Classification and Treatment of Zygomatic Fractures: A Review of 1,025 Cases

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The treatment of zygomatic fractures varies among surgeons, and the cosmetic and functional results are frequently less than optimal. A treatment guideline based on a simple classification of zygomatic fractures is presented. The emphasis is placed on the indications for closed and open reduction, consistent methods of three-dimensional alignment and fixation, and the management of concomitant infraorbital rim and orbital floor fractures. Postoperative results with regard to infraorbital nerve and maxillary sinus dysfunction, malar asymmetry, and orbital complications in the treatment of 1,025 consecutive zygomatic fractures are presented.

Fractures of the zygoma are relatively frequent and their management has been extensively described. Yet, postoperative complications such as malar asymmetry, visual disturbances, diplopia, orbital dystopia, enophthalmus, and sensory deficits involving the infraorbital nerve have been reported by various authors.¹⁻⁶

This article discusses the classification of fracture patterns, the indications for closed and open reduction, the surgical technique, and modifications that have been made. The functional and esthetic results obtained with these methods in the treatment of 1,025 consecutive zygomatic fractures are presented.

Material

One thousand twenty-five consecutive fractures of the zygoma managed by the Department of Cranio-maxillofacial Surgery at the University Hospital in Bern, Switzerland, during the years 1978 to 1989 were reviewed retrospectively. Standard radiographs with Caldwell, Waters, and submental vertex views had been obtained in all patients preoperatively. Patients with more extensive craniofacial, orbital, or midface fractures underwent high-resolution axial and coronal computed tomography (CT). In selected cases, three-dimensional reconstruction of the CT was performed. Ophthalmology consultations were obtained preoperatively in all patients suspected of ocular injury, diplopia, and possible extraocular muscle entrapment.

Surgical Anatomy

The term "tripod fracture" attributed to a specific type of zygomatic fracture is a misnomer because, along with its frontal, maxillary, and temporal articulations, the orbital extension of the zygoma has a broad abutment against the greater wing of the sphenoid, thus rendering it a tetrapod.⁷,⁸ This surface of the zygoma constitutes most of the lateral orbital wall and also forms part of the orbital floor lateral to the infraorbital groove. Therefore, a displaced zygomatic fracture, by definition, is also an orbital floor fracture. Failure to
accurately reposition the lateral orbital complex, as well as insufficient repair of the orbital floor, can, therefore, be a major factor in the development of posttraumatic visual disturbances. Inaccurate three-dimensional restoration of the original configuration of the malar complex will consequently result in enlargement of the orbital cavity. Additionally, even a minor displacement of the malar prominence leads to unfavorable esthetic results.

**Fracture Classification**

The patients were subjected to a simple classification system for zygomatic fractures based on the previously described anatomic points and the fracture patterns as follows:

**Type A**: Incomplete zygomatic fracture. Low-energy injuries frequently cause isolated fractures of only one zygomatic pillar. This may be an isolated zygomatic arch fracture (A1), a lateral orbital wall fracture (A2), or an infraorbital rim fracture (A3). Displacement of the malar complex does not occur because the remaining pillars are intact (Fig. 1A-C).

**Type B**: Complete monofragment zygomatic fracture (tetrapod fracture). All four pillars of the malar bone are fractured and displacement may occur. This is the so-called “classic tripod fracture,” but anatomically these fractures are actually tetrapod fractures and should be thus called (Fig. 1D).

**Type C**: Multifragment zygomatic fracture. Same as Type B, but with fragmentation, including the body of the zygoma (Fig. 1E).

Occasionally, the distinction between Type A, B, and C fractures was evident on high-resolution CT only. There were 8% (79) type A, 57% (587) type B, and 35% (359) type C fractures in our series.

**Treatment Modalities and Surgical Methods**

The purpose in treating zygomatic fractures is to restore the premorbid malar and orbital configuration.
while avoiding complications such as facial asymmetry, visual disturbances, diplopia, orbital dystopia, enophthalmus, and infraorbital paresthesia. The surgical treatment of the various types is shown in Table 1.

