Evidence-Based Medicine: Evaluation and Treatment of Zygoma Fractures

Craig B. Birgfeld, M.D.
Gerhard S. Mundinger, M.D.
Joseph S. Gruss, M.D.

Seattle, Wash.

Learning Objectives: After studying this article, the participant should be able to: 1. Diagnose zygomaticomaxillary complex fractures from physical examination and radiographic findings. 2. Plan the necessary surgical approaches for operative treatment of zygomaticomaxillary complex fractures depending on severity. 3. Understand the three-dimensional anatomy of the orbit and zygomaticomaxillary complex and the importance of the zygomaticosphenoid suture along the lateral orbital sidewall. 4. Be aware of pitfalls and associated fractures that can complicate anatomical reduction of zygomaticomaxillary complex fractures.

Summary: Fractures of the zygoma are some of the most commonly treated facial fractures, yet reconstruction of the three-dimensional structure of the zygomaticomaxillary complex can be challenging, and malunions are common. This article presents an evidence-based, systemic approach to the assessment and treatment of zygoma fractures from the simple to the complex. Anatomy, approaches, techniques, and pitfalls are described in an effort to improve the treatment of these common facial fractures. (*Plast. Reconstr. Surg.* 139: 168e, 2017.)

American Board of Plastic Surgery
ABMS MOC®

Fractures of the zygoma are among the most common types of facial fractures treated by plastic surgeons. The prominent position of the malar eminence leaves the zygoma prone to injury in low-velocity trauma (such as simple assault) and high-velocity injury (such as seen in motor vehicle collisions),[1,2] and the zygoma is often involved in multilevel facial fractures. Treatment varies from simple and satisfying to complicated and frustrating. To obtain a successful result, the surgeon must understand the three-dimensional anatomy of the zygoma, the relationship with neighboring facial bones, orbital anatomy, safe surgical approaches, adequate reduction and fixation, and careful handling and reapproximation of the facial soft tissues. Lack of attention to any of these details can lead to an unfavorable result.

ANATOMY

The zygoma defines the width and projection of the midface and contributes greatly to the shape and volume of the orbit. It serves as the attachment of the masseter, temporalis, and zygomaticus major and minor muscles.[3] It articulates with the skull at the zygomaticofrontal suture, the zygomaticosphenoid suture, and the zygomatic arch, and to the maxilla at the zygomaticomaxillary buttress and the inferior orbital rim (Fig. 1). In cases of zygomaticomaxillary complex fractures, proximity of the infraorbital nerve typically leads to neurapraxia.[4] Involvement of the orbital contents can lead to enophthalmos, exophthalmos, and/or disconjugate gaze caused by entrapment (Fig. 2). Proximity of the coronoid process of the mandible and the temporomandibular joint can lead to trismus and temporomandibular joint dysfunction. The zygomaticomaxillary complex is often mislabeled as a "tripod,"[5] when in fact it is a quadripod[6] with five points of articulation as mentioned above (Fig. 3). (**See Video, Supplemental Digital Content 1**, which discusses zygomaticomaxillary complex fracture reduction

From the University of Washington, Harborview Medical Center, and Seattle Children's Hospital.
Received for publication March 8, 2016; accepted May 10, 2016.

DOI: 10.1097/PRS.0000000000002852

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

Supplemental digital content is available for this article. Direct URL citations appear in the text; simply type the URL address into any Web browser to access this content. Clickable links to the material are provided in the HTML text of this article on the *Journal*'s website (www.PRSJournal.com).

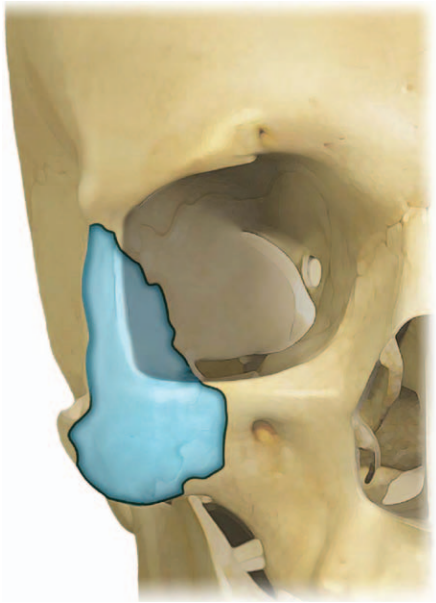

Fig. 1. Articulation of the zygomaticomaxillary complex.

Fig. 2. Disconjugate gaze caused by entrapment of left periorbita in left orbital floor trapdoor fracture restricting upward gaze.

and fixation. This video is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/B912***.)

EVALUATION

As with any facial fracture, initial assessment involves the Advanced Trauma Life Support protocol, as concomitant injuries are frequently present.[7–11] Particular attention should be paid to the cervical spine, as injuries occur at rates as high as 8 percent with an isolated facial fracture and 10 percent with two or more fractures.[12] A detailed history of the mechanism of injury, previous history of facial injury, and current symptoms is mandatory, as is premorbid presence of facial asymmetry

Fig. 3. Backlit human skull demonstrating four points of fixation of the zygoma (i.e., lateral orbital rim, inferior orbital rim, lateral maxillary buttress, and zygomatic arch). Not shown is the zygomaticosphenoid suture across the lateral orbital sidewall.

and dentofacial disharmony. The patient should be questioned about malocclusion, trismus, numbness, visual acuity changes, and diplopia. Typical symptoms are listed in Table 1.

Particular focus needs to be given to the visual examination. By nature, zygomaticomaxillary complex fractures are orbital fractures and therefore involve the globe and orbital structures to varying degrees. Initial assessment must document visual acuity and rule out orbital apex or superior orbital fissure syndrome, as sphenoid fractures can occur concomitantly with zygomaticomaxillary complex fractures in high-velocity trauma. In addition, a retrobulbar hematoma is a surgical emergency requiring prompt decompression (lateral canthotomy and cantholysis).[13–15] These can occur with zygomaticomaxillary complex fractures or after operative treatment of zygomaticomaxillary complex fractures and must be diagnosed and adequately treated within hours to avoid permanent loss of vision.[16–18] At our institution, an ophthalmologic consultation is part of the workup for zygomaticomaxillary complex fractures to rule out these and other ocular injuries such as traumatic optic neuropathy and retinal detachment.[19]

Physical examination begins with inspection of the face, noting edema, ecchymosis, lacerations, asymmetry, and facial width and projection. Blood in the lateral sclera is a hallmark of the lateral orbital wall component of the zygomaticomaxillary complex fracture (Fig. 4). Next, the examiner proceeds with inspection of the globe, noting exophthalmos and enophthalmos and testing all extraocular muscles for signs of

Video. Supplemental Digital Content 1 discusses zygomaticomaxillary complex fracture reduction and fixation. This video is available in the "Related Videos" section of the full-text article on PRSJournal.com or at ***http://links.lww.com/PRS/B912***.

