An Evidence-Based Approach to Zygomatic Fractures

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The Maintenance of Certification module series is designed to help the clinician structure his or her study in specific areas appropriate to his or her clinical practice. This article is prepared to accompany practice-based assessment of preoperative assessment, anesthesia, surgical treatment plan, perioperative management, and outcomes. In this format, the clinician is invited to compare his or her methods of patient assessment and treatment, outcomes, and complications, with authoritative, information-based references.

This information base is then used for self-assessment and benchmarking in parts II and IV of the Maintenance of Certification process of the American Board of Plastic Surgery. This article is not intended to be an exhaustive treatise on the subject. Rather, it is designed to serve as a reference point for further in-depth study by review of the reference articles presented. (Plast. Reconstr. Surg. 127: 891, 2011.)

CLINICAL SCENARIO

A 22-year-old woman is assaulted by her husband and suffers a displaced fractured zygoma. She has diplopia and enophthalmos, and complains of decreased vision in the affected eye. What is the best evidence to guide you in managing this patient?

Most surgeons manage zygomatic fractures based on what they learned in training, altered only by anecdotal evidence with regard to complications and personal outcomes. The purpose of this article is to provide a summary of the best available evidence on zygomatic fractures that, when combined with individual clinical expertise, can assist the surgeon in the continuing evolution toward optimal outcomes.

METHODS FOR IDENTIFYING EVIDENCE

A literature search of PubMed, the Cumulative Index to Nursing and Allied Health Literature, and the Cochrane Library was performed to obtain the best available evidence on zygomatic fractures, with emphasis on preoperative assessment, treatment, and outcomes. The following search terms were combined as appropriate, and PubMed MeSH terms were used when available: "zygomatic fractures," "zygoma fracture," "orbital fractures," "orbital floor fractures," "diagnosis," "tomography," "x-ray," "computed," "magnetic resonance imaging," "preoperative assessment," "risk factors," "DVT prophylaxis," "antibiotic prophylaxis," "anesthetics," "premedication," "reconstructive surgical procedures," "surgical treatment plan," "treatment," "surgery," "outcome," "complications," "postoperative complications," "hematoma," "seroma," "visual changes," "blindness," "plate exposure," "infection," "pain management," and "analgesia." The initial search was limited to human studies that were published from 1999 to 2009 and indexed as meta-analyses, randomized controlled trials, clinical trials, comparative studies, or case series; however, additional references were included if deemed necessary for discussion. Articles were excluded if they involved cadaver studies or if the full text was inaccessible or of non-English language, as the study quality could not be evaluated. Relevant studies were appraised for quality and validity according to criteria published by the Critical Appraisal Skills Programme1 and assigned a level of evidence with the American Society of Plastic Surgeons Evidence Rating Scales (Tables 1 and 2). Studies included

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Evidence on Preoperative Assessment

A variety of mechanisms are at the heart of the cause of zygomatic fractures. Whether they are associated with multiple facial injuries caused by motor vehicle accidents or isolated components secondary to direct trauma, the diagnosis and assessment of these fractures are critical (Fig. 1). A multitude of diagnostic studies are available to classify and evaluate zygomatic fractures. Nkenke et al. recently compared computed tomography and optical three-dimensional imaging with Hertel exophthalmometry (Diagnosis: Level II Evidence). After evaluating 32 patients, 20 without orbital abnormality and 12 with zygomatic fractures, no statistically significant differences were found between Hertel exophthalmometry and optical three-dimensional imaging. On evaluation of individual measurements, however, Hertel exophthalmometry showed protrusion and enophthalmos in patients with and without dislocated lateral orbital rims that were not apparent on computed tomographic slices. The authors suggest that computed tomographic and optical three-dimensional imaging provide more realistic data on zygomatic fractures than Hertel exophthalmometry.