Type A1: Zygomatic arch fractures. Zygomatic arch fractures may be reduced effectively by closed reduction. A J-shaped, curved hook elevator is inserted just below the zygomatic arch anterior to the articulating eminence through a preauricular transcutaneous stab incision. After positioning the tip of the hook directly under the dislocated bone fragments, reduction is achieved by well-controlled lateral traction. Stabilization with miniplates via a coronal flap has become fashionable in the last few years. It is an unnecessarily aggressive form of treatment, because the temporalis and masseter muscles and fasciae, along with the adjacent soft tissues, splint the arch sufficiently to stabilize the fragments. No functional loads are exerted that will result in displacement. Closed reduction in experienced hands gives optimal functional and aesthetic results. Minimal postoperative fragment in congruency, even if present, is neither functionally nor esthetically relevant.

Type A2: Lateral orbital rim fractures. Open reduction and osteosynthesis give the most favorable functional and aesthetic results in this type of fracture. A lateral brow incision of not more than 2 cm was used for access of isolated fractures. A coronal flap is preferred only if concomitant supraorbital-frontal fractures are present.

Type A3: Infraorbital rim fractures. Infraorbital rim fractures are mostly associated with orbital floor fractures. Open reduction is indicated if the fragments are dislocated, or if there is an entrapment of peri-orbital soft tissue. The transconjunctival route, without lateral canthotomy, is used exclusively, regardless of fracture severity or fragment displacement. This approach gives optimal exposure of the fractured area without any cutaneous scars, and causes less complications than the standard transcutaneous approaches. Particular caution is taken to avoid injury to the tarsal plate, cornea, and lacrimal duct. Because dissection of the muscle and damage to the lymphatic vessels are avoided, complications such as lower lid edema or entropion can be reduced to a minimum. The use of this approach for all infraorbital rim and orbital floor fractures has been described previously. Prolapsed orbital tissue has to be elevated and defects in the orbital floor up to 5 mm in diameter are covered with lyophilized dura. For larger defects, lyophilized cartilage or split calvarial grafts are used. Even in cases with extremely large defects, a broad exposure, including the lateral and medial walls, as well as up to the orbital apex, will usually provide sufficient three-point support for the cartilage layers or bone graft. Only seldomly is additional lag screw fixation necessary. The screw is usually inserted in the infraorbital rim and along the orbital part of the lateral orbital wall. Even small orbital floor fragments are repositioned. In our opinion, miniplates or application of mesh plate implants are generally contraindicated. Infraorbital rim fragments are stabilized with absorbable sutures or wire ligatures only. Miniplates are used only in cases with loss of bone in this area.

Type B: Monofragment zygomatic fractures (tetrapod fractures). Closed reduction is indicated for tetrapod fractures without extensive disruption of the orbital floor and infraorbital rim. Prolapse or incarceration of orbital contents through the orbital floor defects, as well as insufficient postoperative stability of the cheekbone, necessitate open reduction.

Closed reduction is performed with a J-shaped, curved hook elevator inserted through an intraoral incision or a stab incision just below the zygomatic arch (Fig 2A). The elevator is then engaged directly under the body of the zygoma (Fig 2B) and traction is applied to reduce the fracture. The site of insertion for the elevator hook depends on the fracture configuration and the force vectors required for reduction. For example, in simple distocaudal dislocations of the zygoma, an intraoral insertion usually enables forward advancement of the zygoma into the correctly reduced position, but if the fractured zygoma is displaced distally with medial collapse, lateral traction will need to be applied.

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**Table 1. Treatment Modalities**

<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>No. of Fractures</th>
<th>No. of Closed Reduction (%)</th>
<th>No. of Open Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (isolated zygomatic arch)</td>
<td>63</td>
<td>63</td>
<td>-</td>
</tr>
<tr>
<td>2 (isolated lateral orbital rim)</td>
<td>7</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3 (isolated infraorbital rim)</td>
<td>9</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>Type B (tetrapod fracture)</td>
<td>587</td>
<td>164 (28)</td>
<td>423 (72)</td>
</tr>
<tr>
<td>Type C (multifragment fracture)</td>
<td>359</td>
<td>-</td>
<td>359</td>
</tr>
<tr>
<td>Total</td>
<td>1,025</td>
<td>229 (22.3)</td>
<td>796 (77.7)</td>
</tr>
</tbody>
</table>
FIGURE 2. Insertion of the hook for closed reduction of type A1 and type B fractures through a preauricular transcutaneous access. Arrowheads show distal contour of zygomatic arch up to the articular eminence.

