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Analysis of Treatment for Isolated Zygomaticomaxillary Complex Fractures

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Purpose: The purpose of this study was to evaluate the adequacy of reduction and stability of fixation of isolated zygomaticomaxillary complex (ZMC) fractures treated by various methods over a 5-year period.

Patients and Methods: Forty-eight patients with isolated, unilateral ZMC fractures that had at least 6 weeks' clinical follow-up were studied. Demographic information and methods of treatment were obtained from the medical records. Quality of reduction was assessed by examination of postoperative images. Stability of the repositioned ZMC was assessed by comparing immediate postoperative images with those obtained at least 5 weeks later. Cosmetic outcomes were assessed by clinical assessment and examination of photographs.

Results: A variety of surgical approaches and fixation sites were used in the sample. All patients but five had satisfactory reductions performed during surgery. In two of the latter, no noticeable facial deformity was apparent. No patient showed postsurgical change in position of the reduced ZMC. Three patients showed postsurgical enophthalmos at longest follow-up. Approximately 20% of those having lower eyelid incisions had some amount of scleral show at longest follow-up.

Conclusions: A variety of techniques can be used to produce a satisfactory outcome. Based on the results and a review of the literature, recommendations for treatment are proposed.

Zygomaticomaxillary complex (ZMC) fractures are common facial injuries after maxillofacial trauma.[1] Although a great volume of literature exists on the treatment of these injuries, there is no consensus. In fact, treatments range from reduction with fixation only if necessary to routine exposure and fixation of at least three of the four articulations. Obviously, a multitude of methods must be effective in the management of ZMC injuries, depending on their severity and the materials available for fixation.

Plate and screw fixation has revolutionized the treatment of ZMC fractures. More stable fixation can be provided with plate and screw fixation than with wire fixation, even when fewer points on the ZMC are stabilized. Surgeons are claiming improved outcomes resulting from the use of plate and screw fixation. However, it remains unclear whether improved results, if they exist, are attributable to more stable fixation or to better reduction. To place bone plates, more exposure is required, and the increased exposure may improve the reductions by allowing visualization of more points of articulation with adjacent, uninjured bones.

Most studies in the literature have evaluated patients some time after treatment of ZMC fractures and noted that, in some instances, malar prominence was reduced when compared with the opposite, uninjured side. This led the authors to surmise that the ZMC had become displaced (after an adequate reduction), blaming inadequate fixation as the reason, and citing the pull of the masseter muscle as the primary destabilizing force. However, it was never shown that the ZMC was properly reduced during surgery; this was assumed.

Despite the volume of literature, there has been no well-designed study to assess the efficacy of various

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treatment methods for ZMC fractures. Designing such a study is fraught with difficulties because few ZMC fractures are similar. The amount of orbital involvement, the amount and direction of ZMC displacement, comminution of articulations, and concomitant fractures are just a few of the variables that must be considered. However, if one examines a homogenous sample and uses limited outcomes assessments, some information can be obtained.

The purpose of this retrospective study was to evaluate patients with isolated, unilateral ZMC fractures treated by a number of methods by one surgeon over a 5-year period to determine: 1) adequacy of reduction, 2) adequacy of fixation, 3) associated complications, and 4) suitability of treatment methods. Need for and adequacy of internal orbital reconstruction was not a primary subject of this investigation because not all patients had computed tomography (CT) scans to assess the preoperative and postoperative state. However, as much information as possible concerning this topic is assessed.

Patients and Methods

The charts of all patients treated for unilateral ZMC fractures at Parkland Memorial Hospital by the same staff surgeon from January 1, 1989 until December 31, 1994 were collected. The records were reviewed for the following data: age, sex, cause of injury, diagnosis, side of injury, associated facial fractures, abnormal eye signs preoperatively, radiographic examinations obtained preoperatively and postoperatively, and details of surgery. Patients were excluded if 1) they had a fracture of the other ZMC, or an associated Le Fort maxillary fracture; 2) there was less than 6 weeks' clinical follow-up; 3) good-quality images (plain radiographs or CT scans) were not available either immediately before and immediately after surgery; 4) a thorough clinical examination or good-quality facial photograph that allowed a thorough assessment of facial form and eye position were unavailable at the longest follow-up period.

