being the maxilla (25.5% of cases).³ This is similar to rates of civilian midface

trauma, which accounts for approximately 70% of all maxillofacial injuries.^{4,5} However, because of the high-energy nature of IED-related injuries, the majority of midface injuries include both bony and soft-tissue trauma, and are typically more extensive than civilian midface trauma. It is imperative for the deployed otolaryngologist to have an understanding of the anatomy, pathophysiology, evaluation, and management of midface trauma to mitigate the effects of injury and maximize functional and cosmetic outcomes.

ANATOMY

The middle third of the face, or the midface, can be conceptualized as a system of linked vertical and horizontal buttresses, designed to bear the physiological forces of mastication. These buttress systems surround and protect the orbits, oral and nasal cavities, and paranasal sinuses. Additionally, these buttresses maintain the height, width, and anteroposterior projection of the middle third of the face.⁶⁻⁸ The vertical buttress system is formed by three paired vertical structures running from the alveolar process to the base of the skull. An-

teriorly, the nasomaxillary (NM) buttress runs from the premaxilla to the maxillary process of the frontal bone. Laterally, the zygomaticomaxillary (ZM) buttress runs from the maxilla to the zygomatic process of the frontal bone. Posteriorly, the pterygomaxillary buttress runs from the maxillary tuberosity to the sphenoid portion of the frontal bone via the pterygoid plates (Figure 25-1). The ZM buttress is largely comprised of the zygoma that serves not only as the cornerstone of the buttress

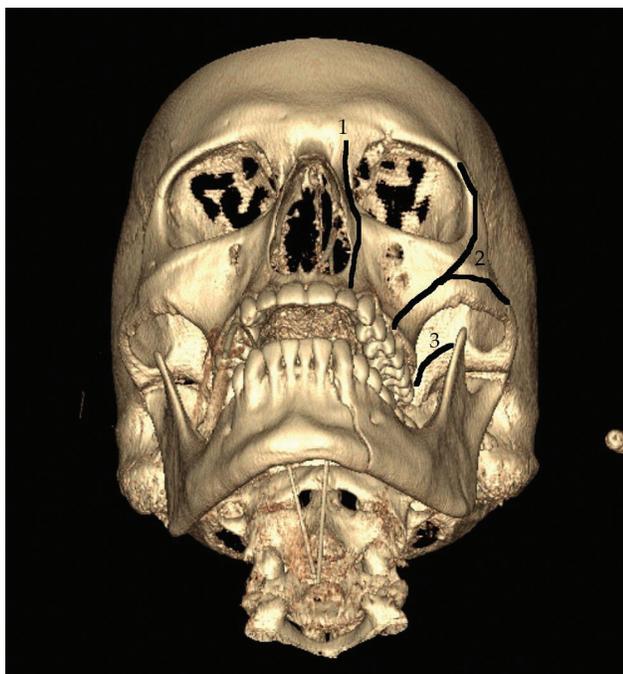


Figure 25-1. Vertical buttresses of the face. Nasomaxillary buttress (1), zygomaticomaxillary buttress (2), and pterygomaxillary buttress (3).

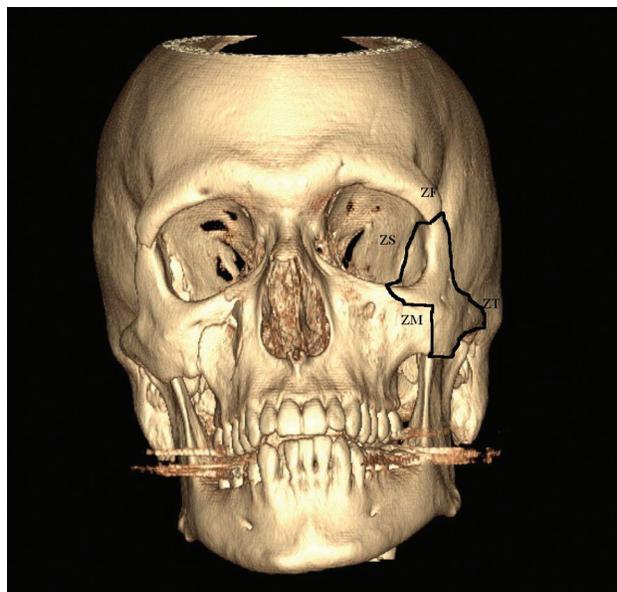


Figure 25-2. Anatomy of the zygomaticomaxillary (ZM) complex. The zygoma has four critical articulations with the surround facial skeleton: (1) articulation with the frontal bone at the zygomaticofrontal (ZF) suture, (2) articulation with the maxillary bone at the zygomaticomaxillary suture, (3) articulation with the temporal bone at the zygomaticotemporal (ZT) suture, and (4) articulation with the sphenoid bone at the zygomaticosphenoid (ZS) suture.

system, but also provides an important landmark for midface projection—the malar eminence.^{7,9} The vertical buttresses tend to be stronger than the horizontal buttresses.⁴

The zygoma is central to normal malar/midface projection, with the malar eminence being the most anterior projection of the lateral face.^{4,9} The thick bone of the zygoma makes this the cornerstone of the vertical buttress system and provides support to the other facial bones.¹⁰ Precise restoration of this segment is essential to successful management of midface fractures.⁷ The zygoma has four critical articulations that surround the facial skeleton:

1. articulation with the frontal bone at the zygomaticofrontal (ZF) suture;

2. articulation with the maxillary bone at the ZM suture;
3. articulation with the temporal bone at the zygomaticotemporal (ZT) suture; and
4. articulation with the sphenoid bone at the zygomaticosphenoid (ZS) suture (Figure 25-2).^{4,9}

The horizontal buttress system is comprised of the superior orbital rims, infraorbital rims, maxillary alveolus and palate, zygomatic arch, and pterygoid plates. It should be noted that the pterygoid plates are important in both the vertical and horizontal buttress systems.^{7,9} Additionally, the 45-degree angle between the skull base and the maxilla acts as a supplemental horizontal buttress by resisting horizontal compressive forces.¹¹