Ultrasonography can also play a role in the diagnosis of zygomatic fractures (Diagnosis: Level II Evidence). Over a period of 10 months, 60 patients with orbital trauma were evaluated with ultrasonography, using a curved array transducer. Computed tomography was used as a reference method. The ultrasound investigation of the infraorbital rim showed a sensitivity of 94 percent and a specificity of 92 percent, with a diagnostic accuracy of 92 percent. Ultrasonography was determined to be a cost-effective and widely available method, without the disadvantages of radiation exposure.

Finally, although computed tomographic scan examination is the criterion standard for evaluation of facial fractures, magnetic resonance imaging combined with a microscopy orbital coil is a valuable alternative to the computed tomographic

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Table 1. American Society of Plastic Surgeons Evidence Rating Scale for Diagnosis

<table>
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<tr>
<th>Level of Evidence</th>
<th>Qualifying Studies</th>
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<tbody>
<tr>
<td>I</td>
<td>High-quality, multicenter or single-center, cohort study validating a diagnostic test (with a criterion standard as reference) in a series of consecutive patients; or a systematic review of these studies</td>
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<tr>
<td>II</td>
<td>Exploratory cohort study developing diagnostic criteria (with a criterion standard as reference) in a series of consecutive patients; or a systematic review of these studies</td>
</tr>
<tr>
<td>III</td>
<td>Diagnostic study in nonconsecutive patients (without a consistently applied criterion standard as reference); or a systematic review of these studies</td>
</tr>
<tr>
<td>IV</td>
<td>Case-control study; or any of the above diagnostic studies in the absence of a universally accepted criterion standard</td>
</tr>
<tr>
<td>V</td>
<td>Expert opinion; case report or clinical example; or evidence based on physiology, bench research, or “first principles”</td>
</tr>
</tbody>
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Table 2. American Society of Plastic Surgeons Evidence Rating Scale for Therapy

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Qualifying Studies</th>
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<tbody>
<tr>
<td>I</td>
<td>High-quality, multicenter or single-center, randomized controlled trial with adequate power; or systematic review of these studies</td>
</tr>
<tr>
<td>II</td>
<td>Lesser quality, randomized controlled trial; prospective cohort study; or systematic review of these studies</td>
</tr>
<tr>
<td>III</td>
<td>Retrospective comparative study; case-control study; or systematic review of these studies</td>
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<tr>
<td>IV</td>
<td>Case series</td>
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Fig. 1. Classic clinical finding demonstrating periorbital ecchymosis associated with fractures of the zygomaticoorbital area.

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scan in the primary diagnosis of pediatric orbital fractures. Floor fractures, and particularly muscle incarceration, should be diagnosed by high-resolution magnetic resonance imaging combined with a microscopy coil instead of computed tomography to avoid irradiation to the lens and to obtain a better soft-tissue depiction (Diagnosis: Level II Evidence).4

EVIDENCE ON ANESTHESIA

Although no specific evidence could be found on anesthesia, most patients undergo reduction under general anesthesia. It is critical to ensure that the anesthesia tube is away from the site of the injury and that it is secured with wire fixation to the teeth to prevent dislodgement during introral plating of the maxillary buttresses.

EVIDENCE ON ANTIBIOTIC PROPHYLAXIS

Only one study was found on the use of antibiotics for mandibular fractures and, consequently, no formal comments can be made regarding the use of antibiotics for zygomatic fractures. Andreasen et al., however, did note that a one-shot or 1-day administration of prophylactic antibiotics seemed to be the best documented regimen for reducing infections in the management of mandible fractures (Therapy: Level II Evidence).5