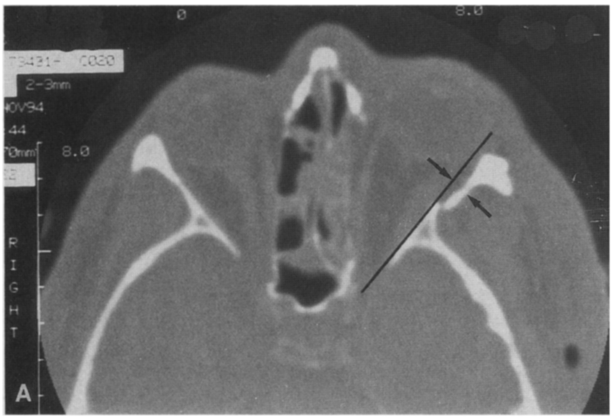
Adequacy of Reduction

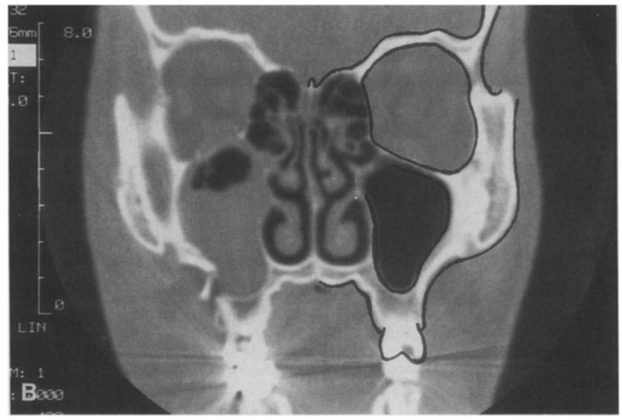
Adequacy of reduction was determined by assessing the postoperative images taken within 24 hours of surgery. In those patients for whom CT scans were available, they were used exclusively if the scans contained ample information. When unavailable, plain radiographs were assessed. It was realized that the plain radiographs were somewhat magnified. No magnification correction was used for plain films because the correction factor was not known. It is doubtful that a standardized subject-film distance was used during acquisition in such trauma patients. However, most comparisons were made with the opposite side and tabulated in millimeters of difference. The hard copies of CT images were not enlarged to anatomic size for measurements. Measurements made on acetate tracings of the CT images were done with a vernier caliper (Helios, Inoxyd, Germany) to the nearest 0.1 mm. Measures were corrected to anatomic size mathematically using the metric scale on the images. Any asymmetry on the images less than 2 mm in magnitude was considered acceptable reduction of the fracture. It has been shown that a trained clinician can detect a 2-mm difference in facial form only 50% of the time.[2] Asymmetries > 2 mm were tabulated.

When CT scans were unavailable, the Water's and submentovertex radiographs were used for analysis. The following were assessed on the postoperative Water's film, using the opposite side for comparison: 1) orbital size; 2) alignment of the infraorbital rim; 3) contour of the zygomaticomaxillary buttress; 4) approximation of the frontozygomatic suture. The widths of midportions of the orbits were measured in millimeters, and the difference between them was scored. Alignment of the medial and lateral portions of the infraorbital rims was measured with a millimeter ruler when not continuous. If not well aligned, the lateral portion of the rim was scored as being a certain distance above or below the medial portion. Contour of the zygomaticomaxillary buttress was assessed by the amount of displacement the ZMC showed in relation to the alveolar process. An acetate tracing of the opposite zygomaticomaxillary complex, including the orbit, was reversed and placed over the injured side to assist in determination of this value. Separation of the frontozygomatic suture (or fracture area), if present, was measured.

The following were assessed on the postoperative submentovertex radiographs: 1) projection of the malar buttress and 2) contour of the zygomatic arch. The vertical portion of a clear T-ruler was aligned along midline structures within the cranium, and the horizontal limb of the T was aligned with the uninjured malar prominence. The distance between the operated malar prominence and the other limb of the T was measured with direction (anterior or posterior). The contour of the zygomatic arch was assessed in relation to the opposite, uninjured side. The injured zygomatic arch was classified as aligned, bowed laterally, or displaced posteriorly. No measurement was made for quantification.