PATHOPHYSIOLOGY

The degree of fractures, fracture patterns, amount of displacement, and amount of soft-tissue injury are determined by the interaction of the following six factors:

1. the inherent rigidity (or limited elasticity) of the facial bones;
2. the amount of force related to the velocity of the head, traumatic agent, or combination of both;
3. the ability of the neck to bend and help absorb momentum;
4. the direction and duration of the applied force;
5. the point of impact; and
6. the mass of the impacting agent.⁷

Forces applied to the midface skeleton result in fractures that can be classified as simple nasal fractures, nasoorbitoethmoid (NOE) fractures, ZM complex (ZMC) fractures, and Le Fort fractures. With the exception of the simple nasal fracture, all of these fracture types disrupt the vertical buttress system. Regardless of the mechanism of injury or amount of comminution or displacement of fractures, the ZF suture is the strongest articulation of the zygoma to the facial skeleton. Thus, there is often a clean separation at the ZF suture, allowing this point to serve as an important landmark for resuspension of the midface.^{4,7} The underlying goal of surgical treatment is restoration of the normal relationship of the disrupted buttresses to the skull base.⁴ NOE fractures are discussed in Chapter 24, Orbital Trauma and Nasoethmoid Fractures. Additionally, associated fractures of the hard palate occur in 15% to 46% of

patients with Le Fort fractures and represent a special situation requiring the surgeon's attention when treating midface fractures.^{12,13}

The prominence of the nasoseptal complex results in frequent nasoseptal complex fractures.⁴ These can occur in isolation or frequently as part of more complex maxillofacial injuries. The most important consideration in the setting of midface trauma (omitting NOE fractures from this discussion) is early identification of septal hematomas. Blood trapped between the septal mucoperichondrium and the underlying septal cartilage can compromise the blood flow to the cartilage, leading to chondronecrosis. This may result in infection and/or a saddle nose deformity. For this reason, septal hematomas must be recognized and evacuated in a timely fashion.

The prominent position of the zygoma and malar eminence makes the zygoma particularly susceptible to trauma. Although the central portion of the zygoma is thick and sturdy, the articulations of the zygoma with the ZM, ZT, and ZS sutures are relatively weak and susceptible to fracture, with the ZF suture being the most stable. Fractures of the zygoma typically result in fractures along these suture lines. Although traditionally referred to as a "tripod" fracture (ZF, ZM, and ZT fractures), this term should be avoided because it fails to take into account the ZS suture and its associated fracture. In fact, a ZMC fracture demonstrates five distinct fractures:

1. lateral orbital wall,
2. orbital floor,
3. anterior maxillary wall,
4. lateral maxillary wall, and
5. zygomatic arch.

ZMC fractures can range from nondisplaced, isolated zygomatic arch fractures to severe fracture dislocations of the zygoma and surrounding bones.^{4,9}

More than 100 years ago, René Le Fort observed that blunt facial trauma tends to result in three predictable patterns of fractures along inherent weaknesses in the facial skeleton. These fractures, collectively termed Le Fort I, II, and III fractures, have in common disruption of the pterygomaxillary buttress.^{4,9}

- *Le Fort I* fractures involve a horizontal fracture through the maxilla and piriform aperture above the maxillary dentition. Fractured bones may include the nasal septum, inferior portion of the piriform aperture, canine fossae, and both ZM buttresses.
- *Le Fort II* fractures are pyramidal-shaped and involve the nasofrontal junction, medial orbital wall, orbital floor, infraorbital rim, and ZM suture line.
- *Le Fort III* fractures can be classified as craniofacial dissociation, resulting in separation of the facial bones from the cranial base through the nasofrontal and ZF suture lines. In addition, Le Fort III fractures involve both the medial and lateral orbital walls, as well as the zygomatic arch.^{4,8,9}

Although the conditions used to originally describe Le Fort fractures (low-energy blunt trauma in cadavers) do not accurately represent the types of high-energy injuries seen in modern military or civilian trauma, the classification system is still useful as a framework to describe patterns of midface injuries and provide a common language of communication between physicians. Pure Le Fort injuries are rare and are usually found along a spectrum of injury that may have combinations of different fracture patterns.

Palatal fractures or fractures of the dentoalveolar unit deserve special mention. As previously stated, these fractures occur in up to 46% of patients with Le Fort type injuries.¹² These fractures are typically longitudinal and parasagittally oriented, because this area represents an area of weaker bone in the hard palate. Typically, these fractures will exit between the central incisors or more laterally between the lateral incisor and canine tooth, resulting in anterior, lateral, and buccal displacements of the fractured segment. Fractures can also occur more laterally through the maxillary tuberosity. Although rare, transverse palatal fractures can also occur.^{14(pp121-122)} Reconstitution of normal midface projection requires restoration of normal occlusion. Identification and proper reduction of palatal fractures are essential in optimizing functional outcomes.

EVALUATION

As with any traumatic injury, basic primary and secondary trauma assessments need to be performed, with management of the airway and control of hemorrhage paramount. These important steps in the management of maxillofacial trauma are covered in earlier chapters. For the purposes of this chapter, one can assume that the proper initial management of the trauma patient has occurred. Additionally, significant closed or open cranial injuries can occur with midface trauma and need to be evaluated. This is especially true with the types of injuries seen on the battlefield. Close collaboration with neurosurgeons is essential in the evaluation and management of these patients.

Fine-cut, noncontrast axial and coronal computed tomography (CT) scanning is the mainstay of radiographic evaluation of midface fractures.^{4,7} Views should be obtained in both bony and soft-tissue algorithms to assess the both the bony and soft-tissue components of injury, as well as to give the surgeon an idea of the amount of soft-tissue loss and/or swelling present. Careful evaluation of the relationship of the vertical buttresses to the skull base should be made, as well as the extent of comminution, displacement, and rotation of fracture segments. The pull of the masseter

muscle oftentimes will result in downward rotational deformity of zygomatic fractures and should be recognized preoperatively.⁴ Identification of the extent of injury will help with the preoperative planning of surgical approaches and exposure. Additionally, the use of three-dimensional reformatting of fine-cut CT scans provides information regarding the facial width, height, and projection of the facial skeleton and the impact of fractures in a way that is often not appreciated on plain axial and coronal images.⁴ Three-dimensional imaging should be used whenever possible as part of the preoperative evaluation. Fortunately, the ability to obtain three-dimensional rendering is generally available at most in-theater hospitals.

