V. Fractures of the Zygoma

Yadranko Ducic, MD
Department of Otolaryngology
University of Texas Southwestern Medical Center
and John Peter Smith Hospital
Dallas-Fort Worth, Texas

Rick M. Odland, MD, PhD
University of Minnesota
Minneapolis, Minnesota

Introduction

Key Points

Evaluation and treatment of fractures of the zygoma must focus on two major concerns: ocular and cosmetic. As a result of the zygoma's intimate relationship with the orbit, ophthalmologic findings, including classic enophthalmos, are often seen in association with significant zygoma fractures. The body of the zygoma, specifically the malar eminence, represents a key aesthetic highlight of the face, contributing to facial width and projection. As the palate is not displaced in a zygoma fracture, malocclusion is not typically noted. Signs and symptoms of malocclusion, however, can be produced by impingement on the coronoid process of the mandible and by pain and splinting caused by masseter damage at the fracture site.

The treatment of these injuries may be quite simple. If inadequately treated, however, what may appear to be a minor skeletal disruption at the time of initial evaluation can leave the patient with significant aesthetic and functional sequelae. Inadequate fixation of these fractures, which is more likely with closed reduction or non-rigid fixation techniques, often allows for migration and malrotation of the fractured segments. A malpositioned zygomatic complex represents one of the more challenging surgical problems to address secondarily. Therefore, the key to successful primary reconstruction of these fractures is a knowledgeable evaluation of the injury, followed by injury-specific reduction and fracture fixation. With the exception of simple, non-comminuted fractures, treatment usually involves wide surgical exposure of the fracture sites with application of rigid internal fixation devices (miniplates).

Incidence

After nasal and mandible fractures, the zygomatic complex is the most common fracture of the maxillofacial skeleton, being noted in up to 60% of major facial fractures.[1,2] More than 80% of zygoma fractures occur in the young male adult population, predominantly as a result of motor vehicle accidents, assaults, and sports-related injuries.[3] The overall proportion of these injuries caused by motor vehicle accidents has steadily decreased with the more routine availability of air bags, collapsible steering wheels and dashboards, and shoulder seat belts.[2]

Anatomy

The zygomatic bone exists in a complex spatial relationship with the adjacent bones of the midface and the orbit. It consists of a central zygomatic or malar body, from which extend three distinct processes: temporal, orbital, and maxillary.

Body of the Zygoma

The body of the zygoma is variably pneumatized on its medial aspect by the maxillary antrum, and it provides foramina for passage of the zygomaticofacial and zygomaticotemporal nerves, which provide cutaneous sensation to the area over the malar eminence. The natural external convexity of the body of the zygoma produces the malar eminence of the cheek, which determines facial contour.

The body of the zygoma represents the strongest portion of the zygomatic complex. The body of the zygoma forms part of the zygomaticomaxillary (lateral) buttress as it courses from the anterolateral wall of the maxillary antrum, through the body of the zygoma, to end at the zygomatic process of the frontal bone. This buttress, together with the nasomaxillary and pterygomaxillary buttresses, forms a vital structural support of the midface.

Temporal Process (Zygomatic Arch)

The temporal process of the zygomatic bone arises from the posterolateral aspect of the malar body to articulate with the zygomatic process of the temporal bone. This articulation creates the zygomatic arch. The arch provides for the attachment of both the masseter muscle and the two layers of the deep temporal fascia. It is intimately related to vital neurovascular structures in the area: the superficial temporal and the internal maxillary vessels. The frontal branch of the seventh cranial nerve is closely associated with the anterior aspect of the arch. With the temporomandibular joint located posterior to the arch, and the coronoid process of the mandible deep to the arch, arch collapse can lead to significant masticatory problems.

Frontal Process

The frontal process is thick and serrated. It articulates above with the zygomatic process of the frontal bone, and behind with the greater wing of the sphenoid. These surfaces form the lateral orbital wall. About 1 cm below the frontozygomatic suture is Whitnall's tubercle, which is the site of attachment of the lateral canthal tendon.

Maxillary Process

The maxillary process of the zygoma articulates inferomedially with the maxilla, forming part of the anterolateral wall of the maxillary antrum. It also provides an anterior limit to the infratemporal fossa. The maxillary process can be further divided into the orbital projection and the lateral maxillary projection.

Orbital Projection

The orbital surface of the zygoma contributes to the formation of the floor and lateral wall of the orbit via its articulation with the orbital plate of the maxilla. The inferior orbital fissure serves to divide the zygomatic and the maxillary contributions to the orbital floor posterolaterally. The infraorbital nerve traverses the bony canal in the floor of the orbit, medial to the zygomatic contribution to the orbital floor. This nerve supplies sensation to the cheek, lower lid, lateral aspect of the nose, and the upper lip. The orbital floor is weak and unsupported, so its propensity to fracture is not surprising. The importance of the zygoma's orbital contribution lies not only in the support that it provides for the orbital contents, but also the aesthetics of the inferior orbital rim.