The following areas were assessed on the postoperative axial CT scans, if available: 1) alignment of the sphenozygomatic suture (fracture) area (lateral orbital wall); 2) contour of the zygomatic arch; and, 3) symmetry of the malar projection. If the patient's head was tilted during the scan, comparison from one side to the other was performed by identifying the opposite CT level that corresponded to the injured side and using the diameter of the globe as a guide. Alignment of the





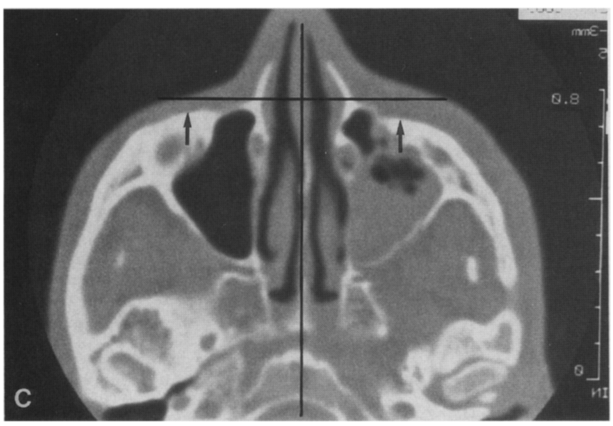


FIGURE 1. Methods used to quantify adequacy of ZMC reduction. *A,* Axial scan through midportion of orbit. Alignment of lateral wall of orbit quantified by measuring between line and orbital wall. This image shows bodily displacement of the ZMC laterally. *B,* Coronal scan through anterior orbit for quantifying displacement of ZMC. Uninjured side traced on acetate and reversed to provide "best-fit" on injured side. Alignment of injured zygomaticomaxillary buttress with tracing quantified. *C,* Axial scan through superior portion of maxillary sinus and zygomatic arch. Distance between bone and line on injured and uninjured side quantified.

sphenozygomatic suture (or fracture) at the midorbital level was scored by indicating where the lateral orbital wall aligned with the stable sphenoid wing posteriorly (Fig 1A). The lateral orbital wall could be aligned, bodily displaced laterally, angled laterally, bodily displaced medially, or angled medially. The contour of the zygomatic arch was assessed in relation to the opposite, uninjured side. The injured zygomatic arch was classified as aligned, bowed laterally, or displaced posteriorly (Fig 1B). No measurement was made for quantification. The amount to which similar cuts through the malar prominence extended from the face on the two sides was measured on the scan. The vertical portion of a clear T-ruler was aligned along midline structures within the cranium, and the one horizontal limb of the T was aligned with the uninjured malar prominence. The distance between the operated malar prominence and the other limb of the T was measured with direction (anterior or posterior) (Fig 1B).

The following areas were assessed on the postoperative coronal CT scans, if available: 1) alignment of the zygomaticomaxillary buttress and 2) alignment and continuity of the internal orbit. Alignment of the zygomaticomaxillary buttress was assessed by tracing the opposite side on acetate paper and reversing it to the injured side (Fig 1C). The amount that the ZMC was malaligned with the alveolar process was measured with direction (medial vs lateral displacement). The alignment and continuity of the internal orbit was necessarily qualitative. If the floor of the internal orbit was obviously misaligned, it was noted. The size of osseous defects in the internal orbit was not quantified. However, if orbital soft tissues were beyond the level of the osseous floor/walls, it was noted qualitatively.

Adequacy of Fixation

To determine whether there was any postsurgical displacement of the ZMC, immediate postoperative images were compared with those obtained at least 5 weeks after surgery. Not every patient had follow-up radiographs taken, because this was not part of the inclusion criteria. However, an attempt was made to contact patients for a late postoperative clinical and radiographic examination. In most instances, only plain radiographs were available for this analysis. However, in cases where concomitant orbital reconstruction was performed, some had CT scans available at 6 months or 1 year postoperatively. Any differences between the immediate postoperative and the longest postoperative images were recorded using the measures previously described. A gross assessment of stability was also inferred by assessing the facial photographs as described further.