Evaluation of the extent of orbital injury is essential for proper preoperative planning, and helps to identify the need for orbital exploration. Although full discussion of orbital fractures is covered in Chapter 24, it is nevertheless important to realize the common occurrence of orbital fractures with ZMC and Le Fort type injuries. With these fractures, displacement of both the lateral and inferior orbital walls can occur, leading to increased orbital volume and postoperative enophthalmos and/or diplopia if not adequately

reduced. Another common finding is displacement and/or entrapment of orbital contents, particularly the inferior rectus muscle, into the sinus cavity. Additionally, because the lateral canthal ligament inserts approximately 1 cm below the ZF suture line, inferior displacement of the zygoma can result in rounding and downward sloping of the lateral canthus if not adequately reduced. Therefore, reduction of fractures and restoration of pretraumatic orbital volume are the primary goals of ZMC fracture repair.^{4,9} CT scanning has been found to be highly reliable in determining preoperatively which orbits need exploration. Radiographic criteria indicating a need for orbital exploration include severe comminution or displacement of the orbital rim, >50% displacement of the orbital floor, prolapse of the orbital contents into the sinus cavity, an orbital floor fracture >2 cm², or combination of inferior and medial orbital wall fractures.^{15,16}

Careful examination of the orbital apex is necessary, as well as in cases of high-energy midface trauma. Oftentimes, fracture lines will traverse the orbital apex and may be in close approximation to the carotid canal. Disimpaction of fractured bone segments in these

cases often requires substantial force by the surgeon. Knowledge of involvement of the orbital apex will alert the surgeon to the potential for cerebrospinal fluid leak, optic nerve injury, or carotid injury with vigorous disimpaction and allow modification of the surgical technique in these cases.¹⁷

Given the amount of energy required to cause ZMC and Le Fort type injuries, it is critical to carefully evaluate the patient for associated intracranial injuries. This includes intracranial hemorrhage, injury to brain parenchyma, and skull base injury that may predispose the patient to cerebrospinal fluid leak.⁴ Furthermore, there is a high risk of cerebrovascular injury associated with Le Fort injuries, such as internal carotid artery dissection or pseudoaneurysm. CT angiography is indicated in these cases to rule out these life-threatening injuries.^{18,19}

As previously discussed, careful attention to the hard palate is necessary to document the presence of associated palatal fractures. Failure to properly identify and reduce a palatal fracture prior to fixation will result in functional deficits caused by malocclusion, as well as cosmetic deficits caused by flattening of the midface.

TREATMENT

It became evident early during the conflict in Iraq that in-theater repair of facial fractures did not compromise the outcome of repair or increase the infection rates in these patients. Lopez et al²⁰ established good guidelines for in-theater repair:

- fracture sites exposed through an adjacent soft-tissue injury or adjacent surgical approach,
- treatment does not delay evacuation from theater, and
- treatment would allow the service member to remain in theater.

One must keep in mind that in today's conflicts, deployed otolaryngologists will find themselves caring for a large number of civilians and coalition forces. The same standards of care applied to US service members need to be applied in the care of these patients.

Patients may arrive from the battlefield with a tracheostomy or cricothyrotomy in place. In patients with a cricothyrotomy, they should be converted to a standard tracheostomy. In patients with isolated midface fractures, standard orotracheal or nasotracheal intubation is indicated. If there is suspected skull base trauma, care needs to be taken to prevent further injury or inadvertent insertion of the endotracheal tube through the defect. Patients with massive midface

injuries, associated open skull injuries or intracranial injuries, or massive polytrauma should almost always have their airways secured by tracheostomy. (See Chapter 12, Airway Management.)

The overall goal of treatment is restoration of the three-dimensional form and function of the facial skeleton: the occlusion, facial projection, and facial height.^{7,9} To achieve this goal, reestablishment of the preinjury occlusion is key, as is restoration of the position of the zygoma.^{7,14} Failure to restore proper occlusion will result in postoperative malocclusion, oftentimes as an anterior open bite deformity.¹⁴ In cases with a stable mandible, or uncomplicated mandibular fractures, initial placement of maxillomandibular fixation, either with standard arch bars or four-point fixation, should be performed. This reestablishes normal occlusion and provides a stable foundation from which to realign the midface buttresses. Keep in mind that placement of maxillomandibular fixation does not necessarily completely reduce and/or stabilize palatal fractures, nor does it completely reduce impacted segments of midface fractures. The surgeon must pay particular attention to adequate disimpaction of fracture segments, as well as reestablishment of the palatal arch to ensure accurate fracture reduction prior to fixation. If this is not done, the overall cosmetic and functional results will be compromised.

In cases of severe mandibular injury (severe comminution, missing bone), which is not uncommon in battlefield injuries, adequate establishment of preinjury occlusion may not be possible with maxillomandibular fixation. In these cases, placement of an external fixation device on the remaining mandibular segments can be used (see Chapter 26, Mandible Fractures) or can reestablish the mandibular arch and allow fracture reduction and realignment. In cases where adequate maxillomandibular fixation cannot be obtained, the ZF suture line is often a good point of reference for resuspension of the midface fractures. As the strongest point of the midface skeleton, the ZF suture line is commonly cleanly fractured, allowing easy and accurate reduction, or intact/greenstick fractured, even in cases of significant midface/panfacial trauma.^{4,7}

Oftentimes, palatal fractures will be reduced with maxillomandibular fixation. It is important to ensure that the palatal fractures are reduced anteriorly, as well as posteriorly, to restore the palatal arch and to ensure normal postoperative occlusion. Reduction of the palatal fractures should occur prior to plating of the buttresses to restore the maxillary arch and maxillary width. If overtightening of the maxillomandibular fixation wires is required to reduce the palatal fractures, the maxillary teeth will likely be lingually canted, resulting in a cross-bite deformity. In these cases, placement of transosseous wires or miniplates placed across the palatal fractures (through incisions made in the palatal mucosa) will adequately reduce the palatal fractures without overtightening of the maxillomandibular fixation wires.^{7,14} Other methods to reduce palatal fractures include the use of palatal splints, although the materials necessary for fabrication of a palatal splint may not be available in theater. Additionally, if the surgeon lacks the experience of creating a palatal splint, it will be better to use plates or wires so as not to compromise the reduction of the fracture with a poorly made or improperly placed splint.