Table 1. Common Symptoms Reported by Patients with Zygomaticomaxillary Complex Fractures

Periorbital swelling and pain
Ocular pain in extremes of gaze
Diplopia
Numbness in the V_2 distribution
Trismus
Subjective malocclusion*

*This is not a "true" malocclusion, as there is no displacement of the maxilla or the mandible in an isolated zygomaticomaxillary complex fracture. Rather, masseter spasm can pull the mandible toward the affected side, giving the sensation and temporary presence of a crossbite or premature contact on the affected side.

entrapment. Generalized restriction in movement caused by edema is common, as is early diplopia in far lateral gaze. Significant disconjugate gaze, photophobia, and nausea are common signs of entrapment.[20] A forced duction test may be necessary for confirmation. Gentle palpation of the face follows, noting point tenderness, step-offs, and lack of malar prominence. Common signs of a zygomaticomaxillary complex fracture are listed in Table 2.

IMAGING

Once the physical examination indicates a facial fracture, imaging should be performed to confirm the diagnosis and plan for surgery, taking particular note of potential pitfalls. Although a Water view plain radiograph can confirm the presence of a zygomaticomaxillary complex fracture, a craniofacial computed tomographic scan is considered the gold standard.[21–26] Fine-cut (0.3 to 0.5 mm) axial images from vertex through menton with coronal views are mandatory, and three-dimensional reconstructions can be helpful for complex cases and sagittal reconstructions can be helpful to evaluate orbital floor defects. The use

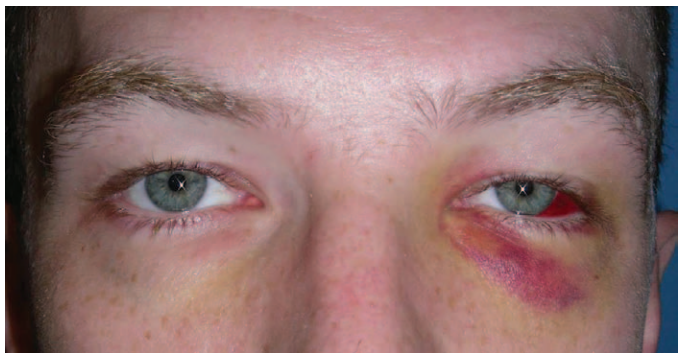

Fig. 4. Lateral scleral blood at the site of a left lateral orbital wall fracture.

Table 2. Common Signs of a Zygomaticomaxillary Complex Fracture

Lack of malar prominence
Increased facial width*
Lateral subconjunctival blood
Generalized ocular restriction in extreme gaze
Enophthalmos or exophthalmos†
Lack of sensibility in the V_2 distribution
Epistaxis

*Most zygomaticomaxillary complex fractures increase facial width as the zygoma is pushed in and the arch is pushed out. However, with a deforming force emanating from lateral to medial, the zygoma can rotate inward, which *decreases* facial width.
†Most zygomaticomaxillary complex fractures create enophthalmos once edema has subsided, but with lateral blow-in fractures and rotational deformities of the zygoma, exophthalmos may occur.

of ultrasound has been documented and may be a feasible alternative to reduce cost and radiation exposure.[27–29] However, the surgeon should not accept suboptimal images that do not allow adequate diagnosis and planning of fracture repair regardless of modality.

INDICATIONS FOR TREATMENT

On diagnosis of a zygomaticomaxillary complex fracture, the surgeon and patient must now make the decision of whether or not to treat. Overall medical condition, patient comorbidities, degree of displacement, functional consequences, and amount of deformity are all taken into consideration. Functional impairment centers on orbital and masticatory issues. Changes in orbital volume can lead to enophthalmos, hypoglobus, and diplopia. Because the zygoma supports the lower eyelid, an impacted zygomaticomaxillary complex fracture can lead to loss of lower lid support, ectropion, and corneal dryness or epiphora. An impacted arch can impinge on the coronoid process of the mandible (Fig. 5), causing trismus and inability to obtain a functional mouth opening. Impingement of the infraorbital nerve typically leads to loss of sensibility in the V_2 distribution, but it can lead to intractable pain that may or may not be improved with operative treatment[4] and can worsen after surgery.[30]

Aesthetic indications for treatment center on the degree of deformity of the malar eminence and the amount of globe malposition. Two to 3 mm of enophthalmos is clinically detectable and 5 mm or more is disfiguring.[31] It alters the appearance of the eye and can affect the interface between the lid and globe. Loss of malar projection leads to an asymmetry of the face in which the affected side appears flatter and wider than the contralateral side.

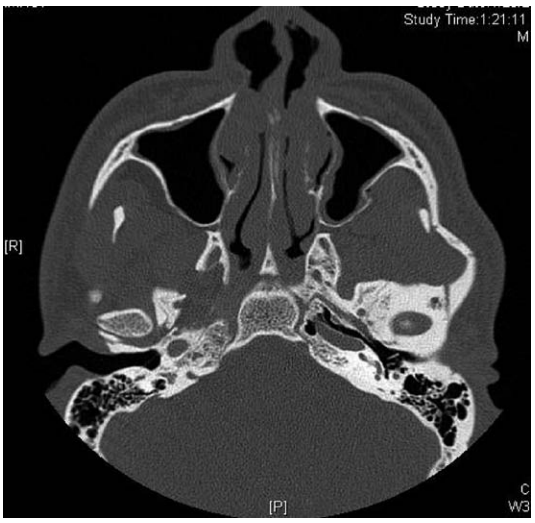

Fig. 5. Temporomandibular joint dysfunction caused by impingement of the coronoid process.

TIMING OF TREATMENT

In the absence of entrapment, retrobulbar hematoma, and superior orbital fissure/apex syndrome, zygomaticomaxillary complex fractures do not require emergent treatment. Initial edema often camouflages the degree of actual deformity, and a short waiting period of 1 to 2 weeks has been recommended for adults to more accurately assess the injury and to create a more precise surgical plan.[6,32,33] Bony consolidation occurs approximately 2 to 3 weeks after injury and likely sooner in children, which necessitates treatment within 1 week in pediatric patients.[3] Treatment after 4 weeks may require osteotomies and bone grafting,[34] greatly increasing the complexity of the reconstruction.

ANTIBIOTIC THERAPY

Before operative intervention, many patients with zygomaticomaxillary complex fractures are placed on sinus precautions and antibiotics.[35,36] However, support for this practice in the medical literature is scant[37] to nonexistent.[38–42] In addition, a more extensive review of the literature describing antibiotic use in mandible fractures revealed no proven benefit.[43] Currently, the recommendation for antibiotic therapy in the treatment of zygomaticomaxillary complex fractures by means of open reduction and internal fixation is a prophylactic dose within 60 minutes before the incision is made and then discontinued within 24 hours postoperatively, as with any clean contaminated case.[44]

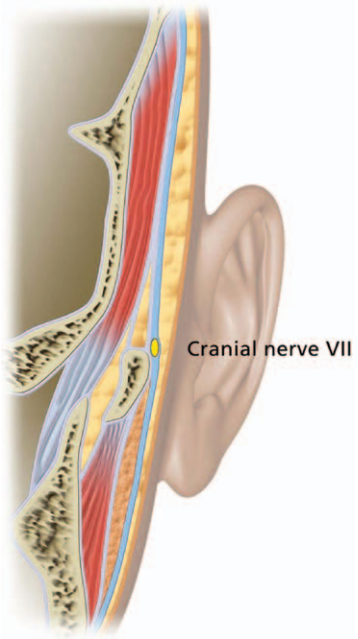

Fig. 6. Relationship of the frontal branch of the facial nerve to the layers of the superficial temporal fascia.