to the body and arch of the zygoma. Injury to the facial nerve can be avoided if the hook is inserted preauricularly at the level of the articular eminence where facial nerve branches are absent, and if before applying lateral traction one is sure that the hook is engaged underneath the arch and/or the body of the zygoma. However, if the hook is not adequately engaged, it may slide along the surface of the body of the zygoma, thus damaging the nerve branches.

Open reduction is indicated if there is instability on digital pressure following reduction. One must first correctly reduce the three pillars: frontozygomatic, zygomaticomaxillary buttress, and the infraorbital rim. The zygomatic arch is subsequently aligned with the help of the J-hook. As already mentioned, miniplates are limited to the load-bearing buttresses; the infraorbital rim is only adapted with wire ligatures. With the majority of the type B fractures, a miniplate applied to the frontozygomatic buttress is sufficient to maintain the achieved reduction.

Type C: Multifragment zygomatic fractures. Multifragmentation represents an absolute indication for open reduction and stabilization with adequate osteosynthesis. Access to multifragmented zygomatic fractures is provided through a lateral eyebrow and a buccal incision, combined with the transconjunctival approach, avoiding a lateral canthotomy. A coronal flap is used only if there are concomitant skull base and/or craniofacial fractures.

Exposure, inspection, and alignment of the following are crucial for successful three-dimensional reduction: 1) frontozygomatic buttress, 2) medial surface of the lateral orbital wall-greater wing of sphenoid area, 3) inferior orbital rim, 4) orbital floor, and 5) zygomaticomaxillary buttress area. The inspection of the frontozygomatic articulation, and particularly the medial surface of the lateral orbital wall-greater wing of the sphenoid area, is of utmost importance, presenting a key component for the achievement of an accurate three-dimensional reduction and restoration of the preinjury configuration.

Saving and repositioning of even tiny bone fragments of the infraorbital rim are crucial. Conservation of these fragments enables the achievement of the correct premorbid contours. It should be emphasized that the adaptation of the multiple fragment borders is crucial for maintaining the curvature of the infraorbital rim, but more important are the correct angulation and inclination. Even slight inaccuracies at this site may result in major displacement of the malar prominence. Although replacement of such small fragments by bone grafts is easier, an aberration of the original contour is often an unpleasant complication.

Concomitant orbital floor fractures should be treated as previously described for type A3 fractures. Prior to definitive fixation of this severely comminuted fracture of the zygomatic complex, congruency and alignment of the fracture borders must be inspected again to assure correct three-dimensional repositioning of the frontozygomatic suture, lateral orbital rim fragments, and the zygomaticomaxillary buttress. The achieved reduction is maintained by manual pressure and with help of a hook, as well as by tightening of the tempo-
REDUCTION OF 1,025 ZYGOMATIC FRACTURES

FIGURE 3. Multifragmented, displaced fracture of the zygoma (arrowhead) and nasal buttress (arrow). A. Axial CT. B. Lateral eyebrow incision and miniplate fixation of frontozygomatic suture. C. Buccal approach for miniplate osteosynthesis of the zygomaticomaxillary buttress. D. Multifragmented infraorbital rim (arrowhead) and orbital floor (arrow) fractures exposed transconjunctivally. E. Lower lid. F. Reduced infraorbital rim fragments fixed by wire ligatures (arrowhead). G. Lyophilized cartilage layer (c) for bridging of the orbital floor defect (arrow). H. Reconstructed infraorbital rim and orbital floor. Note that the upper eyelids are closed for corneal protection. I. Lyophilized cartilage layer. J. Postoperative radiograph showing miniplate (arrow) and infraorbital wire ligatures (arrowhead). K. View of patient 6 months postoperatively.