EVIDENCE ON SURGICAL TREATMENT PLAN

Approaches to the zygoma can be variable and will depend on the extent of injury.6–32 The zygoma forms the lateral structure of the midfacial skeleton and comprises the lateral and inferior orbital rim and malar eminence. The projections articulate with the sphenoid bone in the lateral orbit and with the frontal bone superiorly, the maxilla medially, and the maxillary alveolus inferiorly. The prominent position of the zygoma makes it susceptible to traumatic injury and accounts for its frequency in injury (Fig. 2). Zygomatic fractures, with the exception of arch fractures, always include a component of the orbital floor. These injuries may be linear or more severe, such as orbital blowout fractures. A general classification of zygomatic fractures includes the following: group I, no significant displacement; group II, zygomatic arch fractures; group III, unrotated body fractures; group IV, medially rotated body fractures with outward displacement at the zygomatic prominence or inward at the zygomatic frontal suture; group V, laterally rotated body fracture with upward displacement at the infraorbital margin or outward displacement at the zygomatico-frontal suture; and group VI, complex comminuted injury (Fig. 3).2–32

Adequate reduction and stabilization is the mainstay of treatment. Wittwer et al. examined the use of biodegradable plates measuring 1.5 or 1.7 mm. Insufficient fracture stabilization, especially at the infraorbital rim and the zygomatico-maxillary crest/anterior sinus wall, was the main reason to switch to titanium osteosynthesis. The biodegradable screw design is possibly too bulky for these particular bony structures. However, no differences in biodegradable fixation plates were found (Therapy: Level II Evidence).6 Furthermore, no differences between biodegradable materials and titanium fixation with respect to fracture healing and postoperative complications were noted (Therapy: Level II Evidence).7

Twelve patients treated using the subtarsal approach for orbital floor fractures were evaluated. One patient suffered from mild lid edema, one scar was noticeable, one patient had scleral show, and one patient had keratoconjunctivitis. No other complications were recorded. The subtarsal approach is a safe and simple procedure for treating orbital floor fractures (Therapy: Level IV Evidence).8

Preseptal incisions were used in 80 patients for different fracture indications. All operative procedures were performed without an additional lateral canthotomy. There was no ectropion or entropion in any of the patients. One laceration to the tarsal plate and one temporary entropion occurred. The preseptal approach is preferable to a
Inappropriate treatment of untreated fractures of the zygomatico-orbital area can result in secondary deformities such as loss of malar projection, enophthalmos, and dystopia. Although contour restoration can be performed with bone grafting, the use of porous polyethylene implants for contour restoration of mild to moderate secondary deformities is safe, with minimal morbidity (Therapy: Level IV Evidence).^{13}

Assessing intraoperative reduction is often difficult. Recently, 14 patients underwent intraoperative cone-beam computed tomography for evaluation of adequate reduction. This technique assisted with evaluating bony reduction, with a low level of metal artifacts in primary and secondary reconstruction (Diagnosis: Level III Evidence).^{14} The integration of a flat-panel detector with the cone-beam computed tomographic imaging will overcome the limitations of the currently available systems. The size of the field of view is increased, allowing visualization of the whole facial skeleton. This is important particularly in unilateral fractures (Diagnosis: Level III Evidence).^{15} It is now possible and financially viable to make relatively inexpensive anatomical models on the basis of computed tomographic images that can be used as templates to form titanium mesh implants that are used in reconstruction of the orbit (Therapy: Level IV Evidence).^{16}

The optimal surgical method for managing blowout fractures is still controversial. Kwon et al. have evaluated 102 patients with pure inferior blowout fractures. Patients with large orbital floor fractures or posterior half-fractures of the orbit should undergo surgery through a transantral or a combined approach. Patients with a trapdoor fracture or anterior half-fracture of the orbit should undergo surgery by means of a transorbital or a combined approach (Therapy: Level IV Evidence).^{17} Ozyazgan et al. have recently reviewed the efficacy of conchal cartilage grafts in defects in the orbital wall that are encountered isolated or in combination with other orbitozygomatic fractures. They examined 10 patients who had defects varying from 100 to 400 mm². In the postoperative period, cartilage grafts were palpated slightly in two patients at the edge of the infraorbital rim. Limitation in eye movement, diplopia, and enophthalmos did not occur in the patients. Conchal cartilage could then be considered as one of the autogenous materials among those materials suitable for the repair of defective orbital wall fractures that are not oversized. It has the following advantages: it is adequate for reconstruction of the facture, easily obtainable, and eas-
ily adaptable to the orbital walls, and it has minimum morbidity at the donor site (Therapy: Level IV Evidence).18