SURGICAL APPROACH

Once the diagnosis and decision to treat is made, the surgeon must plan his or her surgical approach and operative intervention. In general, the treatment that provides the best restoration of facial form with adequate stability and the least morbidity is chosen. Isolated fractures of the zygomatic arch may be treated with a Gillies temporal approach, a Keen intraoral approach,[45] and/or a percutaneous hook with or without fixation[46,47] and use of intraoperative imaging. The percutaneous hook requires placement of a conspicuous scar and places the facial nerve at some risk. The temporal approach hides the scar in the hairline, and the facial nerve can be preserved by staying deep to the superficial layer of the deep temporal fascia during dissection (Fig. 6). The intraoral approach hides the scar in the mouth and avoids risk to the facial nerve and is therefore our preferred technique. As the fracture pattern becomes more complex, greater exposure and fixation are necessary for proper treatment.

Although minimal access approaches and Kirschner wire fixation of the zygoma have been described[48–54] and may have utility, the surgeon should never cut corners or accept an inferior result in an effort to minimize exposure and/or fixation. One must be confident of the bony reduction at all five points of bony articulation either through adequate exposure, navigation, or intraoperative imaging before fixating the fractures. Otherwise, an open reduction and internal fixation becomes an open internal fixation *without* reduction and the patient and surgeon are left to deal with the negative sequelae of the open internal fixation.

Controversy exists around the amount of fixation that is necessary to maintain proper position of the zygomaticomaxillary complex,[55] but this may be because of the variation in fracture comminution, degree of displacement or impaction, and available bone stock. Some have argued that "relapse" described by some authors is really incomplete reduction at the initial operation.[56] In some cases with good bone stock, no comminution, and minimal displacement, a single sturdy plate across the lateral buttress may suffice.[57] However, in cases involving comminution, frail bone, and associated midfacial fractures, additional stability with plates at the orbital rim, zygomaticofrontal suture, and zygomatic arch may be necessary (Fig. 7).

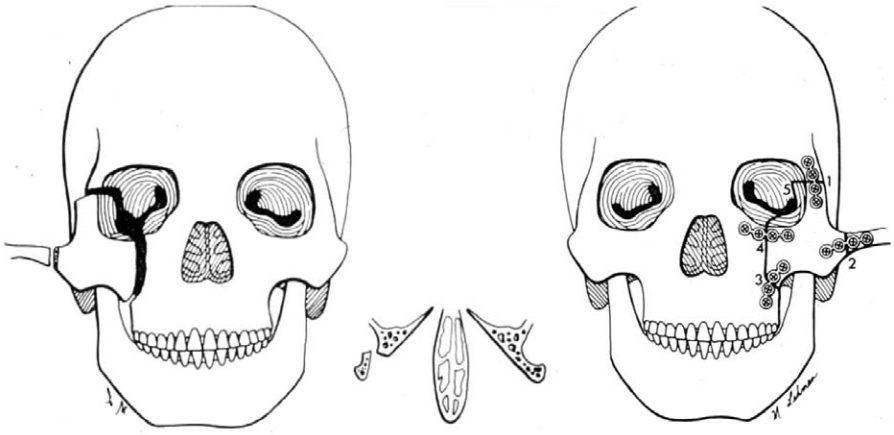

Fig. 7. Common fracture pattern of zygomaticomaxillary complex injuries (*left*) with disruption of the lateral orbital sidewall (*center*) and locations of plate fixation for zygomaticomaxillary complex fractures (*right*).

EXPOSURE

Access incisions are planned to provide exposure of the fractures and visualization of important sites of reduction and to minimize disfigurement and optimize aesthetics. Careful handling of the soft tissue is essential to prevent complications such as ectropion, alopecia, and fistulae. A perfect bony reduction can be ruined by careless dissection, and a suboptimal scar or soft-tissue may result. The gingivobuccal sulcus incision allows access to the lateral buttress. It is important to leave a healthy cuff of mucosa attached to the gingiva to aid in closure. Once through the mucosa, dissection is performed in the submucosal plane down to the maxilla to minimize damage to the facial musculature (Fig. 8).

A lower eyelid incision allows access to the orbital rim and orbital floor[58] (Fig. 9). The subciliary incision lies just beneath the lash line atop the tarsal plate and provides the best aesthetic result but at the price of the highest rate of ectropion.[59] A subtarsal incision sits just inferior to the tarsal plate and is slightly more visible but has a lower rate of ectropion. The mid-lid incision lies within the first skin crease inferior to the tarsus and has a lower rate of ectropion, with a more acceptable aesthetic result. An incision at the lid-cheek junction avoids the lid altogether, but is aesthetically unacceptable and should be used only if a serendipitous laceration exists at this location. The transconjunctival approach optimizes the aesthetic result but does not provide equivalent exposure to the anterior face of the inferior orbital rim and therefore midface resuspension is difficult. Adding a lateral canthotomy can improve the exposure with little aesthetic detriment. Through the transconjunctival approach, the retroseptal dissection avoids the risk of lid malposition, and the preseptal dissection increases the risk of entropion (Fig. 10).[60]

The zygomaticofrontal suture can be exposed through a lateral upper eyelid blepharoplasty incision (Fig. 11), a brow incision, an extension of the lower eyelid incision, or a coronal incision if

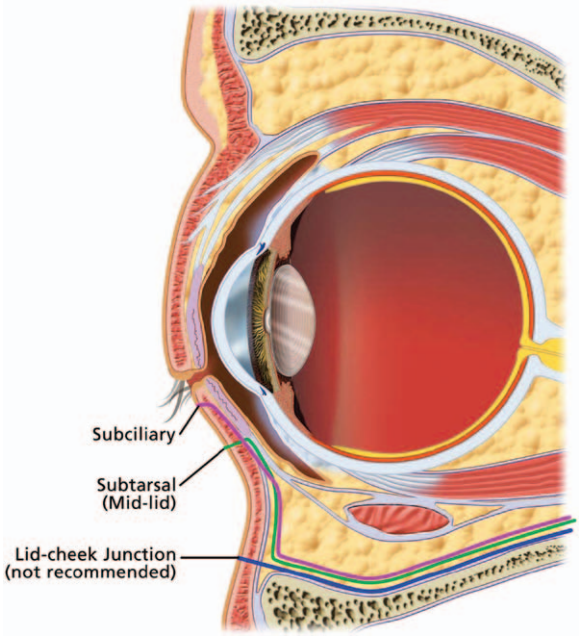

Fig. 9. Lower eyelid incisions to approach the orbital rim and orbital floor in treating zygomaticomaxillary complex fractures.