Prior to reduction and fixation of fracture segments, the fractures must be adequately exposed. Exposure of fractures will sometimes be afforded the surgeon by way of preexisting soft-tissue injuries or incisions made for other procedures (most commonly a craniotomy). Every attempt should be made to utilize any preexisting incisions or injuries to minimize unnecessary incisions and improve the overall efficiency of the surgery. In cases where existing soft-tissue injuries do not provide adequate access, standard gingivobuccal sulcus incisions allow adequate exposure of all four (left and right NM and left and right ZM) anterior buttresses.¹⁴ Care should be taken to leave enough of a mucosal cuff (2–4 mm) along the alveolus to allow closure of the incisions after fracture fixation. Failure to leave an adequate

mucosal cuff results in retraction of the mucosa along the incision line and can complicate closure. In cases where the traumatic event does not allow creation of this mucosal cuff, closure can be obtained by suturing around the teeth. Exposure of the periorbital bones can be obtained via subciliary, transconjunctival, lateral canthotomy/cantholysis, and brow approaches.¹⁴ Full exposure of the zygomatic arch, especially the ZT suture line may require a hemicoronal or preauricular incision for adequate exposure.

After adequate exposure is obtained, all impacted segments need to be disimpacted to allow proper realignment and fixation. This can be accomplished with disimpaction forceps or commercially available disimpaction devices. Once fragments have been disimpacted, proper reduction and alignment of the fracture segments can proceed. Initial attention should focus on restoration of the proper orientation of the zygoma because it is central to normal facial projection and maintenance of proper facial width. Initial reduction at the ZF suture line provides a reliable starting point for resuspending the facial skeleton and restoring proper vertical height. Furthermore, the ZF suture is the strongest point for stabilization of the midface.^{7,14} Fixation of the ZF suture is easily accomplished with 1.3 or 1.5 mm plates. The use of larger plates is not required in this location and can often result in the reconstruction plates being conspicuous under the relatively thin skin in this location. In order to ensure proper midface projection, at this point, the author prefers to assess the reduction and position of the zygomatic arch. Failure to properly reduce the arch will result in a loss of facial projection and malar flattening. It may not be necessary to fixate arch fractures; however, if the arch is comminuted or is unstable after reduction, it should be plated. Because this is not a load-bearing bone, use of smaller plates is indicated and will reduce the incidence of plate prominence through the skin. The surgeon should remember that the midpoint of the zygomatic arch is actually straight and needs to be reconstructed in this manner to restore proper midface projection.⁷ Once proper arch position is established, reduction and fixation of any malar/orbital rim fractures give stability to the reconstruction and helps to reestablish midface width and projection. Failure to properly reduce these fractures results in a flattened, widened midface.⁷

The question of orbital exploration often arises in the treatment of midface fractures. Enophthalmos is the most significant complication of inadequate reduction of orbital fractures (see Chapter 24, Orbital Trauma and Nasoethmoid Fractures for a thorough discussion of orbital fractures).⁴ Preoperatively, radiological criteria exist to guide the surgeon in making this decision. Severe comminution or displacement of the orbital rim,

prolapse of orbital contents, >50% displacement of the orbital floor, floor fractures >2 cm², or the combination of medial and orbital floor fractures are considered radiological indications for orbital exploration.⁹ However, even without these radiological findings, impaction of fracture segments can mask the full extent of orbital fractures. Reduction of these fractures then results in a much larger floor defect than may have been appreciated. In the author's opinion, if there is any question of the extent of an orbital floor fracture, or the stability of the orbital floor, the orbit needs to be explored. This can be done endoscopically through defects in the antral wall or via standard approaches. The risks of postoperative enophthalmos far outweigh the risks of orbital exploration at the time of fracture reduction.

At this point, fixation of the ZM and NM buttresses restores the vertical height of the midface. The ZM buttress is more stable and more important in reestablishing the vertical height of the midface than the NM buttress.^{7,14} In cases of severe comminution or loss of bone of the ZM and NM buttresses, bone grafting may be necessary. Reconstruction plates and screws (including mesh plates) are not designed to bear the

loading forces of mastication and will fail over time without good bone-to-bone contact.^{7,14} This may result in postoperative malocclusion, loss of midface width, and loss of midface height. As a general rule, gaps >5 mm should be bone grafted to ensure the stability of the repair.¹⁴ It is not uncommon during the initial treatment of battlefield craniofacial injuries that a concomitant craniotomy is performed. The inner table of the cranial flap provides an excellent bone source for grafting of midface defects, provides a large amount of bone, and does not require additional incisions or an additional harvest site. Split calvarial bone grafts are also useful in the repair of orbital bone defects. The iliac crest provides another excellent source of bone. However, the iliac crest may not be available in cases of severe polytrauma involving the limbs.

A short comment on concomitant soft-tissue injuries. Battlefield trauma often involves not only severely comminuted craniofacial fractures, but also substantial loss of overlying soft tissue. Soft-tissue injuries and treatment are covered elsewhere in this book; however, the surgeon must keep in mind that the underlying bony construct must have adequate, well-vascularized soft-tissue covering for ultimate success.