Lateral Maxillary Projection

The inferolateral aspect of the maxillary process forms the lateral buttress, which provides the surgeon with a useful guide to proper positioning of the maxillary process and malar prominence. It forms a smooth vertically oriented contour line. The malar prominence normally lies at the intersection of this line with a smooth horizontal arc, arising from lacrimal fossa, running through the body of the zygoma, and ending in the zygomatic arch.[4]

Classification

Clinical Distinctions

Clinically, fractures of the zygoma may be divided into two broad categories: the classic tripod fracture, and the isolated fracture of the zygomatic arch. The term *tripod* refers to the fact that all three articulations of the zygoma (temporal, frontal, and maxillary processes) are fractured in a classic zygoma fracture (Fig 1). Some investigators have used the term *quadripod fracture*, noting the four aspects of a zygoma fracture (temporal and frontal processes, and orbital and lateral projections of the maxillary process). An isolated zygomatic arch fracture involves only the temporal process of the zygoma (and, largely, the zygomatic process of the temporal bone). While the distinction between a tripod fracture and arch fracture is occasionally blurred by novices, these fractures are distinct clinical entities, both in terms of mechanism of injury and complexity of treatment.

Nahum determined the amount of force necessary to fracture various parts of the maxillofacial skeleton.[5] Less force was required to elicit a fracture of the zygomatic arch (average = 1515 newtons) than was required to fracture the sturdier body of the zygoma (average = 2200 newtons). Thus, it is common to see isolated fractures of the arch, usually caused by a lateral blow.

Classification of Zygoma Fractures

Various classification systems have been decribed based on plain facial X-rays,[6] computed tomographic scanning,[7] and emphasizing the importance of the zygomatic arch,[8] but few have come into widespread clinical use. The most widely accepted and clinically useful classification system is the one proposed by Jackson,[9] which divides zygomatic fractures into four groups (Table 1). This system relates the pattern of injury and the magnitude of the force vector to a general approach to treatment.

Principles of Treatment

Tripod fractures must be managed with great attention to ophthalmic and cosmetic issues. Fractures of the zygomatic arch are generally less morbid, but can result in masticatory and cosmetic deficits. Adequate understanding of the anatomy and injury, precise reduction, and secure fixation will allow satisfactory outcomes.
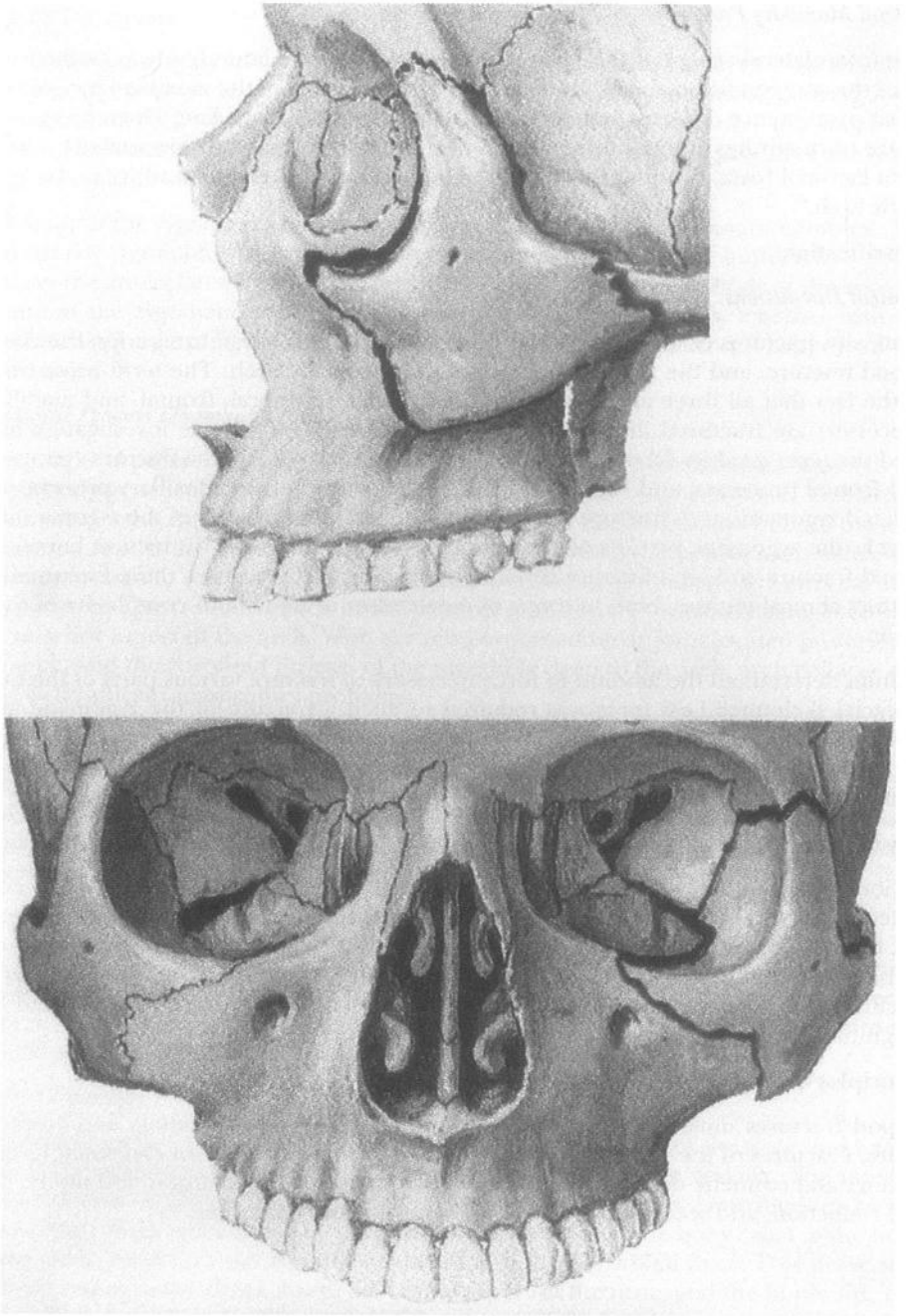
Fig 1.—Drawing of zygomatic complex fracture.