Fig. 8. Careful submucosal dissection to the lateral buttress, leaving a cuff of mucosa attached to the gingiva to aid in closure.

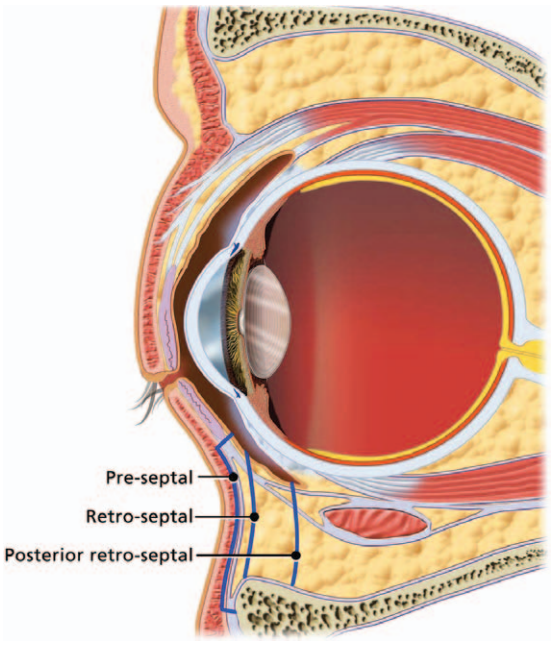

Fig. 10. Transconjunctival approach to the orbital floor by means of either a preseptal or retroseptal dissection.

Fig. 11. Upper eyelid incisions to approach fractures of the zygomaticofrontal suture and lateral orbital sidewall. Not shown is the coronal incision, which also can be used to approach this anatomy.

used. This incision is important not only to expose and fixate the fracture but to visualize the lateral orbital sidewall and zygomaticosphenoid suture. Anatomical reduction of the lateral orbital sidewall is the most important point of reference. It is the thickest part of the orbit and is rarely comminuted. Also, because of its natural curvature and three-dimensional shape, one can confirm vertical, horizontal, and rotational reduction of the zygomaticomaxillary complex. The coronal incision is necessary to approach the zygomatic arch. The arch should be approached and fixated if it is comminuted, laterally displaced, telescoped, and shortened, and if there are multiple levels of comminuted fractures, as in panfacial fractures. It allows the surgeon to set the proper facial width and projection and adds stability to the midface. The incision begins above the ear within hear-bearing scalp and is zig-zagged for camouflage. The use of cautery and Rainey clips is avoided to prevent alopecia, and careful use of bipolar cautery can control bleeding at the incision. The incision is carried through the galea, and the scalp is reflected in the subgaleal plane. Dissection proceeds on the shiny deep temporal fascia just deep to the superficial layer of the deep temporal fascia (Fig. 9) just above the temporal fat pad. This avoids injury to the frontal branch of the facial nerve and preserves the fat pad to prevent temporal hollowing. The zygomatic arch is curved only at its anterior and posterior extents (Fig. 12, *left*), and the plate used to fixate the arch should not be bent to prevent bowing of the reduction (Fig. 12, *right*). Also, their commonly exists a greenstick fracture off of the temporal bone above the external auditory canal which, if not recognized and reduced, can lead to facial widening.

FRACTURE REDUCTION

Careful preoperative assessment of the facial computed tomographic scan can help plan the intraoperative maneuvers that will be necessary to attain a perfect anatomical reduction. Sometimes, the arch is fractured in isolation in a V deformity (Fig. 5). More commonly, the entire zygomaticomaxillary complex is displaced and is either impacted (Fig. 13), rotated (Fig. 14), or both. In broad terms, the goal of fracture reduction is to reestablish facial width and projection. This is most often achieved by realigning the fractured segments at each of the five points of contact to the skull and facial bones. In reality, it can be difficult to obtain this goal because not all points can be visualized concomitantly: manipulation of one fracture site may displace another site that is

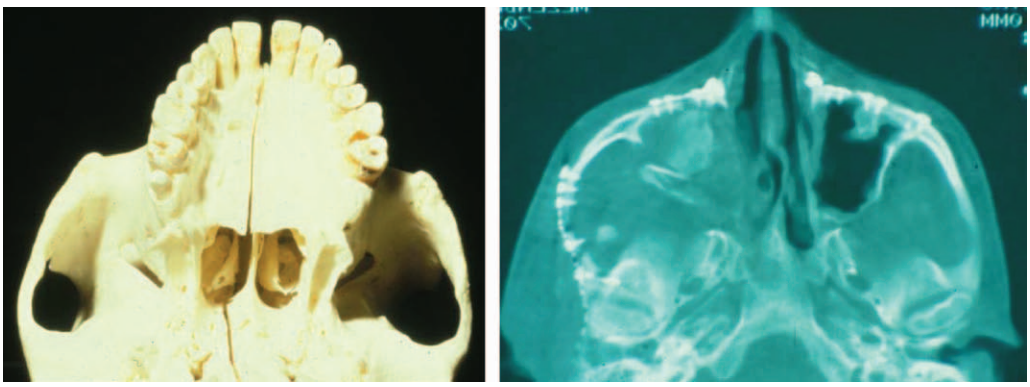

Fig. 12. (*Left*) Submental view of human skull displaying zygomatic arches, which are curved only at the takeoff from the temporal bone of the skull. (*Right*) Radiograph displaying malreduction of right zygomatic arch because of bending of the fixation plate in an effort to create an "arch."

Fig. 13. Impacted fracture of the right zygomaticomaxillary complex with comminution.

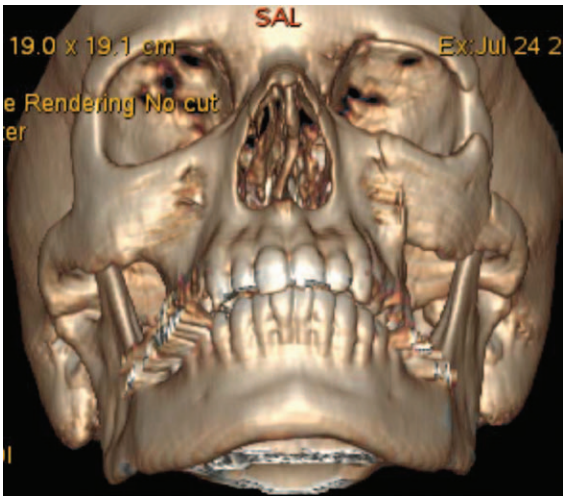

Fig. 14. Rotated fracture of the left zygomaticomaxillary complex without comminution.

not currently being visualized. Moreover, severe comminution of the zygomaticomaxillary complex may make fragmentary reduction impossible (Fig. 15), and in these cases, the surgeon should remember the broader goal: reestablishment of facial width and projection (**see Video, Supplemental Digital Content 1**, ***http://links.lww.com/PRS/B912***).