Orbital floor fractures can occur isolated or with zygomatic arch fractures. Computed tomographic scan examination appears to be the first-choice investigation for an orbital floor fracture (Fig. 4).19 Various materials such as autogenous bone, cartilage, and alloplastic implants have been used to reconstruct orbital floor fractures. Floor fractures larger than 2.0 cm should be considered for repair.32 Between 2002 and 2004, 17 maxillofacial trauma patients complicated with orbital floor fractures were treated with resorbable mesh plate through a subciliary or transconjunctival incision. Patients were evaluated by computed tomographic examination at 3, 6, and 12 months. No infections, diplopia, or gaze restrictions were noted. Three patients had scleral show. Resorbable mesh appears to be safe and effective for reconstruction of the nonextensive orbital floor fracture (Therapy: Level IV Evidence).20 Other implants have been used for the orbital floor. Villarreal et al. reviewed 32 patients with orbital floor fractures that were treated with porous polyethylene ultrathin sheets. There were four cases of postoperative facial infections: two resolved with systemic antibiotics, one resolved with bone sequestrum resection, and one required removal of the implant. The orbital infections were related in all cases to titanium osteosynthesis miniplates or skull bone graft. Correction of hypoglobus is technically easier than enophthalmos, because enophthalmic correction requires a wide, deep subperiosteal dissection and implant positioning, posterior to the equator of the globe, with the inherent risk of orbital apex injury (Therapy: Level IV Evidence).21 Xu et al. further followed 68 patients who underwent corrected for orbital blowout fractures. Only one patient developed postoperative ectropion, for which local suspending was required. All orbital floors were reconstructed with porous polyethylene sheets that were determined to be reliable. Overcorrection by 1 to 2 mm is necessary during surgery to neutralize the tissue swelling or atrophy (Therapy: Level IV Evidence).22 Reconstruction of the inferior orbital wall with the use of bone grafts harvested from the anterior maxillary wall have been reviewed. In 11 patients, these fractures were “blowout,” and in seven the orbital wall accompanied zygomatico-orbital fractures. In all cases, full improvement was affirmed and there were no postoperative complications (Therapy: Level V Evidence).23

Wolfe et al. recently reviewed 317 patients operated on for orbital fractures. A number of causes for reoperation seen in the posttraumatic, postsurgical orbital deformity group were not seen in the group that was operated on primarily. These included lower eyelid retraction attributable to use of the subciliary incision, displacement and extrusion of alloplastic materials, and fixation of fractures in a nonreduced position. These differences validate the application of the basic principles of craniofacial reconstruction set forth by Paul Tessier for these posttraumatic orbital deformities to achieve the best overall results (Therapy: Level IV Evidence).24

Although plate-and-screw fixation is the mainstay for zygomatic and orbital fractures, Yonehara et al. recommend that fixation of the inferior orbital rim with miniplates or microplates should be avoided because of postoperative scarring and sensory disturbances caused by a subciliary incision. They confirm the status of the inferior orbital rim reduction by palpation. Naturally, fixation for comminuted fractures of the inferior orbital rim with herniation of internal orbital components is recommended (Therapy: Level IV Evidence).25