SUMMARY

In general, the same standard guidelines for the management of midface trauma seen in the civilian setting hold true for the management of midface trauma seen in the wartime setting. It is important to remember, however, that the injuries seen in war tend to be larger, more complex, and have a higher incidence of concomitant intracranial or open cranial injuries, orbital injuries, soft-tissue loss, and polytrauma that can complicate and possibly delay treatment of the fractures.

Key points that the surgeon should remember include the following:

- Preoperative evaluation should include three-dimensional CT rendering of the injury to provide a better assessment of the fractures.
- Careful evaluation of preoperative imaging is required to look for associated orbital and

intracranial injuries to include vascular injuries and palatal injuries.

- Initial establishment of preinjury occlusion is essential and may require proper reduction of palatal fractures to reestablish the maxillary dental arch.
- Prior to plating of the vertical buttresses, the ZT suture and proper reduction of any zygomatic arch fractures are required to reestablish the width and projection of the midface. Plating of the vertical buttresses first will result in posterior displacement of the vertical buttresses and midface flattening.
- Bony loss of >5 mm will require bone grafting because the rigid plates and screws will not support the forces of mastication and will fail over time, thus compromising the functional and cosmetic results of repair.^{4,7,9,10,12,14,17,18}

CASE PRESENTATIONS

Case Study 25-1

Presentation

A 23-year-old US forces male was injured by an IED that struck his vehicle while on patrol outside of Baghdad, Iraq, in September 2009. He arrived at the emergency

department in Balad, Iraq, intubated and unresponsive. Vital signs were stable upon arrival. Physical examination demonstrated significant right-sided midface bony and soft-tissue injuries, with an obvious fragmentary injury to the right temporoparietal scalp, as well as multiple contusions and lacerations to the head and neck. Trauma resuscitation began in the emergency department.

Preoperative Workup/Radiology

Fine-cut facial and head CT were performed, demonstrating significant midface, orbital, and intracranial injuries, from both the blast and fragmentary injury. Injuries included a large subdural hematoma, a comminuted right ZMC fracture with extensive comminution of the malar eminence and orbital rim, lateral and inferior orbital wall fractures, and a large metal fragment lodged in the right orbit. CT angiography did not demonstrate any major intra- or extracranial vascular injuries.

Operative Planning/Timing of Surgery

The presence of a large, expanding intracranial hemorrhage necessitated immediate neurosurgical intervention and craniotomy. Management of the midface fractures occurred after initial neurosurgical treatment and stabilization.

Operation

Initial management involved a large craniotomy with control of intracranial hemorrhage and removal of intracranial fragments in conjunction with neurosurgery. The midface fractures were then exposed, revealing loss of bone of the lateral and inferior orbital walls, as well as loss of some malar bone. Split calvarial bone grafts were obtained from the inner table of the cranial bone flap (Figure 25-3). The metal fragment was carefully removed from the right orbit, and the globe



Figure 25-3. Split calvarial bone grafts. Split calvarial bone grafts can often be obtained during in-theater fracture fixation from the cranial bone flaps done during craniotomy procedures. This bone is sturdy and well suited for grafting areas of bone loss in the midface and orbit.

was preserved. The fractures were then reduced and rigidly fixated, with bone grafts used in the orbital floor, lateral orbital wall, and ZM buttress. The comminuted nature of the fractures involving the lateral orbital wall were secured with a combination of plates and wires because the small bone fragments would not allow for rigid screw fixation (Figure 25-4). Because of a delay in evacuation, a postoperative scan was obtained to evaluate the intracranial injury. Scans revealed that the right ZT suture and a posterior zygomatic arch fracture were inadequately reduced, causing widening of the midface. This required secondary reconstruction stateside (Figure 25-5).

Complications

There was inadequate reduction of the right ZT suture and posterior zygomatic arch fracture, resulting in midface widening and decreased projection. This required secondary reconstruction stateside.

Lessons Learned

This case illustrates several important points. First and foremost, failure of adequate identification and reduction of the ZT suture and zygomatic arch resulted in flaring and widening of the midface and required a secondary reconstruction. It cannot be overstressed the importance of properly identifying and reducing the ZT suture in order to properly reestablish midface width and projection prior to securing the ZM and NM buttresses. Second, this case illustrates the ease and utility of cranial bone grafts in stabilizing fractures in cases of bone loss. Third, in cases of severely comminuted fractures, the small bone fragments may not accept screw fixation. In these cases, it is often possible to use transosseous wires to secure the bony fragments in place to an overlying rigid plate. Finally, this case illustrates the frequency of concomitant orbital and cranial injuries that occur with the midface injuries seen in wartime.

Case Study 25-2

Presentation

A dismounted 32-year-old Iraqi Forces soldier was injured by an IED blast while on patrol in Balad, Iraq, in May 2009. He presented with a massive left midface bony and soft-tissue injury, as well as an orbital fracture. He suffered loss of the majority of the ZM buttress and malar eminence. His injuries were initially repaired using rigid fixation; however, the loss of bone was not addressed (Figure 25-6). He returned several months after his initial injury with cosmetic concerns.