Associated Complications

Only those complications that were obvious from an analysis of good-quality facial photographs or the latest clinical examination were tabulated. Photographic results were evaluated by two surgeons independently examining the latest postoperative facial photographs (frontal, profile, bird's-eye, worm's-eye, and three-quarter views). Malar symmetry, position of the globe (enophthalmos, pupillary height), eyelid position and form, facial width, and obvious scars were qualitatively assessed. Both examiners had to have listed no obvious complications for the case to be considered as satisfactory.

Results

Over the 5-year period, the records of 104 patients with ZMC fractures treated by one staff surgeon were available for analysis. This represented less than one third of such injuries, because midface fractures are shared by three surgical specialties, and because of the unavailability of some records. Of these 104 cases, those with at least 6-weeks' clinical follow-up and good-quality photographs totalled 82. When patients with Le Fort fractures or fractures of the opposite ZMC were excluded, the number dropped to 61. When the radiographs were collected and assessed for quality, the number of patients dropped to 48.

The sample included 11 (23%) women or girls and 37 men or boys (77%), with a mean age of 34 years (SD 8.4; range, 12 to 62). Most male patients were in the fourth decade of life, whereas most female patients were in the third decade of life. The racial breakdown was 38% non-Hispanic caucasians, 26% Hispanic, and 36% African Americans. Altercations accounted for 54% of fractures, followed by motor vehicle accidents (38%), falls (6%), and sports (2%). Fractures in female patients were most commonly caused by motor vehicle accidents, whereas in male patients, altercations were more frequent. The left/right ratio of the ZMC fractures was 23:25. Three patients had associated frontal bone, five had nasal, and five had mandibular fractures.

On initial examination, five patients (10%) had significant eye findings (excluding binocular diplopia), including 1 hyphema, 2 traumatic mydriasis, 1 ruptured globe, and 1 with a positive forced duction test. Preoperative and postoperative axial and coronal CT scans were obtained (in addition to plain radiographs) in 41 (85%) of the patients.

Treatment varied greatly from one case to the next, ranging from reduction without fixation to open reduction and complete exposure of the ZMC with four-point fixation. Reduction was accomplished in all but a few cases by placement of a Carroll-Girard bone screw (Walter Lorenz Surgical Instruments, Jacksonville, FL) transfacially into the malar prominence. In two cases (4.2%), after reduction without surgical exposure of the fracture, the repositioned ZMC was stable, and no exposure or fixation was deemed necessary.

Table 1. Exposure and Fixation of the ZMC

Surgical Approach	Point of Fixation	N
Treatment of 15 ZMC Fractures With One-Point Fixation		
Maxillary vestibular	ZMB	9
Maxillary vestibular + lower lid	ZMB	1
Maxillary vestibular + lower lid	FZ	1
Lower lid	FZ	3
Maxillary vestibular + lateral brow	FZ	1
Total		15
Treatment of 13 ZMC Fractures With Two-Point Fixation		
Lower lid	IOR, FZ	1
Maxillary vestibular + lower lid	IOR, FZ	2
Maxillary vestibular + lower lid	ZMB, FZ	4
Maxillary vestibular + lateral brow	ZMB, FZ	1
Maxillary vestibular + laceration	ZMB, FZ	2
Maxillary vestibular + lower lid	ZMB, IOR	2
Coronal	FZ, ZA	1
Total		13
Treatment of 13 ZMC Fractures With Three-Point Fixation		
Maxillary vestibular + lower lid	ZMB, FZ, IOR	5
Maxillary vestibular + lower lid + laceration	ZMB, FZ, IOR	1
Maxillary vestibular + lower lid + lateral brow	ZMB, FZ, IOR	2
Maxillary vestibular + coronal	ZMB, FZ, ZA	2
Maxillary vestibular + coronal + lower lid	ZMB, FZ, ZA	2
Maxillary vestibular + coronal + lower lid	FZ, ZA, IOR	1
Total		13
Treatment of 5 ZMC Fractures With Four-Point Fixation		
Maxillary vestibular + coronal + lower lid	ZMB, FZ, IOR, ZA	5

Abbreviations: ZMB, zygomaticomaxillary buttress; FZ, frontozygomatic area; IOR, infraorbital rim; ZA, zygomatic arch.