FIGURE 3 (Cont'd).
rarily applied ligatures; then, stable fixation is performed. In this type of fracture, stabilization with miniplates at the frontozygomatic and zygomaticomaxillary buttresses, as well as at the malar prominence, is often indicated. Inspection and alignment of the orbital floor and zygomatic arch should always be performed. This sequence of reduction and stepwise fixation is crucial for the achievement of a correct anatomic relationship.

**Zygomatic arch.** Following alignment of the arch, type A1 fractures need no further fixation. When involved in multifragment fractures, regarding this pillar as a main reference point for establishing the correct position of the malar bone will often lead to disappointing results. Even slight differences in the inclination of the fragments following miniplate fixation can result in an altered contour, as well as displacement of the malar prominence. The displacement is particularly disturbing when it is in a lateral direction.

Anterior maxillary wall fragments displaced into the sinus have to be elevated, repositioned, and stabilized with resorbable sutures. Defects are bridged by lyophilized cartilage layers\(^{19}\) or split calvarial grafts. Miniplate fixation of these fragments seems to promote fragment resorption and latent chronic sinusitis, and should therefore be minimized.

In the presence of associated craniofacial or midface fractures, a one-stage management of all fractures is a precondition to achieve optimal results. Guidelines concerning integral treatment of craniofacial fractures have already been described.\(^{15-17}\) Concomitant Le Fort I, II, and alveolopalatal process fractures should be reduced first. After correct establishment of the occlusion, the proper maxillary relation is maintained by miniplates applied adjacent to the nasal aperture and at the zygomaticomaxillary buttresses. Multiple fragments in these areas are interpositioned so as to achieve the correct relationship to the reduced zygoma. The following cases highlight key aspects and special problems in the management of zygomatic fractures.

**Report of Cases**

**Case 1**

This case represents an incidence of isolated multifragment zygomatic fracture (Fig 3A-I). The infraorbital rim, zygomaticomaxillary buttress, and anterior maxillary wall were multirighted, and the floor of orbit was depressed. For inspection of the fractured areas, a lateral eyelid incision (Fig 3B), a buccal incision (Fig 3C), and a transconjunctival approach (Fig 3D) were used. Careful inspection of all fractured areas, especially of the frontozygomatic area, and the medial surface of the lateral orbital wall—greater wing of the sphenoid area is one of the key points to establish correct three-dimensional positioning of the malar complex. Fracture fixation with miniplates over the frontozygomatic (Fig 3B) and zygomaticomaxillary (Fig 3C) buttresses guarantees the anterolateral stability of the malar complex. The multiple small fragments of the infraorbital rim (Fig 3D) are wedged and compressed and then stabilized with wire ligatures (Fig 3E). Lyocartilage is used for the reconstruction of the floor of the orbit (Fig 3F, G). The postoperative result (Fig 3H, I) illustrates the advantage of the transconjunctival approach to the infraorbital rim.

**Case 2**

In this case of an open multifragmented zygomatic fracture, extensive disruption of the supraorbital-frontal area and concomitant fracture of the frontal skull base were evident (Fig 4A-F). Several fragments of the supraorbital region and orbital roof were traumatically exposed (Fig 4B, C). Following subcranial management of the frontobasal skull base fractures,\(^{15-17}\) the supraorbital-frontal region was reconstructed through the extensive laceration. Reimplantation and miniplate fixation of the frontal fragments were necessary (Fig 4D) to achieve reduction of the zygoma in correct relation to the reduced supraorbital rim and frontozygomatic articulation (Fig 4E). No primary bone grafts were used in this situation because only the original fragments can guarantee a correct three-dimensional reduction. The 1-year postoperative result is shown in Fig 4F.

**Case 3**

The patient in Figure 5 had an open multifragmented zygomatic fracture with considerable loss, extending into the frontotemporal skull (Fig 5A-C). An associated nasoethmoidal and frontobasal skull base fracture with cerebrospinal fluid leakage also was present. Exposure through the large laceration enabled the management of the anterior skull base (Fig 5C), as well as the reduction and miniplate fixation of the supraorbital-frontal fractures (Fig 5D). The infraorbital region and floor of the orbit were managed through the transconjunctival approach. The extensive bone loss in the frontotemporal area and supraorbital rim required bone grafting, harvested from the iliac crest, as well as miniplate osteosynthesis (Fig 5D, E). The postoperative result after 6 months (Fig 5F) showed some unfavorable scars from the facial lacerations, but there was no facial asymmetry. Because of resorption of bone grafts, the 2-year postoperative result (Fig 5G) shows some asymmetry of the supraorbital-frontal area, but no diplopia was present.