For isolated arch fractures, the V deformity can be reduced with one of many available instruments (e.g., Dingman, Goldman, Gilles elevator) placed beneath the fractured segment through a Gilles or Keen approach. For impacted zygomaticomaxillary complex fractures, the zygoma is first disimpacted by applying anterolateral force on an elevator or curved Mayo scissors placed beneath the body of the zygoma through the intraoral approach. Severely impacted fractures may require placement of a Carroll-Girard screw (Fig. 16) for the surgeon to gain mechanical advantage over the fracture. Once the fracture is disimpacted, it can often be manipulated into reduction, with the surgeon's other hand placed along the face with the thumb on the zygoma providing medial pressure. If the zygomaticomaxillary complex is freely mobile, the Carroll-Girard screw can be used as a joystick to manipulate the segment into reduction. Some will grasp the zygoma with a Kocher clamp for control, whereas others will place a temporary screw into the body, which is then clamped with a tonsil through the intraoral approach to allow manipulation.

Once the surgeon has gained control over the zygoma, it is first manipulated into reduction at

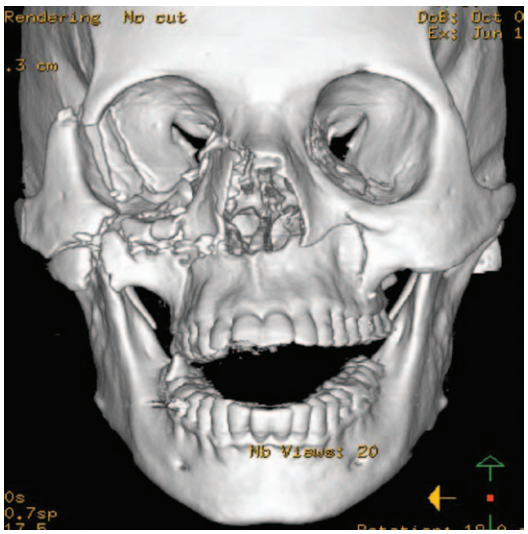

Fig. 15. Comminution of the right zygomaticomaxillary complex may make interfragmentary reduction impossible, but facial width and projection can and must be reestablished.

Fig. 16. The Carroll-Girard screw can be used to disimpact and reposition severely impacted zygomaticomaxillary complex fractures.

the zygomaticosphenoid suture along the lateral orbital wall. The fracture of the zygomaticofrontal suture is then temporarily wired into reduction. This maintains vertical height and allows for some manipulation of the fracture segments at the orbital rim and lateral buttress until a perfect anatomical reduction is attained.[61] The rim is then fixated, the wire is removed and replaced with a plate, and the lateral buttress is finally fixated. In severely comminuted fractures or zygomaticomaxillary complex fractures associated with multiple other midface or panfacial fractures, the zygomaticofrontal suture is wired, and then the arch is rigidly fixated to establish facial width and projection before proceeding with fixation of the other fracture sites. It is important to note that the zygomatic arch is only an arch at its takeoff from the temporal bone and its attachment to the maxilla. Between these, the arch is straight, and plates used to fixate the arch in this location should not be bent (Fig. 12, *right*).

FRACTURE FIXATION

In general, the least amount of rigid fixation needed to obtain a stable bony union is applied. For isolated, noncomminuted zygomaticomaxillary complex fractures, this may require one or two plates at the lateral buttress and/or the zygomaticofrontal suture. If in doubt, it is prudent to add another site of fixation or a stronger plate rather than "hope" the patient will not experience relapse postoperatively, especially if the fracture site is already exposed. Generally, stronger plates are placed across the lateral buttress where forces are greater and the soft tissue is more robust and able to hide a thicker plate. Thinner plates are placed around the orbit where the soft tissue is scant and the plates are more likely to be palpable. One exception is the zygomaticofrontal suture, where displacing forces are relatively high[62] and may require a stronger plate.

The advent of bioresorbable plates and screws has led some authors to advocate their use in facial trauma.[63–67] Facial fracture fixation with titanium plates and screws has led to complaints of pain, infection, exposure/extrusion, palpability, temperature sensitization, sinus infections, and dental injury.[67–72] Biomechanical studies have shown less strength with the resorbable system.[69] However, in some cases, the bioresorbable plates alone or in combination with titanium plates appear to provide adequate strength to resist the deforming forces of the masticatory muscles.[73] Of course, resorbable plates are not without issues, such as infection,[74,75] swelling, and granuloma formation.[76,77] Although bioresorbable plates may have utility in the pediatric population,[78] the surgeon should not sacrifice stable bony fixation in an attempt to avoid the use of titanium, which has a proven track record and low complication profile in zygomaticomaxillary complex fractures compared with mandible fractures.[79]

SOFT-TISSUE MANAGEMENT

Reapproximation of the soft tissue violated during fracture exposure is not an afterthought; it is just as important as proper reduction and fixation for avoiding an unfavorable result and an unhappy patient. Lack of attention to the soft tissue can lead to eyelid malposition and corneal exposure, temporal hollowing, brow ptosis, midface descent, fistulae, and plate exposure. Many of these sequelae can be avoided with proper incision placement and careful dissection while obtaining exposure. Nevertheless, the surgeon must resist fatigue and continue a careful closure after fracture treatment. If a coronal incision is used to approach the arch, the temporoparietal fascia must be reapproximated to prevent temporal hollowing. Most importantly, the midface should be aggressively resuspended to the orbital rim to prevent descent.[80] Midface descent not only creates premature aging of the affected side but can also pull the lid down, leaving the patient with lid malposition, corneal exposure, and epiphora. If the lateral canthal tendon is detached during exposure of the lateral orbital sidewall, it must be reattached to prevent asymmetry and lower lid laxity. Careful closure of the orbicularis oculi muscle and lower lid skin can minimize ectropion. The use of Frost sutures postoperatively can help reduce ocular edema but does little to prevent the lid malposition caused by an incision that was improperly dissected or closed. Lastly, a careful, watertight closure of the intraoral incision can prevent plate exposure in the mouth and oroantral fistula formation to the maxillary sinus.

COMPLICATIONS

Complications of zygomaticomaxillary complex fractures can occur from the initial trauma, from the operative intervention, or from inaccurate surgical treatment. Table 3 lists the most common complications of zygomaticomaxillary complex fractures and their treatment. Most of

Table 3. Complications of Zygomaticomaxillary Complex Fracture Treatment

Facial asymmetry
Scarring
Infection
Bleeding (epistaxis)
Hardware failure (exposure, palpability)
Neurapraxia
Facial nerve palsy
Temperature sensitivity
Blindness*
Decreased visual acuity*
Diplopia*
Lid malposition/ectropion/entropion*
Corneal exposure/abrasion*
Enophthalmos*
Epiphora*
Orbital dystopia*

*Orbital complications are more common if a clinically relevant orbital floor component exists in conjunction with the zygomaticomaxillary complex fracture.

these can be avoided with careful assessment, complete fracture exposure, and anatomical reduction with stable bony fixation. As with most complications, the best treatment is avoidance of the complication in the first place. Complications of zygomaticomaxillary complex fracture treatment can be difficult[81] if not impossible to correct. One common cause of unfavorable reduction is the lack of recognition of a concomitant hemi–nasoorbitoethmoid fracture[82] (Fig. 17). If the nasoorbitoethmoid component is not recognized and reduced, the zygomaticomaxillary complex will be fixated in a lateral position, leaving the face wide and the orbit too large (Fig. 18). Other pitfalls to accurate reduction include concomitant sphenoid fractures (Fig. 19) or frontal bone fractures (Fig. 20).