TABLE 1

JACKSON'S CLASSIFICATIONS OF ZYGOMA FRACTURES

Fracture	Treatment
Group 1- Nondisplaced	No treatment required
Group 2- Localized segmental	Require exposure and direct fixation
Group 3- Low-velocity injury causing displaced "tripod" fractures	Require simple elevation or elevation, direct exposure, and rigid fixation
Group 4- High-velocity injury causing displaced comminuted fracture	Require wide surgical exposure and rigid fixation at multiple points

Surgical Approaches

A useful approach to this region is the transoral sublabial approach. Subperiosteal dissection along the anterolateral face of the maxilla allows access to the body of the zygoma with the attached masseter muscle. This approach will also provide the surgeon with the ability to place rigid fixation devices at any fracture segments along the anterolateral face of the maxilla, including the area of the zygomaticomaxillary buttress. The orbital rim can be visualized through the sublabial approach, often allowing placement of a plate transversely across the fracture line. If necessary, direct exposure of the inferior orbital rim and the orbital floor is best achieved via the use of either the subciliary or the transconjunctival approach.

When access to the zygomaticofrontal suture area is needed for the placement of fixation devices, a brow incision was traditionally recommended. The incision must be parallel to the hair roots to avoid alopecia, and the brow should not be shaved. More desirable is to use an upper blepharoplasty type incision that is well camouflaged postoperatively within the upper eyelid sulcus. Care must be taken not to extend this incision laterally to avoid damage to the frontal branch of the facial nerve as it courses along a line drawn from the tragus to approximately 1.5 cm lateral to the brow. There is no cross-innervation of mimetic muscles in the forehead from adjacent branches of the facial nerve.

The bicoronal flap provides the best exposure of the zygomatic arch. Extension of the coronal flap to the preauricular region is often necessary to allow for the complete visualization of the zygomatic arch. This approach is best suited for the repair of complex, comminuted fractures of the zygoma. Accurate comparison and realignment of the two zygomatic arches is quite possible with a bicoronal approach.

Reduction of Impacted and Rotated Fragments

The key to treatment is reduction in three planes. Because of the complex anatomy and the impaction and rotation typical of zygoma fractures, adequate reduction and fixation can be challenging. Consideration of the force of impact can be helpful in visualizing reconstruction.

Disruption of the zygomaticomaxillary buttress as part of a classic zygomatic complex fracture will allow inferomedial rotation of the zygomatic bone. This rotation arises as a result of the release of the bony attachments of the zygoma, with a subsequent unopposed inferomedial pull produced by the powerful masseter muscle. This inferomedial position of the zygoma will often impinge on the coronoid process, leading to trismus. The masseter muscle seems to be the major force maintaining the displacement of a rotated zygomatic fracture.[10]

Miniplate Fixation Versus Interosseous Wiring

Traditionally, two-point wire fixation of tripod fractures has been advocated. However, even well-executed wire fixation may allow postoperative rotation and continued motion at the fracture line. Interosseous wiring remains a worthwhile option in patients with associated comminuted Le Fort fractures with uncertain occlusion. Use of wires and intermaxillary fixation will allow for some settling of the patient's occlusion into a more normal and predictable bite pattern. However, fixation with plates will allow for primary bone healing to take place. Rohrich et al[11] found a significantly lower complication rate and a more accurate globe and cheek position when fractures were fixed with miniplates rather than wires. Therefore, the use of miniplates is recommended in the fixation of most zygomatic fractures.

Two- or Three-Point Fixation

Two-point fixation (zygomaticomaxillary and zygomaticofrontal areas) will provide for enough stability in the majority of these fractures. Although lateral rotation is uncommon, it is best prevented by the addition of the third point of fixation at the level of the inferior orbital rim. Often, a plate can be placed transversely just above the infraorbital nerve through the sublabial incision. Alternatively, because the inferior orbital rim is not a major load-bearing area of the maxillofacial skeleton, wire fixation may be adequate. If there is a bony defect exceeding 1 cm in the inferior orbital rim, the lateral buttress, or possibly the zygomatic arch, primary reconstruction with bone grafting should be considered. Three-point fixation will provide the most stable three-dimensional reconstruction possible.

Evaluation

As always, the most urgent component of the initial evaluation of the patient who has sustained injury to the maxillofacial skeleton is the evaluation of the patient's airway and circulation. The potential for cervical spine injury and central nervous system insult is especially common in association with fractures of the midface.[12] These injuries take priority over any assessment of facial fractures until the patient's overall condition has been stabilized.

A careful history should take note of the mechanism of injury, as well as the magnitude and direction of the force vector. With any history of trauma to the cheek, fracture of the zygomatic complex should be considered. The specific symptoms of which the individual patient complains will vary with the degree of displacement and comminution of the zygoma.

Physical Examination

Tripod fractures are usually associated with tenderness and palpable step-offs across the suture lines. Most easily noted is disruption of the inferior orbital rim at the junction of the medial one third and lateral two thirds. With a greater application force, disruption

and comminution at several points along the rim can occur. The zygomatic arch can be easily palpated and may be bowed outward (but not completely disrupted) or depressed and crepitant. The zygomaticofrontal suture is not as easily palpable. Flattening of the cheek and enophthalmos are prominent signs of displaced zygoma fractures (Figs 2A and B).