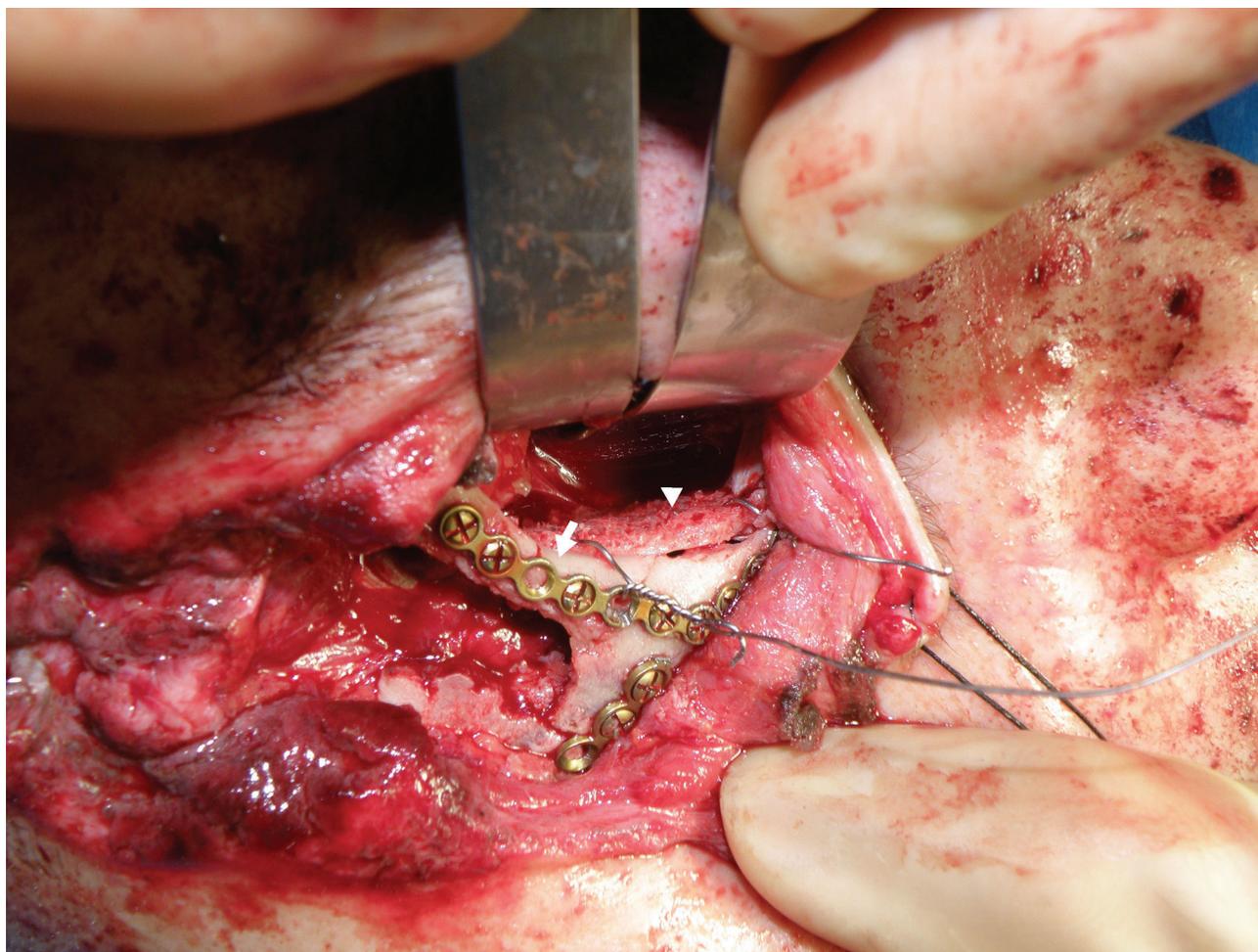


Figure 25-4. Wire reduction of comminuted bone fragments. This photo demonstrates the combined approach of rigid screw and plate fixation combined with wire fixation of comminuted lateral orbital rim fragments (*arrow*), as well as split calvarial bone grafts to the lateral orbital wall (*arrowhead*).

Examination demonstrated collapse of the midface soft tissues over the injury site, as well as flattening of the midface and loss of midface height (Figure 25-7).

Preoperative Workup/Radiology

Three-dimensional CT revealed near total loss of the left malar eminence and ZM buttress system. The zygoma, alveolar ridge, and lateral and infraorbital rims were in good position (see Figure 25-6).

Operative Planning/Timing of Surgery

As this was essentially a secondary cosmetic repair, surgery was scheduled on a routine basis. The reconstructive procedure occurred in October 2009, approximately 5 months after his initial injury and repair.

Operation

The patient subsequently underwent repositioning and bone grafting of the left midface defect using an iliac crest free bone graft (Figure 25-8). The approach was made through the scar left from his initial injury, and at the same time a scar revision was performed. Repair restored the proper midface height and volume, and greatly reduced the volume loss of the midface (Figure 25-9).

Complications

None.

Lessons Learned

This case illustrates what happens in cases of bone loss that is not repaired. The overlying soft-

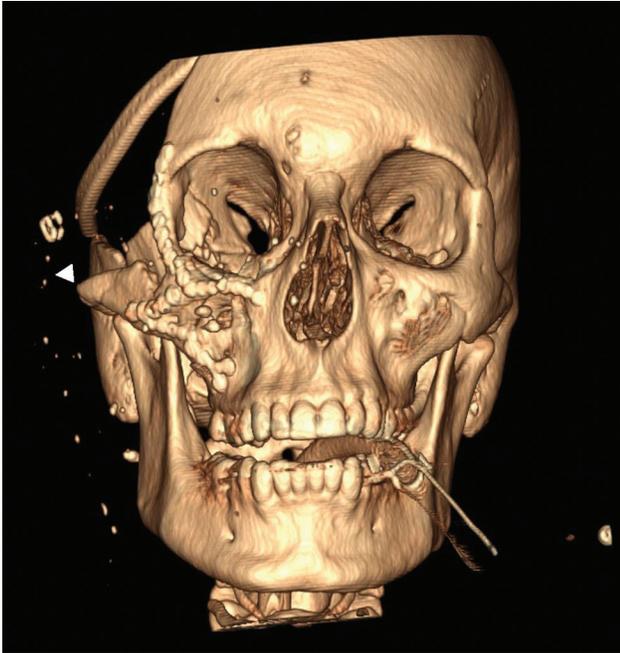


Figure 25-5. Midface widening and flattening. This photo demonstrates a suboptimal result due to inadequate fracture reduction at the zygomaticotemporal suture line and failure to adequately address a zygomatic arch fracture (*arrowhead*).