**Case 4**

The combination of a multifragmented zygomatic fracture along with extensive disruption and displacement of the midface is shown in Figure 6. First, the occlusion was established with maxillomandibular fixation, and temporary fixation of the malar complex with a wire ligature across the frontozygomatic suture was done. After alignment of all pillars and placement of all fragments in proper relation, miniplate osteosynthesis was performed across the load-bearing buttresses (Fig 6D). Management of the infraorbital rim (Fig 6C) was done through a transconjunctival approach; wire ligatures were used exclusively for stabilization of the wedged and compressed fragments in this area. The postoperative view shows good facial symmetry, with no cutaneous scars (Fig 6E).

**Results**

Of the total 1,025 patients reviewed, there was a male preponderance of three to one. The average age was
FIGURE 5. Axial CT of patient. Combined multifragmented zygomatic complex fracture and intracranially dislocated frontal and skull base fractures (arrowhead). C. Intraoperative view showing soft tissue injury, loss of bone at the supraorbital region (arrowhead), and exposed lacerated dura (d). D. Following watertight closure of the dural tears along the frontoethmoidal skull base planes, reconstruction of the supraorbital region using bone grafts (g) and miniplates was performed. E. Radiograph. F. View of patient 3 months postoperatively illustrate correct esthetic and functional relations. G. View of patient 1 year postoperatively showing result of slight resorption of the bone graft (arrow).

37.5 years, with a range from 2 to 89 years. Follow up was from 2 to 5 years, with an average of 18 months. Cosmetic and functional analysis of the results of surgical intervention included ophthalmic and otolaryngologic evaluations, along with anthropometric measurements for facial symmetry. These data were registered in the patient's file on serial follow-up examinations to ensure proper documentation and to facilitate retrieval of information. The low dropout rate in our series was attributable to the Swiss medical insurance system, which calls for close serial follow-up evaluations.

Infraorbital nerve dysfunction (Table 2) was noted in 23.9% of the patients in our series. Complete anes-
FIGURE 6. Preoperative radiograph (A) and coronal CT (B) showing combined (arrowhead) zygomatic complex and midface fractures (arrow). C. Transconjunctival approach used for reduction of the infraorbital rim fragments using wire ligatures (arrowhead). D. Miniplate osteosynthesis of the load-bearing buttresses (arrowhead) and wire ligatures at the infraorbital rim (arrow). E. Patient 1 year postoperatively showing good symmetry.

Anesthesia was defined as the loss of sensation over the entire V-2 distribution, and dysaesthesia was defined as an abnormal sensation with only partial nerve involvement. The difference between patients with open and closed reduction is evident. The lower rate of infraorbital nerve dysfunction involved with closed reductions can be explained by the lesser degree of displacement associated with fractures treated in this manner. On the other hand, damage to the infraorbital nerve resulting in total anesthesia in 24 cases of type C fracture is likely attributable to the force of impact and the severity of the injuries. The discrepancy in total and partial dysfunction between surgically treated type B and C fractures was somewhat unexpected. The most probable explanation for this is that perhaps in certain type C fractures, the force of impact is completely absorbed by the zygoma complex and the orbital frame resulting in multifragmentation; the infraorbital nerve is subsequently spared or even decompressed in these instances.

Maxillary sinus dysfunction (Table 3) in the form of clinical or subclinical sinusitis and oroantral fistula was very low in this series (8.4%). We believe that it was owing to our policy of reconstructing this area. Furthermore, the biocompatibility of lyophilized cartilage may also be a factor. Gauze or balloon catheter packing of the antrum were strictly avoided. Dysfunction appears to be directly related to the severity of the fracture, as shown in Table 3. Sinus complications refractory to local treatment or medical therapy underwent surgical management.