In all other cases (n = 46), exposure and fixation of the ZMC was performed (Table 1).

Various surgical approaches and points of fixation were used in the 46 patients who had open exposure of the fractures. The most frequently used approach was the maxillary vestibular incision, used alone (n = 9) or in combination with other approaches (n = 32) in 41 of the 46 patients who had open exposure of their fractures. The next most frequently used approach was through the lower eyelid. Of the 30 instances of lower lid approaches, 12 were of the retroseptal transconjunctival type, with a lateral canthotomy. The remaining 18 were cutaneous approaches through the lower eyelid, which used either a dissection between the orbicularis oculi and the orbital septum, or a "stepping" of the dissection through orbicularis oculi. The lower eyelid approach was used to expose the infraorbital rim, orbital floor, and in many instances, the fracture through the lateral orbital rim (frontozygomatic area). The coronal approach was used 11 times in the 46 cases. Of the 4 instances listed in the Tables as lateral brow approaches, 2 were by an incision in the upper eyelid, and 2 were incisions placed in the eyebrow. Lacerations were used in 3 cases to expose the frontozygomatic area.

The number of points and locations of fixation for the fractured ZMC varied greatly. Fifteen fractures had one point of fixation (31.2%), 13 had two (27.1%), 13 had three (27.1%), and 5 had four points of fixation applied (10.4%). The most frequent point of fixation was the zygomaticomaxillary buttress, being used in 36 of the 46 fractures that were stabilized by internal fixation. The frontozygomatic area was stabilized in 34, the infraorbital rim in 19, and the zygomatic arch in 11 instances. Bone plates were used in all but two fractures, where a wire was used at the frontozygomatic area instead of a bone plate. Both of these fractures were also stabilized at other points. The size of bone plates varied from mini-dynamic compression plates and 2.0-mm screws to microplates and 1.0-mm screws. When plated, the zygomaticomaxillary buttress was stabilized with 1.5- or 2.0-mm miniplates; the frontozygomatic area with minidynamic compression plates and 2.0-mm screws, low-profile 1.5-mm miniplates or microplates; the infraorbital rim with 1.0-mm microplates or low-profile 1.5-mm miniplates; and the zygomatic arch with 1.5-mm miniplates.

The internal orbit was reconstructed in 21 cases using autogenous calvarial bone (n = 12), autogenous iliac crest (n = 1), or allogeneic rib or ilium (n = 8). All bone grafts were stabilized with lag screws or plates and screws. Orbital floor reconstruction bone plates were used in four cases as a platform for the bone graft.

Adequacy of Reduction

Using the criteria set forth in the Patients and Methods section, the postoperative CTs or plain radiographs of six patients showed asymmetries or malalignments greater than 2 mm. The individual cases are described in Table 2. The complications were malpositioning of the ZMC in five cases and inadequate orbital reconstruction in one. Beyond these six cases, the ZMCs were generally well positioned, at least within the limits of the assessment criteria used.

Adequacy of Fixation

Twenty-two patients had images of sufficient quality available at least 5 weeks after surgery to be included in this portion of the analysis (mean, 26 weeks; range, 5 weeks to 3.5 years). Fourteen of these had CT scans obtained to assess orbital reconstruction. This sample of 22 patients had a variety of fixation methods during their initial treatment (Table 3). In no case was there any perceptible change in ZMC position. Remodeling had occurred at the points of articulation and the internal orbital grafts, but no change in ZMC position could be detected.

Associated Complications

The follow-up assessments or facial photographs (photos were available for all patients) showed significant complications. Three patients had observable asymmetry of the ZMC, one characterized by lack of malar projection, one by lack of projection and some widening of the face, and the other characterized by widening of the face on the side of injury. All three of these asymmetries were detectable to the two observers but were minor. The facial widening was much more noticeable than the deficient malar projection. These individuals were among those previously noted to have had an inadequate reduction.