Intraoral examination will often reveal the presence of ecchymosis, crepitance, and edema in the superior vestibule. Concomitant subcutaneous emphysema may be noted with air escaping from a disrupted maxillary antrum. Epistaxis and cerebrospinal fluid leaks are not prominent features of isolated zygoma fractures.

Paresthesia in the distribution of the infraorbital nerve may be caused by traumatic disruption of the nerve or by bony impaction. Subcutaneous edema or facial hematoma can simulate an apparent injury to the infraorbital nerve. Consideration should be given to decompressing the foramen of the infraorbital nerve to attempt to relieve paresthesia.

Occasionally, instead of being inwardly displaced, the body of the zygoma is rotated anteriorly on a vertical axis, resulting in lateral rotation of the zygomatic arch. This leads to an abnormal prominence of the lateral midface. Also, the arch may be bowed outward (greenstick type fracture) with a subsequent diminution of the anteroposterior projection of the malar eminence if there are extensive concomitant fractures of the maxilla.

Fractures of the Zygomatic Arch

A low-velocity, lateral blow to the zygoma may produce an isolated zygomatic arch fracture. This fracture usually occurs in three places producing two mobile segments. Displacement of these two fractured segments medially will cause the trismus commonly noted in these patients, which is caused by direct impingement of the displaced segment on the coronoid process of the mandible. Also, the origin of the masseter muscle from the zygoma causes discomfort as a result of the continued pull exerted on the fractured bone segments during mastication.

Often there is a palpable depression noted laterally overlying the arch, which may be camouflaged by overlying edema or hematoma. Once the superficial swelling has resolved, an unrepaired depression in the area may leave the patient with a significant cosmetic deformity.
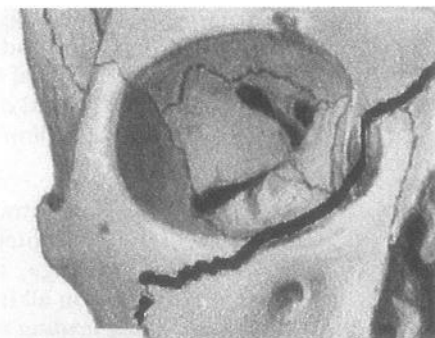
Orbital Floor Fractures

In tripod fractures, disruption of the floor of the orbit is always present, even more than in Le Fort fractures (Fig 3). The degree of bony disruption will vary. On occasion, a simple linear nondisplaced fracture is present that will require no specific treatment (aside from careful exclusion of more serious ophthalmologic injuries). Significant orbital floor comminution or displacement may lead to orbital content protrusion into the maxillary antrum, with consequent enophthalmos. Periorbital edema and ecchymosis may mask the increased volume of the bony orbit soon after trauma. Extraocular muscle entrapment or orbital soft tissue entrapment or edema arising from such an injury may lead to complaints of diplopia.

Forced-duction testing can be utilized to document entrapment preoperatively. Topical conjunctival anesthesia (e.g., tetracaine ophthalmic solution) allows testing of ocular mobility by grasping the sclera (deep in the fornix near the insertion of the extraocular muscles) with 0.5 mm Castro-Viejo forceps, and comparing ease of excursion of the
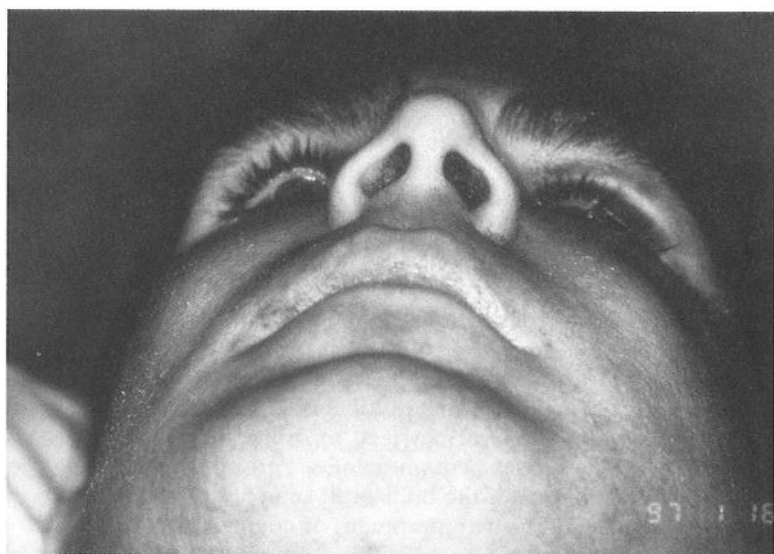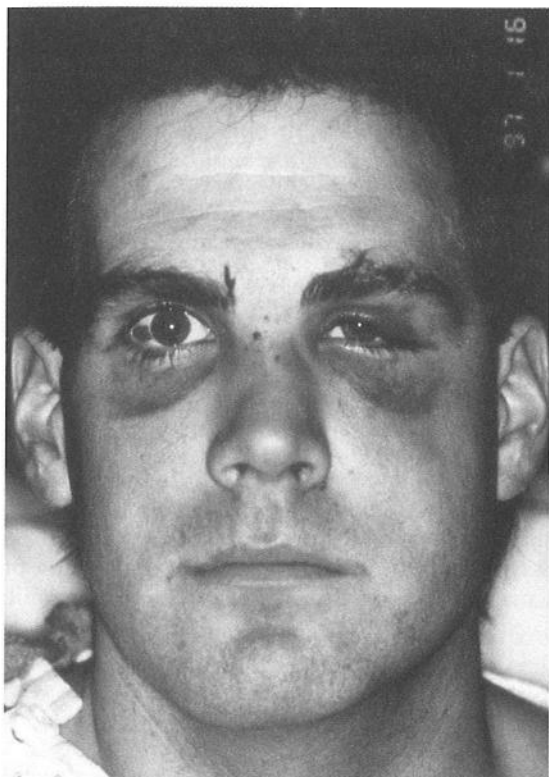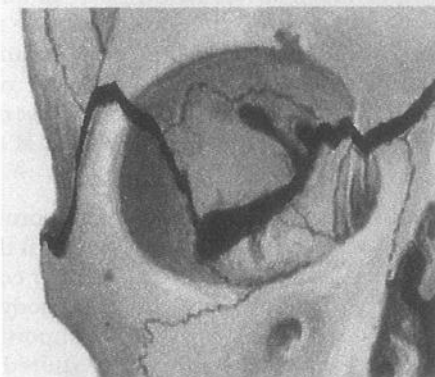
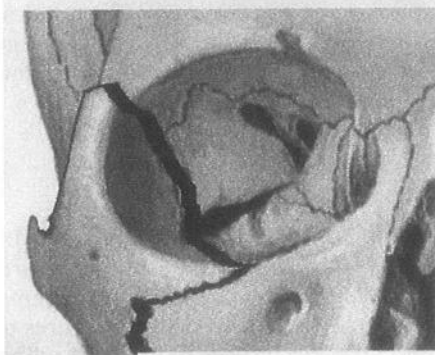Figs 2A and B.—Clinical presentation of left zygomatic complex fracture.