Complications related to inaccurate reduction of the fractures are documented in Table 4. Malar symmetry was analyzed anthropometrically using a screen and the McCoy Facial Trisquare. These measurements alone were, however, insufficient, and not objective
Table 2. *Infraorbital Nerve Dysfunction*

<table>
<thead>
<tr>
<th>Type of Fractures</th>
<th>Treatment Modality</th>
<th>No. of Fractures</th>
<th>Anesthesia Over Complete Area (%)</th>
<th>Over Complete Area (%)</th>
<th>Over Focal Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>Closed reduction</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Open reduction</td>
<td>9</td>
<td>—</td>
<td>2 (1.2)</td>
<td>13 (7.9)</td>
</tr>
<tr>
<td>Type B</td>
<td>Closed reduction</td>
<td>164</td>
<td>—</td>
<td>53 (12.5)</td>
<td>78 (18.4)</td>
</tr>
<tr>
<td></td>
<td>Open reduction</td>
<td>423</td>
<td>24 (6.7)</td>
<td>9 (2.5)</td>
<td>48 (13.4)</td>
</tr>
<tr>
<td>Type C</td>
<td>Open reduction</td>
<td>359</td>
<td>—</td>
<td>64 (6.7)</td>
<td>140 (14.7)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>955</td>
<td>24 (2.5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

enough to assess the malar prominence, where minor discrepancies are often readily apparent. Subjectivity was minimized by having independent assessments performed by the departments of neurosurgery and otolaryngology. A major method of comparison was the use of preoperative and postoperative photographs. The patient’s own assessment and input from family members were also taken into consideration. Minor asymmetries that were not appreciated by patients were not treated. Major asymmetries were mostly corrected secondarily.

Enophthalmos with diplopia was found in 40 patients (3.9%). Inadequate reduction of the zygoma leading to enlargement of the orbital cavity was a major causative factor. Insufficient orbital floor reconstruction and atrophy of traumatized periorbital fatty tissues were other possible causes; these causes were evident at revision surgery.

Complications related to the transconjunctival approach (Table 5) were mainly entropion (0.4%), ectropion (0.7%), and corneal abrasion (0.1%). Poorly placed incisions, inattentive placement of retractor, tarsal plate injuries, inadequate repositioning of the periobita prior to closure, and overlapping closure of the conjunctiva were responsible for these results. Persistent lower lid edema, commonly seen with transcutaneous techniques, was not observed in our patients. The fact that no external skin incisions or lateral canthotomy were performed and the transconjunctival approach was used exclusively explains the low incidence of entropion-ectropion. Dissection of muscle and damage to the blood and particularly lymphatic vessels, as well as unnecessary scar tissue formation in the lower lid region, are thus avoided. Compared with others,15 the incidence of complications is reduced.

**Discussion**

A variety of classifications have been proposed for the zygomatic fractures.25-27 Most of them are descriptive and often fail to consider the three-dimensional nature of these fractures and their surgical implications. A recent attempt at putting forth a new classification,28 based on axial CT images and on the intensity of energy imparted, again shows this shortcoming. Without coronal CT images, the three-dimensional configuration of the fracture is not readily apparent, and particularly in high-energy traumas it is imperative to rule out concomitant anterior skull base injuries.

Table 3. *Maxillary Sinus Complications (Dysfunction)*

<table>
<thead>
<tr>
<th>Type of Fractures</th>
<th>n</th>
<th>Symptomatic Clouding (%)</th>
<th>Asymptomatic Clouding (%)</th>
<th>Oroantral Fistulas (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td></td>
<td>65</td>
<td>1 (0.6)</td>
<td>3 (1.8)</td>
</tr>
<tr>
<td>Closed reduction</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Open reduction</td>
<td>14</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Type B</td>
<td></td>
<td>164</td>
<td>1 (0.6)</td>
<td>3 (1.8)</td>
</tr>
<tr>
<td>Closed reduction</td>
<td></td>
<td>423</td>
<td>8 (1.8)</td>
<td>15 (3.5)</td>
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<td>Open reduction</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Type C</td>
<td></td>
<td>359</td>
<td>14 (3)</td>
<td>37 (10.3)</td>
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<tr>
<td>Open reduction</td>
<td></td>
<td>359</td>
<td>14 (3)</td>
<td>37 (10.3)</td>
</tr>
<tr>
<td>Only</td>
<td></td>
<td>1,025</td>
<td>23 (2.2)</td>
<td>55 (5.4)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,025</td>
<td>23 (2.2)</td>
<td>55 (5.4)</td>
</tr>
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</table>
Table 4. Postoperative Complications Related to Inaccurate Reduction