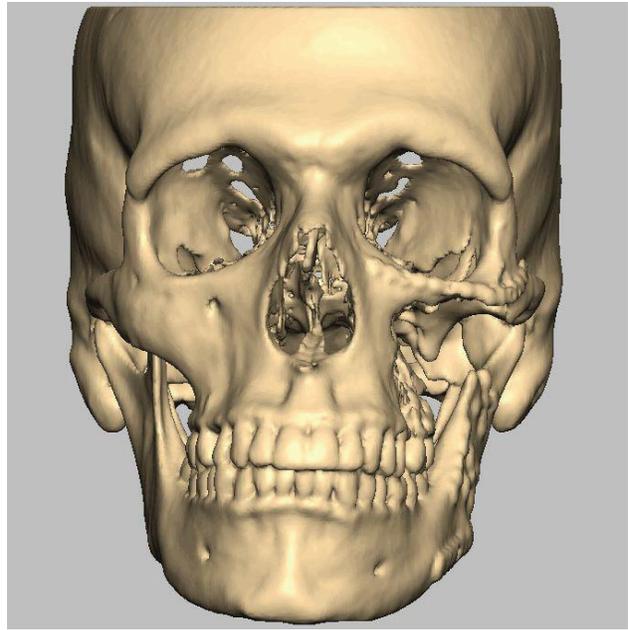


Figure 25-6. Repair of midface fracture without addressing bone loss. Note the significant loss of bone at the malar eminence and zygomaticomaxillary buttress.



Figure 25-7. Loss of midface projection and height. Note the loss of projection of the midface secondary to loss of bone at the malar eminence and zygomaticomaxillary buttress.

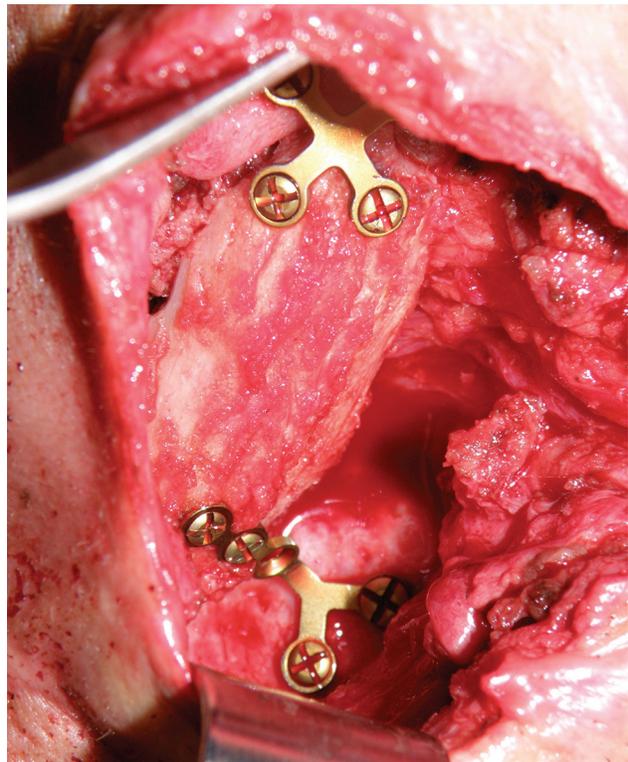


Figure 25-8. Use of iliac crest bone graft. Demonstration of the use of an iliac crest bone graft to restore bone lost at the zygomaticomaxillary buttress and malar eminence.

tissue envelope will invariably scar into the defect, resulting in substantial volume loss and cosmetic deformity. Over time, the soft-tissue envelope will also contract, making subsequent attempts at secondary reconstruction more difficult. Additionally, the loss of bone at the ZM suture in this case resulted in loss of midface height and projection because the remaining zygomatic arch became posteriorly and inferiorly displaced.

Case Study 25-3

Presentation

A 20-year-old US soldier was injured in a noncombat-related fall, sustaining a right ZMC fracture. Physical examination was remarkable for right periorbital edema only. There was no evidence of entrapment and no visual acuity changes. The patient's occlusion was found to be normal, and there was no apparent cosmetic deformity.

Preoperative Workup/Radiology

Fine-cut facial CT revealed right maxillary mucosal thickening with no apparent bony deformity and no evidence of orbital herniation into the maxillary sinus. Subsequent three-dimensional rendering revealed a



Figure 25-9. Postoperative view. Note the improved midface projection after iliac crest bone grafting. Contracture of the overlying soft-tissue envelope limited the overall cosmetic result.

significant orbital rim step-off and flattening of the malar eminence (Figure 25-10).

Operative Planning/Timing of Surgery

Because of a lack of other significant injuries, this patient was managed similar to standard civilian