Le Fort II Orbital Fracture Pattern

Le Fort III Fracture Pattern through the orbit

Orbital Fracture Pattern in a Zygoma Fracture

Fig 3.—Patterns of orbital floor fractures in midface trauma

injured eye to the normal side. Marked resistance to such movement is highly suggestive of muscle entrapment. Such testing is important to differentiate diplopia secondary to muscle entrapment (most commonly noted on upward gaze from restriction of the inferior rectus muscle) from diplopia secondary to edema and hematoma. Forced duction also helps distinguish entrapment from neuromuscular injury which shows limited voluntary motion but a normal forced-duction test.

Orbital floor injuries are important because they are commonly associated with intraocular injury. One should always consider the possibility of injuries such as corneal integrity disruption, hyphema, lens dislocation, vitreous and retrobulbar hemorrhage, and optic nerve injury. Documentation of the patient's visual status is mandatory in all fractures of the zygoma. Uncommonly, the zygoma may be impacted medially, leading to a reduction in the bony orbital volume and subsequent exophthalmos.

Radiologic Assessment

The diagnosis of fractures of the zygomatic complex can be suspected from the history and is confirmed by the physical examination. Radiologic investigations serve as ancillary tools to provide documentation for medicolegal purposes, as well as to provide the surgeon with valuable clues regarding the three-dimensional orientation of the fracture. Plain X-rays will adequately demonstrate most of these fractures. The Caldwell view demonstrates the zygomaticofrontal area and the zygomatic arch; the submentovertex view best visualizes the zygomatic arch; and the Waters view shows displacement at the inferior orbital rim, body of the zygoma, and zygomaticomaxillary buttress area.

For most fractures, computed tomographic (CT) scanning in the axial and coronal planes offers a clearer delineation of the degree of comminution and displacement that may be present. Coronal scans are useful to demonstrate the orbital rim and floor components and the lateral buttress; axial scans best visualize the zygomatic arch, body of zygoma, and lateral wall of the orbit. We routinely utilize CT scanning as an important adjunct in helping to determine how extensive surgical exposure will be required to allow for the most accurate realignment and fixation of the fractures (Figs 4A and 4B). In spite of the outlined benefits, no study to date has confirmed the cost-effectiveness of routine CT scanning in the evaluation of all midfacial fractures.

Three-dimensional scans (dedicated or reconstructions) may be useful to assess a severely comminuted panfacial fracture complex, especially to orient fractured segments. Because of volume averaging, however, three-dimensional scanning is not generally helpful over regular CT scanning for initial evaluation. Magnetic resonance imaging may have a role in evaluation of optic nerve injury.

Managment of Zygoma Fractures

Indications and Timing

The treatment of zygoma fractures can be tailored to the individual's particular fracture. Nondisplaced fractures (Jackson Group One) generally require only supportive treatment. These patients should be placed on a soft diet to facilitate the management of their discomfort during the healing period (up to 4 to 6 weeks). Also, fractures that are more than 2 weeks from the time of injury are probably healed, so treatment should center around late repair rather than open reduction.