<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>No. of Fractures</th>
<th>No. of Minor Asymmetry (%)</th>
<th>No. of Major Asymmetry (%)</th>
<th>No. of Enophthalmus with Diplopia (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed reduction</td>
<td>65</td>
<td>2 (3.1)</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Open reduction</td>
<td>14</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Type B</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Closed reduction</td>
<td>164</td>
<td>16 (9.6)</td>
<td>2 (1.2)</td>
<td>-</td>
</tr>
<tr>
<td>Open reduction</td>
<td>423</td>
<td>31 (7.3)</td>
<td>19 (4.5)</td>
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<tr>
<td>Type C</td>
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</tr>
<tr>
<td>Open reduction only</td>
<td>359</td>
<td>41 (11.4)</td>
<td>16 (4.5)</td>
<td>33 (9.2)</td>
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<tr>
<td>Total</td>
<td>1,025</td>
<td>90 (8.8)</td>
<td>37 (3.6)</td>
<td>40 (3.9)</td>
</tr>
</tbody>
</table>

The simple classification described in this paper was developed from our experience in treating more than 1,000 fractures. We believe that it adequately encompasses the spectrum of fracture patterns and offers a more orderly approach to the management of fractures. When the treatment guidelines are followed, the results are uniformly superior.

The correct three-dimensional reduction and restoration of the premorbid facial contours require adequate exposure of the fracture sites; this is achieved via lateral brow, intraoral and transconjunctival incisions, often used in concert. The coronal flap is used only if concomitant skull base, nasoethmoidal, or frontocranial injuries exist. The standard use of this flap for the lateral orbital rim is not justified, because the lateral brow approach is more direct and is nearly invisible. However, the dictum of "no scar is better than a good scar" is strictly adhered to for access to the orbital floor and infraorbital rim. The transconjunctival approach is used exclusively rather than other standard transcutaneous subciliary or subtarsal incisions.29,30 External incisions, apart from leaving a visible scar, often produce postoperative lower lid edema, ectropion, and other cosmetic and functional deformities. In comparison, the transconjunctival technique is simple and relatively trouble-free. Lateral canthotomy for improved exposure, as advocated by some,31-33 is in our view unnecessary.

Following exposure, precise reduction at the frontozygomatic, zygomaticomaxillary, and infraorbital buttresses is imperative. What is most important, however, is the abutment of the lateral orbital extension of the zygoma with the greater wing of the sphenoid; this is a key area in determining the final outcome. If displacement is unrecognized in this area, axial rotations will lead to less-than-adequate cosmetic and, more importantly, functional results. Even minor inaccuracies in the reduction of zygoma fractures can be unforgiving.

Maintaining the correctly reduced configuration is best achieved by miniplate osteosynthesis. The development and application of this technique over the past 20 years in Europe has recently begun to arouse considerable interest in North America, but often with an overzealous enthusiasm. Extensive plating of the facial skeleton should be discouraged and its use limited to areas of the load-bearing buttresses. Three-point alignment does not necessitate rigid fixation at all three pillars.34 In some instances, a single miniplate may be adequate to preserve the correct reduction;7 on the other hand, an additional plate over the zygomaticomaxillary buttress may be indicated to give the proper anterior projection of the malar complex in unstable type B and most type C fractures. In principle, miniplate osteosynthesis is limited to certain vertical and horizontal buttresses, whereas areas such as the zygo-

Table 5. Complications Related to Transconjunctival Approach

<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>No. of Incisions</th>
<th>No. of Tarsal Lesions</th>
<th>No. of Corneal Abrasion</th>
<th>No. of Entropion</th>
<th>No. of Ectropion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>9</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Type B</td>
<td>423</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Type C</td>
<td>359</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>955</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>
matic arch, infraorbital rim, orbital floor, and the anterior wall of the maxilla should be avoided (Fig 7). The latter areas do not experience any significant functional loads once fixation of the buttresses is achieved. Furthermore, miniplate osteosynthesis in these areas may lead to undesirable consequences, such as inaccurate restoration of the three-dimensional configuration of the zygoma and inflammatory reactions and bone fragment–graft resorption.