Fig. 4. Three-dimensional reconstruction following surgical repair of orbital floor fracture with titanium mesh. The drawback is its unpredictable resorption. In the present study, among the hypophthalmic orbits, intense bone resorption was observed in 60 percent. The decrease in the vertical support of the globe may lead to minor hypophthalmos without enophthalmos. Overcorrection of the fracture area is recommended. (From Kontio RK, Laine P, Salo A, Paukku P, Lindqvist C, Suuronen R. Reconstruction of internal orbital wall fracture with iliac crest free bone graft: Clinical, computed tomography, and magnetic resonance imaging follow-up study. Plast Reconstr Surg. 2006;118:1365–1374.)
Alternative approaches to reduction and fixation can also occur. Recently, segmental osteotomy techniques of the zygoma have been used with success. At 1-year follow-up, the segmental osteotomies have reduced complications and attained a better aesthetic result. Subjective assessment of the patient’s globe position found that 88.5 percent of the patients were satisfied with the outcome, and 11.5 percent of the patients found it unacceptable. Compared with the traditional method, segmental osteotomy is a simple technique that requires less dissection and can reconstruct the orbital anatomical structure and restore globe position effectively (Therapy: Level IV Evidence).26

Endoscopic repair of orbital floor fractures offers an alternative method of approaching the orbital floor. Studies in cadavers indicate that endoscopic repair is efficacious compared with traditional techniques.27

Finally, computer-aided surgery has been found to be useful in reconstructive craniomaxillofacial surgery. Preoperative planning for zygomatic fractures may improve overall outcome. The symmetry of unaffected human skulls and faces was evaluated by midface computed tomographic data of 20 skulls and surface-scan data of 20 healthy individuals. In addition, 18 consecutive cases were selected that had been treated with computer-aided surgery. No differences between the skull and face symmetry were found. The natural asymmetries in humans influence the accuracy of preoperative planning procedures. Transforming the planning to the surgical reconstruction using computer-aided surgery depends on the location, the surgical approach, and the manner of reconstruction (Therapy: Level III Evidence).28

**EVIDENCE ON POSTOPERATIVE OUTCOMES**

The critical aspect of all care is to evaluate the outcomes. Merten and Höng compared two different methods of internal rigid fixation of the frontozygomatic suture line in one group with miniplates and in another group with lag screws. Lag screw fixation in malar fractures could lower hardware treatments costs and is an alternative method that provides sufficient stability in indicated patients.29

Questions have often arisen regarding resorption and bone grafting. Kortio et al. examined 24 patients with unilateral orbital wall fractures that underwent reconstruction with iliac bone grafts. At each follow-up visit, globe posture, diplopia, and eye movements were assessed. The resorption rate was high, but most of it was advantageous remodeling. The overall outcome was good. Secondary operations led to poor outcomes. Thin computed tomographic and magnetic resonance imaging sections are needed to evaluate accurately bone graft placement and posture and orbital volume (Therapy: Level IV Evidence).30

Delayed treatment frequently leads to less ideal reconstructions. Delayed panfacial fractures with accompanying mandible fractures can increase the risk for unreduced segments and increase the rate of complications. Reconstruction of the mandible first with Le Fort I osteotomy is a good way of treating delayed panfacial fractures. Computed tomography and three-dimensional computed tomography and model surgery are occasionally able to identify three-dimensional asymmetries which were often the factors that caused an unfavorable outcome.31

**SUGGESTED TREATMENT FOR CLINICAL SCENARIO**

When practicing evidence-based medicine, the surgeon should consider the strength of the available evidence and integrate the evidence with his or her clinical expertise and the patient’s values and preferences to develop an appropriate treatment plan. The treatment plan below is an example of how the surgeon might use the evidence to care for this particular patient.

A 22-year-old woman is assaulted by her husband and suffers a displaced fractured zygoma. She has diplopia and enophthalmos, and complains of decreased vision in the affected eye. She is evaluated by means of computed tomography. After determining appropriate diagnosis of bony injury and after evaluation of the globe for injury secondary to decreased vision, the patient is taken to the operating room for open reduction and internal fixation (Level II, IV Evidence). Placement of bone grafts or porous propylene for orbital support and volume restoration completes the surgery (Level IV Evidence). Resuspension of the soft tissues assists with overall outcomes (Level IV Evidence).

**PATIENT CONSENT**

The patient provided written consent for the use of her image.
ACKNOWLEDGMENTS

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REFERENCES