The role of prophylactic antibiotics in the treatment of uncomplicated zygoma fractures is unclear. There does appear to be an overall decrease in infectious complications
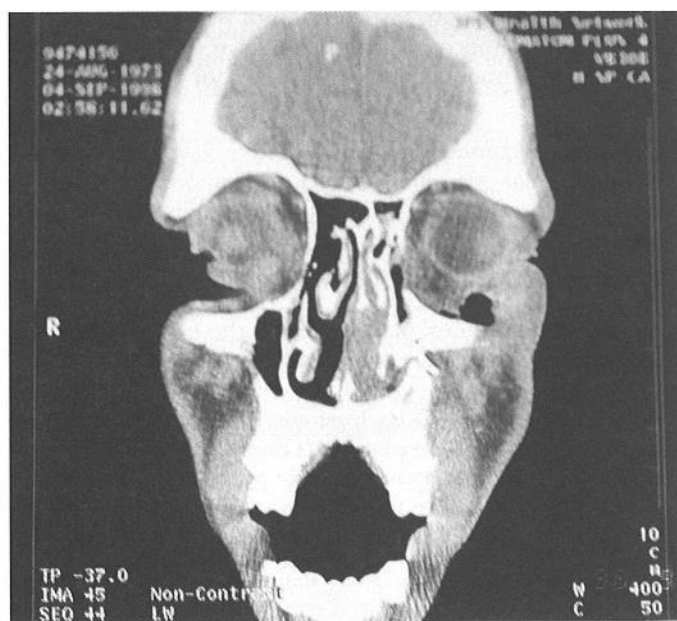
Figs 4A and B.—CT scan shows a zygoma fracture with rotation and flattening of the malar eminence.

when perioperative antibiotics are routinely used in the treatment of major maxillofa-cial injuries.[13] If there is classic tripod disruption of the zygomatic complex to include violation of the anterolateral wall of the maxillary antrum, or if a transmucosal (gin-givobuccal) surgical approach is being utilized, then perioperative cefazolin is recom-mended. Perioperative intravenous steroids should be given early to prevent further edema formation.

Operative Technique

Closed Reduction of the Arch

The classic approach to fractures of the zygomatic arch is the Gillies technique.[14] Here, a 2-cm incision is made in the temporal scalp or temporal hair tuft, approximately 2 cm within the hairline. Dissection is carried through and under the superficial layer of the deep temporal fascia. The frontal branch of the seventh cranial nerve is not at risk of transection below this fascial layer. A Boies elevator is then tunneled below this fascia and under the zygomatic arch. The displaced fractured arch is then disimpacted and elevated laterally into its proper anatomic position. Proponents of the Gillies technique believe that such a maneuver will allow the fractured segments to slide or "snap" into place, and be maintained in such a position by the splinting effects of the underlying temporalis muscle, and by the supportive architecture of the arch in conjunction with the remaining periosteal sleeve. An external eyeshield splint also may be used in mild-ly unstable fractures after reduction. Visualization of the fractured arch is not possible with this approach. Another approach that is similar in concept is the transoral reduc-tion—an incision is made intraorally and a large elevator can be placed from below to reduce the fracture.

Although this is a simple technique to use, and often leaves the patient with an excel-lent aesthetic and functional outcome, the lack of fixation and lack of direct fracture visualization may result in malunion.[15] Thus, careful patient selection and intraopera-tive judgment are necessary.

Closed Reduction of Tripod Fractures

In displaced fractures, a bone hook placed behind the body of the zygoma will allow reduction. An elevator also can be placed behind the zygomatic arch via this approach, but this is performed by palpation, not visualization. If the reduction is not stable, Steinman pin fixation and the use of Kirschner wires can be utilized in selected patients. While this approach is quick and inexpensive, it does not provide for rigid fracture sta-bilization, and may allow rotation around a single point of fixation. On rare occasions, external fixators may still have a role to play in the patient who has suffered a grossly comminuted fracture with a large amount of bone loss.

Open Reduction of Tripod Fractures

Displaced zygomatic complex fractures usually require open reduction and carefully applied internal fixation. Fractured segments can usually be adequately mobilized and rotated into proper position either by the Gillies approach or by the intraoral gin-givobuccal approach. A large hook or a Boies elevator may be levered behind the body of the zygoma to allow for a controlled manipulation. Severe zygoma fractures may be associated with comminution of the anterior wall of the maxillary antrum, and may result in significant loss of skeletal support to the midface if associated with concomi-tant maxillary fractures.

The extent of the exposure that is required will depend on the degree of comminution. If the zygomatic arch component of the tripod fracture is minimally displaced and adequate arch projection is still present, then limited-access approaches (transconjunctival, upper blepharoplasty, and gingivobuccal) are sufficient.

In severely comminuted fractures of the zygoma, many investigators favor a bicoronal flap for accurate arch repositioning and plating. All patients should be counseled preoperatively that such an exposure may be required.

Intraoperative Assessment

To ensure adequacy of reduction, correct bony alignment across each of the fracture lines needs to be assessed frequently during the procedure. If there is minimal comminution, the anterior and lateral maxillary walls are used as guides to reduction (Fig 5). Often there is some comminution through at least one of the fracture sites, making exact repositioning of the zygomatic complex more difficult. The zygomaticofrontal suture area provides the surgeon with the poorest indication of the degree of rotation of the zygoma, but the best indication of the vertical height.

The best indicator of alignment may be found within the lateral orbit. By confirming that exact repositioning of the greater wing of the sphenoid has been achieved (at the articulation between the orbital plate of the frontal process of the zygoma and the greater wing of the sphenoid), one can usually be assured of accurate three-dimensional reconstruction of the zygomatic complex. The orbital rim and lateral buttress also are keys to adequate reduction. After reduction, the infraorbital nerve should be inspected. Any small fragments of bone impinging on the nerve should be removed.