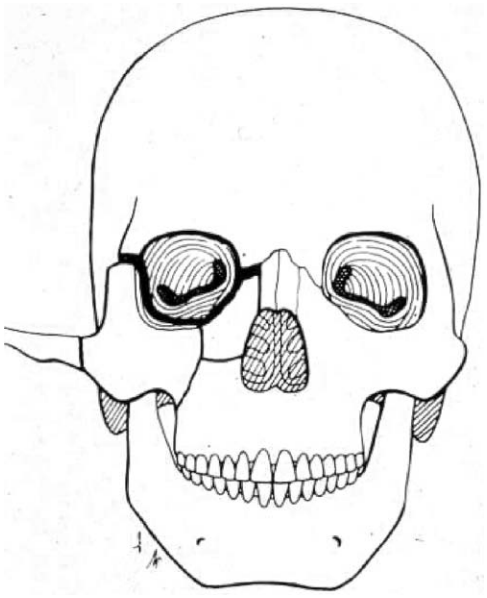

Fig. 17. A common cause for malreduction of a displaced zygomaticomaxillary complex fracture is lack of recognition of a concomitant hemi-naso-orbitoethmoid fracture. The surgeon reduces the fracture at the orbital rim that is too low because of the displaced hemi-nasoorbitoethmoid, failing to correct the deformity created by the displaced zygomaticomaxillary complex.

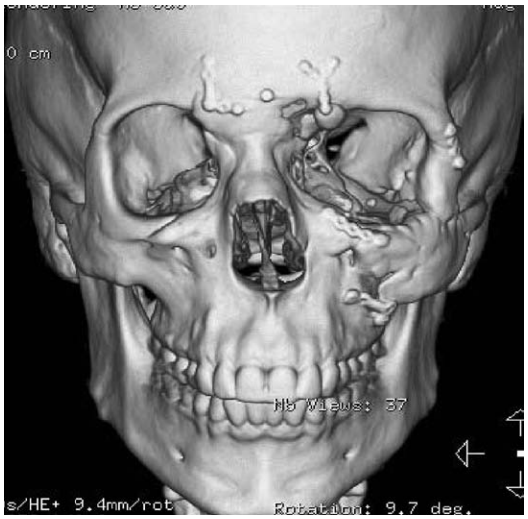

Fig. 18. Inadequate recognition and reduction of the nasoorbitoethmoid fracture led the surgeon to fixate the left zygomaticomaxillary complex too far lateral, leaving the patient with a widened face and enophthalmos secondary to orbital enlargement.

Fig. 19. The presence of a left sphenoid fracture can complicate reduction of a left zygomaticomaxillary complex fracture, as the lateral orbital wall may appear intact with normal contour when, in fact, the entire zygomaticomaxillary complex and sphenoid is impacted.

Fig. 20. Displacement of the frontal bone can complicate zygomaticomaxillary complex reduction. The hemibandeau must be properly elevated and reduced at the time of intracranial exploration to allow proper reduction of the zygomaticomaxillary complex fracture.

CONCLUSIONS

The zygomaticomaxillary complex is a key component to facial form and function, as it contributes to orbital volume, facial width, and malar prominence. It is this prominent position that also makes the zygomaticomaxillary complex prone to fracture with moderate to severe facial trauma. Adequate diagnosis and treatment can readily restore facial and orbital harmony, but at the same time, inadequate treatment can leave the patient with severe deformities that are difficult if not impossible to correct secondarily. Getting it right the first time is essential. To do this, the surgeon must perform a thorough craniofacial physical examination, review adequate imaging studies to formulate a plan, select ample well-hidden incisions to adequately expose the fractures, perform a careful dissection, accurately reduce the fracture, apply sufficient fixation, and carefully reconstruct the soft tissue and close. The approach is straightforward, but the treatment is fraught with pitfalls that must be identified and dealt with by the surgeon to avoid an unfavorable result. However, if one can understand and master the treatment of zygomaticomaxillary complex fractures, one can successfully treat any facial fracture.

Craig B. Birgfeld, M.D.
M/S OB.9.520P.O. Box 5371
4800 Sand Point Way
Seattle, Wash. 98105
craig.birgfeld@seattlechildrens.org

REFERENCES

1. Gassner R, Tuli T, Hächl O, Rudisch A, Ulmer H. Cranio-maxillofacial trauma: A 10 year review of 9,543 cases with 21,067 injuries. *J Craniomaxillofac Surg.* 2003;31:51–61.
2. Kelley P, Crawford M, Higuera S, Hollier LH. Two hundred ninety-four consecutive facial fractures in an urban trauma center: Lessons learned. *Plast Reconstr Surg* 2005;116:42e–49e.
3. Ellstrom CL, Evans GR. Evidence-based medicine: Zygoma fractures. *Plast Reconstr Surg.* 2013;132:1649–1657.
4. Kurita M, Okazaki M, Ozaki M, et al. Patient satisfaction after open reduction and internal fixation of zygomatic bone fractures. *J Craniofac Surg.* 2010;21:45–49.
5. Hwang K. One-point fixation of tripod fractures of zygoma through a lateral brow incision. *J Craniofac Surg.* 2010;21:1042–1044.
6. Kelley P, Hopper R, Gruss J. Evaluation and treatment of zygomatic fractures. *Plast Reconstr Surg.* 2007;120(Suppl 2):5S–15S.
7. Pappachan B, Alexander M. Correlating facial fractures and cranial injuries. *J Oral Maxillofac Surg.* 2006;64:1023–1029.
8. Haug RH, Prather J, Indresano AT. An epidemiologic survey of facial fractures and concomitant injuries. *J Oral Maxillofac Surg.* 1990;48:926–932.
9. Follmar KE, Debruijn M, Baccarani A, et al. Concomitant injuries in patients with panfacial fractures. *J Trauma* 2007;63:831–835.
10. Bynoe RP, Kerwin AJ, Parker HH III, et al. Maxillofacial injuries and life-threatening hemorrhage: Treatment with transcatheter arterial embolization. *J Trauma* 2003;55:74–79.
11. Afrooz PN, Grunwaldt LJ, Zanoun RR, et al. Pediatric facial fractures: Occurrence of concussion and relation to fracture patterns. *J Craniofac Surg.* 2012;23:1270–1273.
12. Mulligan RP, Mahabir RC. The prevalence of cervical spine injury, head injury, or both with isolated and multiple craniomaxillofacial fractures. *Plast Reconstr Surg.* 2010;126:1647–1651.
13. McClenaghan FC, Ezra DG, Holmes SB. Mechanisms and management of vision loss following orbital and facial trauma. *Curr Opin Ophthalmol.* 2011;22:426–431.
14. Popat H, Doyle PT, Davies SJ. Blindness following retrobulbar haemorrhage: It can be prevented. *Br J Oral Maxillofac Surg.* 2007;45:163–164.
15. McInnes G, Howes DW. Lateral canthotomy and cantholysis: A simple, vision-saving procedure. *CJEM* 2002;4:49–52.
16. Ballard SR, Enzenauer RW, O'Donnell T, Fleming JC, Risk G, Waite AN. Emergency lateral canthotomy and cantholysis: A simple procedure to preserve vision from sight threatening orbital hemorrhage. *J Spec Oper Med.* 2009;9:26–32.
17. Goodall KL, Brahma A, Bates A, Leatherbarrow B. Lateral canthotomy and inferior cantholysis: An effective method of urgent orbital decompression for sight threatening acute retrobulbar haemorrhage. *Injury* 1999;30:485–490.
18. Hislop WS, Dutton GN. Retrobulbar haemorrhage: Can blindness be prevented? *Injury* 1994;25:663–665.
19. Bater MC, Ramchandani PL, Brennan PA. Post-traumatic eye observations. *Br J Oral Maxillofac Surg.* 2005;43:410–416.
20. Jordan DR, Allen LH, White J, Harvey J, Pashby R, Esmaeli B. Intervention within days for some orbital floor fractures: The white-eyed blowout. *Ophthal Plast Reconstr Surg.* 1998;14:379–390.
21. Cooper PW, Kassel EE, Gruss JS. High-resolution CT scanning of facial trauma. *AJNR Am J Neuroradiol.* 1983;4:495–498.
22. Laine FJ, Conway WF, Laskin DM. Radiology of maxillofacial trauma. *Curr Probl Diagn Radiol.* 1993;22:145–188.