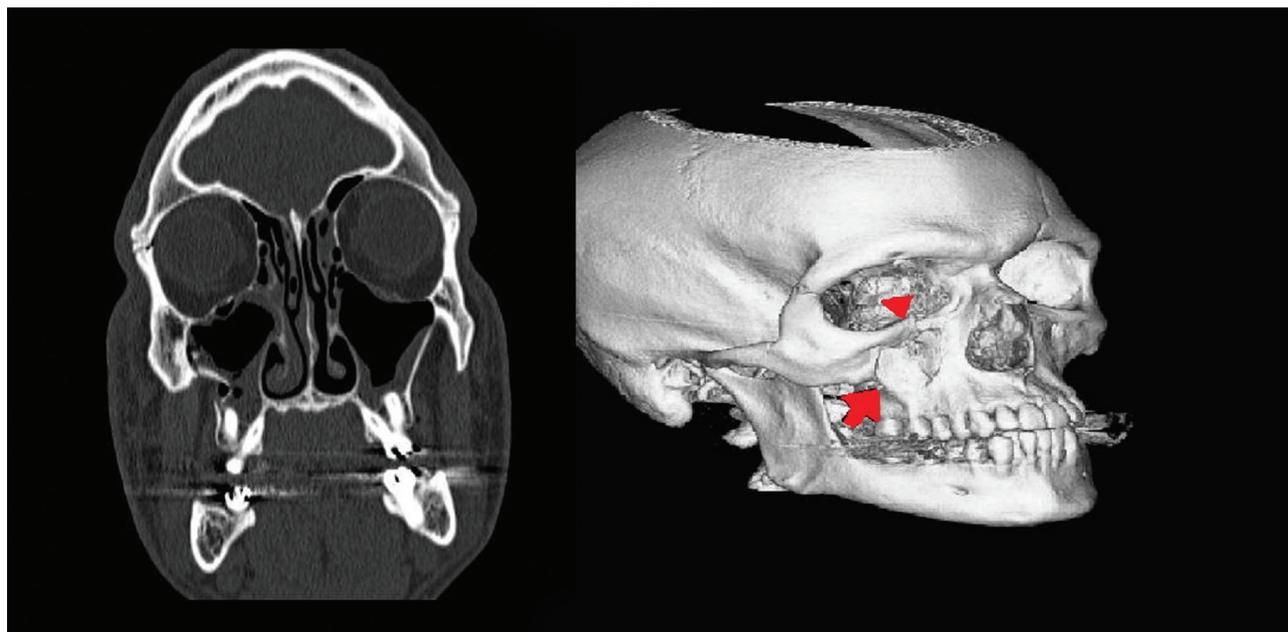


Figure 25-10. Three-dimensional CT (computed tomography) scan. This illustrates the improved detail afforded with three-dimensional imaging. The three-dimensional image demonstrates the significant zygomaticomaxillary buttress fracture (*arrow*) and orbital rim fracture (*arrowhead*) much clearer than the coronal CT scan.

practices. Surgery was performed approximately 12 hours after the initial injury.

Operation

The patient subsequently underwent uncomplicated open reduction and internal fixation of his fractures. Approach was made through a combined lateral canthotomy/cantholysis and sublabial approach. Because of the bony step-off of the infraorbital rim, as well as the associated floor fracture, orbital exploration was performed. The floor was fractured, but well reduced and stable; no orbital floor implants were needed. The patient was subsequently returned to duty 2 weeks after his injury. He did not require evacuation from theater.

Complications

None.

Lessons Learned

This is an illustration of the improved information provided by three-dimensional imaging of midface fractures. This patient could easily have been managed nonoperatively based on the standard CT images. However, the three-dimensional imaging demonstrated a fracture pattern that, if left untreated, would have resulted in a significant cosmetic deformity. Additionally, this case reinforces the findings of Lopez et al²⁰ that plating of fractures in theater is feasible in select cases and improves the return-to-duty rate in theater.

REFERENCES

1. Owen BD, Kragh JF, Wenke JC, Macaitis J, Wade CE, Holcomb JB. Combat wounds in Operation Iraqi Freedom and Operation Enduring Freedom. *J Trauma*. 2008;64:295–299.
2. Lew TA, Walker JA, Wenke JC, Blackburne LH, Hale RG. Characterization of craniomaxillofacial battle injuries sustained by United States service members in the current conflicts in Iraq and Afghanistan. *J Oral Maxillofac Surg*. 2010;68:3–7.
3. Feldt BA, Salinas NL, Rasmussen TE, Brennan J. The Joint Facial and Invasive Neck Trauma (J-FAINT) Project, Iraq and Afghanistan 2003–2011. *Otolaryngol Head Neck Surg*. 2013;148:403–408.
4. Kim JJ, Huoh K. Maxillofacial (midface) fractures. *Neuroimag Clin North Am*. 2010;20:581–596.
5. Ramasamy A, Hill AM, Clasper JC. Improvised explosive devices: pathophysiology, injury profiles and current medical management. *J R Army Med Corps*. 2009;155:265–272.
6. Sturla F, Abnsi D, Bunquet J. Anatomic and mechanical considerations of craniofacial fractures: an experimental study. *Plast Reconstr Surg*. 1980;66:815–820.
7. Stanley RB. Buttress fixation with plates. *Oper Tech Otolaryngol-Head Neck Surg*. 1995;6:97–103.
8. Linnau K, Stanley R, Hallam D, et al. Imaging of high-energy midfacial trauma: what surgeons need to know. *Eur J Radiol*. 2003;48:17–32.
9. Frailoli RE, Branstetter IV BF, Deleyiannis FW. Facial fractures: beyond Le Fort. *Otolaryngol Clin North Am*. 2008;41:51–76.
10. Stanley RB. The zygomatic arch as a guide to reconstruction of comminuted malar fractures. *Arch Otolaryngol Head Neck Surg*. 1989;115:1459–1462.
11. Rowe NC, Killey H. *Fractures of the Facial Skeleton*. Baltimore, MD: Williams & Wilkins; 1955: 205–233.
12. Manson PN, Shack RB, Leonard LG, et al. Sagittal fractures of the maxilla and palate. *Plast Reconstr Surg*. 1983;72:484–488.
13. Chen CH. A 162-case review of palatal fracture: management strategy from a 10-year experience. *Plast Reconstr Surg*. 2008;121:2065–2073.
14. Prein J, ed. *Manual of Internal Fixation in the Cranio-Facial Skeleton*. New York, NY: Springer; 1998: 115–116, 121–122, 134, 135.

15. Shumrick KA, Kersten RC, Kulwin DR, et al. Criteria for selective management of the orbital rim and floor in zygomatic complex and midface fractures. *Arch Otolaryngol Head Neck Surg.* 1997;123:378–384.
16. Ellis E, Reddy L. Status of the internal orbit after reduction of zygomaticomaxillary complex fractures. *J Oral Maxillofac Surg.* 2004;62:275–283.
17. Linnau KF, Hallam DK, Lomoschitz FM, et al. Orbital apex injury: trauma at the junction between the face and the cranium. *Eur J Radiol.* 2003;48:5–16.
18. Cothren CC, Moore EE, Ray CE, et al. Screening for blunt cerebrovascular injuries is cost-effective. *Am J Surg.* 2005;190:845–849.
19. Schneiderei NP, Simons R, Nicolaou S, et al. Utility of screening for blunt vascular neck injuries with computed tomographic angiography. *J Trauma.* 2006;60:209–215.
20. Lopez MA, Arnholt JL. Safety of definitive in-theater repair of facial fractures. *Arch Facial Plast Surg.* 2007;9:400–405.