Once accurate reduction is confirmed, fixation can begin. The frontozygomatic suture may be wired or incompletely fixated to ensure correct vertical height, but also to allow some rotation inferiorly to establish correct reduction in three dimensions. The order of fixation is to wire the frontozygomatic suture, plate the lateral buttress and possibly the infraorbital rim, and then consider plating the frontozygomatic suture (Fig 6). Wires at the frontozygomatic suture often are adequate if the fracture at that site is incomplete (greenstick). Thus, miniplates are applied at the zygomaticofrontal suture (usually 1.2 mm or 1.7 mm plate), the inferior orbital rim (1.2 mm plate or wire fixation—Fig 7), and the zygomaticomaxillary buttress (1.7 mm or 2.0 mm plate). The rim may not need to be plated if there is adequate exposure, reduction, and fixation at the other sites. Leave all incisions open until the procedure is complete.

Orbital Floor

Low-velocity injuries are more apt to cause linear disruptions of the orbital floor with minimal bone comminution. These large bone fragments may be returned to their anatomic position with the use of a small bone hook. They may be secured to each other with miniplates or sutures. Although rarely necessary, another method is to support the bone fragments from below by temporary packing (tape gauze or balloon catheter) placed within the maxillary antrum for 10 to 14 days postoperatively.

Comminution of the orbital floor is a feature of high-velocity injuries. Every effort should be made to correct this deformity primarily, as complete and accurate restoration of orbital volume at a secondary procedure is exceedingly difficult to achieve later when scar contracture has occurred. Late repair is also made more difficult because the infraorbital nerve will be fibrosed in the plane of dissection between the orbital contents and antrum.
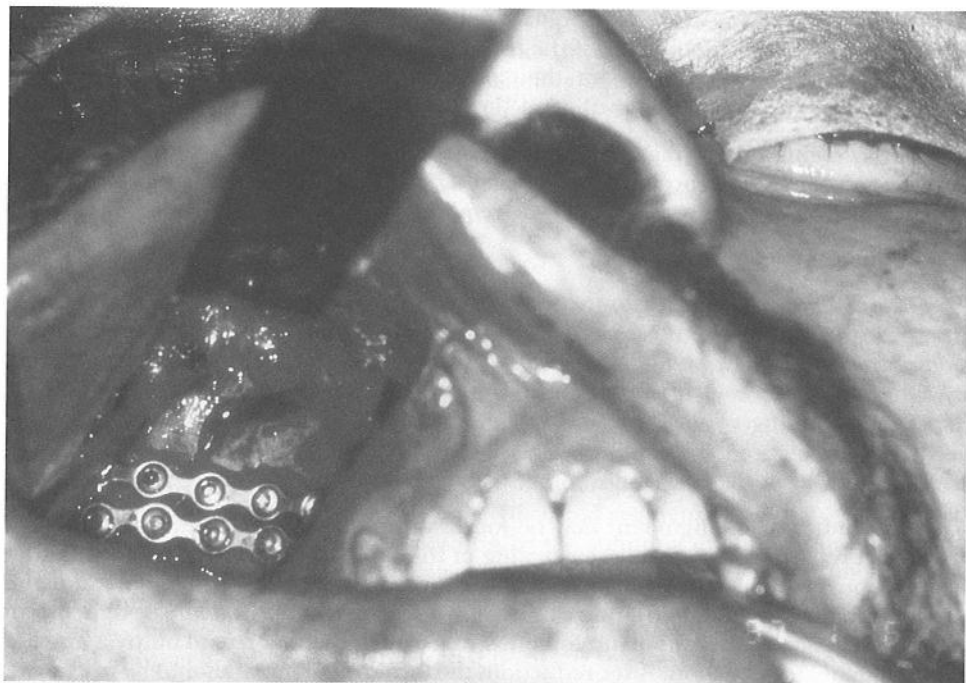
Fig 5.—Maxillary buttress plated.

For defects less than 1 cm diameter in the floor of the orbit, simply placing gelfilm across the bony gap may be all that is required. For larger defects titanium mesh or foil, nylamid, homograft cartilage, or bone grafts (iliac crest, rib, calvarium, anterior maxillary sinus wall, etc.) may be more appropriate to prevent the development of enophthalmos. Graft materials require fixation to the inferior orbital rim to prevent posterior migration to the orbital apex or external migration through the skin. Forced-duction testing should be done at the completion of the reduction and fixation.

Postoperative Care

Postoperatively, patients in whom no fixation has been utilized should be placed on a soft or fluid diet for 3 to 6 weeks to reduce the discomfort felt when a full masticatory load is exerted on the healing fractures. Visual checks are important in the immediate postoperative period. Antibiotics are continued for 48 to 72 hours, and steroids are used to reduce edema.

Routine postoperative plain films, or on occasion CT scans, are worthwhile to ensure adequate reduction of the fractures. If inaccurate repositioning is present, consideration should be given to early re-exploration.

Fig 6.—Plating the frontozygomatic suture.