Many surgeons are tempted to use miniplates in the infraorbital area for ease of reconstruction and at times in conjunction with bone grafts for comminuted fractures where the application of screws is impossible owing to the small fragment size.30,35,36 This method gives a false sense of security, because the mere adaptation of fragments is insufficient. Only the meticulous apposition of the fragments reproducing the premorbid inclination and contour enable the achievement of a correct three-dimensional configuration. To do so often resembles an exercise in piecing together a puzzle, whereby the piecemeal adaptation, although tedious, offers optimal reduction. Vicryl sutures or wire ligatures are best suited for this purpose, although at times fragments may not require further fixation once other buttresses are stabilized. We must emphasize again that undetected axial rotation of the zygoma at the greater wing of the sphenoid is often the culprit in an unsatisfactory outcome. Although substitution of the multiple small fragments by bone grafts is much easier, the failure to keep the correct relationships will in many cases lead to displacement of the malar complex. Primary bone grafting should be limited to cases in which bone loss is substantial.

Zygomatic arch fractures represent another area marked by divergent opinions regarding the ideal mode of therapy9,10 and where miniplate application is undesirable. Once the corpus of the malar bone is correctly reduced and fixed, the arch, if well aligned, is usually splinted by adjacent muscles and fasciae and experiences no significant functional load to induce displacement. None of our patients suffered undesirable functional or esthetic consequences related to the conservative treatment of arch fractures. To rely on the arch as a main point of reference to achieve reduction–fixation,9 however, often proves to be unsatisfactory, as it is difficult to achieve the correct angulation and inclination between the fragments. Because of the long lever arm of the arch, miniplate adaptation commonly results in displacement, usually in a lateral direction.

Infection and resorption. The bony fragments of the maxillary sinus wall and infraorbital rim can easily become devoid of vascularization due to damage of the sinus mucosa and stripping of the periosteum. If miniplates are applied, further compromise of vascularity occurs as additional periosteum is usually separated from the fragments. The end result can be partial or complete resorption. In addition, a poorly vascularized region is susceptible to infection, particularly in the early posttraumatic period before proper sinus drainage is established. Latent, chronic inflammatory reactions are sometimes only observed if long-term follow-up is performed. Screws, when protruding into the sinus cavity, can incite an inflammatory response, with granulation tissue formation leading to loosening of the screws and bony resorption. This is evident at the time of plate removal (usually 1 year later), when the lack of osseointegration and the amount of resorption are remarkable. If applied over the infraorbital rim, plates frequently induce chronic inflammation and may even cause edema of the lower lid and ectropion.

The issue of orbital reconstruction is another hotly debated topic. Lyophilized cartilage19 has been a safe and effective material used in our hands.18,20 Its biocompatibility and its capacity to calcify with time have been clinically confirmed on occasions when revision surgery unrelated to the reconstruction was carried out. In situations of extensive bone loss, split calvarial grafts are obtained and adapted to the orbital floor.

Recently published techniques using a titanium mesh plate for orbital reconstruction have several inherent problems. Infections, scarring, and bony resorption are beginning to emerge even with a relatively
short trial period.21,37 The potential serious complication of implant displacement toward the orbital apex makes it a less than ideal choice of reconstruction.

In light of the popularity of miniplates and screws it would be inappropriate not to mention the time-honored technique of closed reduction, which is often neglected. It is a quick and effective means of treating isolated arch fractures and selected cases of tetrapod fractures that can be reduced drastically.22,38 However, if the reduction is not fully stabilized, and if prolapse or entrapment of the orbital contents exists, open reduction must be initiated.

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References