23. Hopper RA, Salemy S, Sze RW. Diagnosis of midface fractures with CT: What the surgeon needs to know. *Radiographics* 2006;26:783–793.
24. Manson PN, Markowitz B, Mirvis S, Dunham M, Yaremchuk M. Toward CT-based facial fracture treatment. *Plast Reconstr Surg.* 1990;85:202–212; discussion 213–214.
25. Kassel EE, Noyek AM, Cooper PW. CT in facial trauma. *J Otolaryngol.* 1983;12:2–15.
26. Zilkha A. Computed tomography in facial trauma. *Radiology* 1982;144:545–548.
27. Jank S, Emshoff R, Etzelsdorfer M, Strobl H, Nicasi A, Norer B. The diagnostic value of ultrasonography in the detection of orbital floor fractures with a curved array transducer. *Int J Oral Maxillofac Surg.* 2004;33:13–18.
28. Adeyemo WL, Akadiri OA. A systematic review of the diagnostic role of ultrasonography in maxillofacial fractures. *Int J Oral Maxillofac Surg.* 2011;40:655–661.
29. Ogunmuyiwa SA, Fatusi OA, Ugboko VI, Ayoola OO, Maaji SM. The validity of ultrasonography in the diagnosis of zygomaticomaxillary complex fractures. *Int J Oral Maxillofac Surg.* 2012;41:500–505.
30. Kloss FR, Stigler RG, Brandstätter A, et al. Complications related to midfacial fractures: Operative versus non-surgical treatment. *Int J Oral Maxillofac Surg.* 2011;40:33–37.
31. Hazani R, Yaremchuk MJ. Correction of posttraumatic enophthalmos. *Arch Plast Surg.* 2012;39:11–17.
32. Hollier LH Jr, Sharabi SE, Koshy JC, Stal S. Facial trauma: General principles of management. *J Craniofac Surg.* 2010;21:1051–1053.
33. Burnstine MA. Clinical recommendations for repair of orbital facial fractures. *Curr Opin Ophthalmol.* 2003;14:236–240.
34. Carr RM, Mathog RH. Early and delayed repair of orbitozygomatic complex fractures. *J Oral Maxillofac Surg.* 1997;55:253–258; discussion 258.
35. McLoughlin P, Gilhooly M, Wood G. The management of zygomatic complex fractures: Results of a survey. *Br J Oral Maxillofac Surg.* 1994;32:284–288.
36. Knepil GJ, Loukota RA. Outcomes of prophylactic antibiotics following surgery for zygomatic bone fractures. *J Craniomaxillofac Surg.* 2010;38:131–133.
37. Andreasen JO, Jensen SS, Schwartz O, Hillerup Y. A systematic review of prophylactic antibiotics in the surgical treatment of maxillofacial fractures. *J Oral Maxillofac Surg.* 2006;64:1664–1668.
38. Chole RA, Yee J. Antibiotic prophylaxis for facial fractures: A prospective, randomized clinical trial. *Arch Otolaryngol Head Neck Surg.* 1987;113:1055–1057.
39. Soong PL, Schaller B, Zix J, Iizuka T, Mottini M, Lieger O. The role of postoperative prophylactic antibiotics in the treatment of facial fractures: A randomised, double-blind, placebo-controlled pilot clinical study. Part 3: Le Fort and zygomatic fractures in 94 patients. *Br J Oral Maxillofac Surg.* 2014;52:329–333.
40. Mottini M, Wolf R, Soong PL, Lieger O, Nakahara K, Schaller B. The role of postoperative antibiotics in facial fractures: Comparing the efficacy of a 1-day versus a prolonged regimen. *J Trauma Acute Care Surg.* 2014;76:720–724.
41. Adalarasan S, Mohan A, Pasupathy S. Prophylactic antibiotics in maxillofacial fractures: A requisite? *J Craniofac Surg.* 2010;21:1009–1011.
42. Morris LM, Kellman RM. Are prophylactic antibiotics useful in the management of facial fractures? *Laryngoscope* 2014;124:1282–1284.
43. Kyzas PA. Use of antibiotics in the treatment of mandible fractures: A systematic review. *J Oral Maxillofac Surg.* 2011;69:1129–1145.
44. Bratzler DW, Houck PM; Surgical Infection Prevention Guideline Writers Workgroup. Antimicrobial prophylaxis for surgery: An advisory statement from the National Surgical Infection Prevention Project. *Am J Surg.* 2005;189:395–404.
45. Robiony M, Tenani G, Bellini P, Salgarelli AC. Intraoral approach for aesthetic restoration of posttraumatic zygomatic arch deformities. *J Craniofac Surg.* 2012;23:1418–1420.
46. Raoul G, Dujoncquoy JP, Nicola J, Tison C, Wojcik T, Ferri J. Is transfacial Kirschner wire fixation still indicated in *isolated zygomaticomaxillary complex fractures? Retrospective study of 216 cases in CHRU of Lille: Epidemiology, therapeutic management, and results. *J Craniofac Surg.* 2009;20:1231–1239.
47. Mavili ME, Canter HI, Tuncbilek G. Treatment of noncomminuted zygomatic fractures with percutaneous screw reduction and fixation. *J Craniofac Surg.* 2007;18:67–73.
48. Uda H, Kamochi H, Sugawara Y, Sarukawa S, Sunaga A. The concept and method of closed reduction and internal fixation: A new approach for the treatment of simple zygoma fractures. *Plast Reconstr Surg.* 2013;132:1231–1240.
49. Tarabichi M. Transsinus reduction and one-point fixation of malar fractures. *Arch Otolaryngol Head Neck Surg.* 1994;120:620–625.
50. Soejima K, Sakurai H, Nozaki M, et al. Semi-closed reduction of tripod fractures of zygoma under intraoperative assessment using ultrasonography. *J Plast Reconstr Aesthet Surg.* 2009;62:499–505.
51. Forrest CR. Application of minimal-access techniques in lag screw fixation of fractures of the anterior mandible. *Plast Reconstr Surg.* 1999;104:2127–2134.
52. Lee CH, Lee C, Trabulsy PP. Endoscopic-assisted repair of a malar fracture. *Ann Plast Surg.* 1996;37:178–183.
53. Schubert W, Jenabzadeh K. Endoscopic approach to maxillofacial trauma. *J Craniofac Surg.* 2009;20:154–156.
54. Li Z, Yang RT, Li ZB. Applications of computer-assisted navigation for the minimally invasive reduction of isolated zygomatic arch fractures. *J Oral Maxillofac Surg.* 2015;73:1778–1789.
55. Davidson J, Nickerson D, Nickerson B. Zygomatic fractures: Comparison of methods of internal fixation. *Plast Reconstr Surg.* 1990;86:25–32.
56. Ellis E III, Kittidumkerng W. Analysis of treatment for isolated zygomaticomaxillary complex fractures. *J Oral Maxillofac Surg.* 1996;54:386–400; discussion 400–401.
57. Kim JH, Lee JH, Hong SM, Park CH. The effectiveness of 1-point fixation for zygomaticomaxillary complex fractures. *Arch Otolaryngol Head Neck Surg.* 2012;138:828–832.
58. Feldman EM, Bruner TW, Sharabi SE, Koshy JC, Hollier LH Jr. The subtarsal incision: Where should it be placed? *J Oral Maxillofac Surg.* 2011;69:2419–2423.
59. Ridgway EB, Chen C, Colakoglu S, Gautam S, Lee BT. The incidence of lower eyelid malposition after facial fracture repair: A retrospective study and meta-analysis comparing subtarsal, subciliary, and transconjunctival incisions. *Plast Reconstr Surg.* 2009;124:1578–1586.
60. Ridgway EB, Chen C, Lee BT. Acquired entropion associated with the transconjunctival incision for facial fracture management. *J Craniofac Surg.* 2009;20:1412–1415.
61. Hollier LH, Thornton J, Pazmino P, Stal S. The management of orbitozygomatic fractures. *Plast Reconstr Surg.* 2003;111:2386–2392, quiz 2393.
62. O'Hara DE, DelVecchio DA, Bartlett SP, Whitaker LA. The role of microfixation in malar fractures: A quantitative biophysical study. *Plast Reconstr Surg.* 1996;97:345–350; discussion 351.