Complications

By appreciating the true complexity of the zygomatic complex, and by adequately exposing and fixating the various components of the fracture pattern, favorable functional and aesthetic outcome will occur in most patients. If it is evident that incomplete three-dimensional reconstruction was achieved at the completion of the healing period, corrective osteotomies and refixation may be needed in the case of a large, persistent displacement. If only a small contour irregularity is present and function is unaffected, onlay bone grafts may provide the surgeon with a simple solution to an otherwise difficult problem.
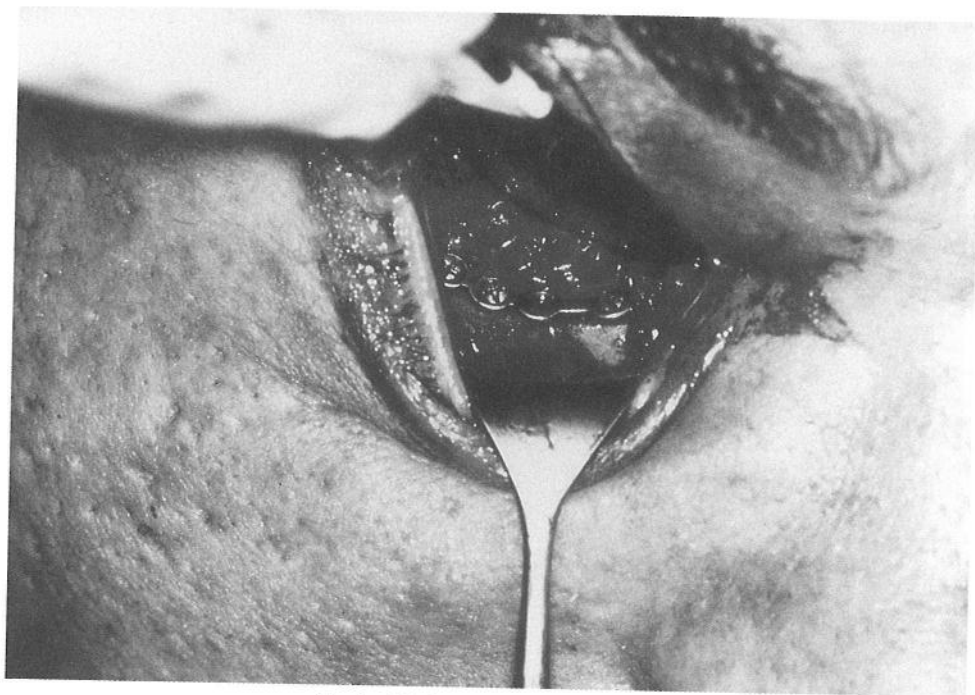
Fig 7.—Plating the infraorbital rim.

There can be serious ophthalmologic complications as a result of zygoma fracture repair. As a consequence of the zygoma's intimate relationship to the eye, intraocular injury is a common finding in patients with fractures of the zygoma. In fact, up to 40% of patients with zygoma fractures involving the floor of the orbit will have concomitant intraocular injury.[16]

The most troubling of ophthalmologic complications for both the patient and the surgeon is blindness. Total loss of vision following reduction of zygomatic fractures is unusual, with about 20 cases reported.[17] Blindness may arise as a consequence of impaction of bone fragments into the optic nerve or secondary to aggravation of an existing intraocular problem. If there is radiological evidence of impingement of the orbital apex or optic nerve by a fracture fragment, reduction may be dangerous. Such a malar fracture is probably best left unreduced unless the person is experiencing loss of vision in the ipsilateral eye. On the other hand, there is often improvement noted after emergent orbital decompression in orbital floor fractures complicated by ophthalmoplegia.[18]

Persistent diplopia is a relatively common complication following reduction of zygomatic complex injuries, occurring in about 7% of patients.[17] Diplopia is most often noted in the upper fields of vision, rather than in primary gaze, thus it is not usually a significant impediment in most affected patients. Persistent enophthalmos may be caused by orbital fat atrophy, by an incompletely repaired herniation of orbital contents into the maxillary antrum, or by expansion of orbital volume. Approximately 11% of

patients will continue to experience marked enophthalmos after fracture reduction and nonrigid fixation. In complex comminuted floor fractures, some overcorrection may be required to prevent this complication. However, postoperative fibrosis and fat resorption make it very difficult to achieve a completely normal bony orbital volume. Orbital floor exploration with split calvarial bone grafts (which provide adequate volume and support) are often necessary to correct this problem secondarily.

Paresthesia and anesthesia in the distribution of the infraorbital nerve are quite common following midfacial trauma. Both amelioration and worsening of these symptoms are possible with surgical repair. This unpredictability in the surgical outcome should be communicated to the patient preoperatively. Most patients with infraorbital nerve problems will experience progressive improvement of their symptoms for as long as 18 months after injury. Some chronic residual sensory deficit is not an unusual finding in this patient population. Transection of the frontal branch results in poor long-term aesthetic outcomes.

Lower lid edema is more apt to be noted when a subciliary approach is used. Long-term edema may lead to subsequent scar contracture with "trap-door" type surface irregularities. This is an unusual problem if the transconjunctival approach is used. Ectropion, or scleral show, is likewise uncommonly noted following the transconjunctival approach. When it does occur, spontaneous resolution may be hastened by daily vigorous superiorly directed massage of the area.

Coronoid process ankylosis may occur as a result of inadequate restitution of the normal zygomatic complex orientation. Correction with secondary osteotomy or coronoid process resection is often necessary to restore effective mastication and jaw opening.

Other unusual complications of zygoma fracture include sinusitis, implant infection and extrusion, dental sensory changes, and soft tissue deformity from detaching the periosteum of the orbital rim.

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