63. Suuronen R, Haers PE, Lindqvist C, Sailer HF. Update on bioresorbable plates in maxillofacial surgery. *Facial Plast Surg*. 1999;15:61–72.
64. Suuronen R, Kallela I, Lindqvist C. Bioabsorbable plates and screws: Current state of the art in facial fracture repair. *J Craniomaxillofac Trauma* 2000;6:19–27; discussion 28.
65. Dorri M, Nasser M, Oliver R. Resorbable versus titanium plates for facial fractures. *Cochrane Database Syst Rev*. 2009;1:CD007158.
66. Singh V, Sharma B, Bhagol A. Evaluating the applicability of a biodegradable osteosynthesis plating system in the management of zygomatico-maxillary complex fractures. *Otolaryngol Head Neck Surg*. 2011;145:924–929.
67. Eppley BL. Zygomaticomaxillary fracture repair with resorbable plates and screws. *J Craniofac Surg*. 2000;11:377–385.
68. Nagase DY, Courtemanche DJ, Peters DA. Plate removal in traumatic facial fractures: 13-year practice review. *Ann Plast Surg*. 2005;55:608–611.
69. Kasrai L, Hearn T, Gur E, Forrest CR. A biomechanical analysis of the orbitozygomatic complex in human cadavers: Examination of load sharing and failure patterns following fixation with titanium and bioresorbable plating systems. *J Craniofac Surg*. 1999;10:237–243.
70. Orringer JS, Barcelona V, Buchman SR. Reasons for removal of rigid internal fixation devices in craniofacial surgery. *J Craniofac Surg*. 1998;9:40–44.
71. Bhatt V, Langford RJ. Removal of miniplates in maxillofacial surgery: University Hospital Birmingham experience. *J Oral Maxillofac Surg*. 2003;61:553–556.
72. Chaushu G, Manor Y, Shoshani Y, Taicher S. Risk factors contributing to symptomatic plate removal in maxillofacial trauma patients. *Plast Reconstr Surg*. 2000;105:521–525.
73. Hanemann M Jr, Simmons O, Jain S, Baratta R, Guerra AB, Metzinger SE. A comparison of combinations of titanium and resorbable plating systems for repair of isolated zygomatic fractures in the adult: A quantitative biomechanical study. *Ann Plast Surg*. 2005;54:402–408.
74. Choi HJ, Kim W, Youn S, Lee JH. Management of delayed infection after insertion of bioresorbable plates at the infraorbital rim. *J Craniofac Surg*. 2012;23:524–525.
75. Lee JH, Chang JW, Choi MS, Ahn HC. Delayed infection after a zygoma fracture fixation with absorbable plates. *J Craniofac Surg*. 2010;21:2018–2019.
76. Katsuragi YT, Gomi A, Sunaga A, et al. Intracerebral foreign body granuloma caused by a resorbable plate with passive intraosseous translocation after cranioplasty. *J Neurosurg Pediatr*. 2013;12:622–625.
77. Kumar CR, Sood S, Ham S. Complications of bioresorbable fixation systems in pediatric neurosurgery. *Childs Nerv Syst*. 2005;21:205–210.
78. Bali RK, Sharma P, Jindal S, Gaba S. To evaluate the efficacy of biodegradable plating system for fixation of maxillofacial fractures: A prospective study. *Natl J Maxillofac Surg*. 2013;4:167–172.
79. Murthy AS, Lehman JA Jr. Symptomatic plate removal in maxillofacial trauma: A review of 76 cases. *Ann Plast Surg*. 2005;55:603–607.
80. Phillips JH, Gruss JS, Wells MD, Chollet A. Periosteal suspension of the lower eyelid and cheek following subciliary exposure of facial fractures. *Plast Reconstr Surg*. 1991;88:145–148.
81. Lee EI, Mohan K, Koshy JC, Hollier LH Jr. Optimizing the surgical management of zygomaticomaxillary complex fractures. *Semin Plast Surg*. 2010;24:389–397.
82. Buchanan EP, Hopper RA, Suver DW, Hayes AG, Gruss JS, Birgfeld CB. Zygomaticomaxillary complex fractures and their association with naso-orbito-ethmoid fractures: A 5-year review. *Plast Reconstr Surg*. 2012;130:1296–1304.