Six of the 30 patients who had an approach through the skin or conjunctiva of the lower eyelid had some noticeable problem with the eyelid. In four patients, there was a very slight amount (approximately 1 mm) of scleral show. Follow-up at the time of assessment in these four patients was 7, 8, 13, and 17 weeks, respectively. Three of these had had a cutaneous approach and one a transconjunctival approach. In two patients, there was slightly more scleral show (approximately 2 mm), and in one of these the lateral canthus appeared to be positioned too far inferiorly. In addition, this patient's lower eyelid did not adapt well to the globe laterally, where a small, unnatural-appearing space existed between the lid and the globe. There was a moderate degree of entropion present. This latter patient had had a transconjunctival approach with lateral canthotomy. The malpositioned lower lid gave the illusion of the globe being elevated, but on careful examination this was not the case. This patient had revision of his lower eyelid at 9 weeks with a satisfactory result. The follow-up in the other case of significant lid deformity was 13 months. This patient had had a subciliary approach to the orbit.

Overall, most incisions placed on the face were imperceptible, with the exception of those in photographs taken within a few months of surgery. Some of these incisions were still erythematous, making them noticeable. In no case was the incision for placement of a Carroll-Girard screw noticeable.

One patient had moderate enophthalmos noted on clinical examination 9 weeks after surgery. A review of her treatment indicated that she was treated without preoperative CT scans. The infraorbital rim was not approached because it was not appreciated that her orbital floor was disrupted. Postoperative CT scans showed an excellent reduction of the ZMC but a mas-

Table 2. Inadequate Reductions of ZMC Fractures

Surgical Approach	Fixation Site	Malalignment	Apparent in Long-Term Photographs/Clinical Exam?
Maxillary vestibular	ZMB	3-mm Medial rotation of ZMB, slight malalignment of infraorbital rim, 2-mm lateral displacement of FZ suture area, slight medial rotation along inferior portion of lateral orbital wall	No
Maxillary vestibular + lower lid	ZMB, FZ	Rotation of ZMC, with arch rotated laterally, infraorbital rim rotated posteriorly, 2.5 mm of lateral rotation along lateral orbital wall	No
Lower lid	FZ, IOR	3-mm posterior displacement of malar prominence (compared with opposite side), bowing of zygomatic arch, 4-mm medial rotation of ZMB	Yes
Coronal	FZ, ZA	3-mm Posterior displacement of malar prominence (compared with opposite side, 5-mm medial rotation of ZMB	Yes
Maxillary vestibular, lower lid	ZMB, FZ, IOR	Postoperative CT shows lateral displacement of entire ZMC approximately 3 mm, laterally rotated around the FZ suture, 2° to unstable medial portion of infraorbital rim	Yes
Maxillary vestibular, lower lid, coronal	ZMB, FZ, IOR, ZA	Orbital floor reconstruction adequate in anterior orbit but did not extend posteriorly to apex—some orbital soft tissue herniating into sinus	Yes

Abbreviations: ZMB, zygomaticomaxillary buttress; FZ, frontozygomatic area; IOR, infraorbital rim; ZA, zygomatic arch.

sive internal orbital defect. The patient declined orbital reconstruction at that time. However, she underwent internal orbital reconstruction to correct the enophthalmos 6 months later.

A second patient had perceptible (approximately 3 mm) enophthalmos both clinically and on the worm's and bird's-eye photographs taken at 8 months postsurgery. He also had a lower pupil level on that side when compared with the uninjured side. This patient did not have preoperative CT scans, and the internal orbit was not reconstructed during surgery. The patient was unconcerned about the finding.

Another patient had perceptible enophthalmos on the worm's- and bird's-eye photographs. This patient had had orbital reconstruction with postoperative CT scans showing inadequate reconstruction in the posterior orbit.

Discussion

Perhaps the four most important considerations in treating ZMC fractures are proper reduction, adequate stabilization, adequate orbital reconstruction (when necessary), and adequate handling/positioning of periorbital soft tissues. Because this study suffers from the same problems as most retrospective investigations, including a limited sample size, uncontrolled variables, inconsistent data accumulation, and lack of availability of records, it does not answer all questions concerning treatment of ZMC fractures. However, it does provide some valuable information on a few specifics of treatment.

Table 3. Initial Fixation for 22 ZMC Fractures Available for Long-Term Assessment of Stability

Points of Fixation	N
No fixation	1
ZMB	5
FZ	3
ZMB + FZ	3
IOR + FZ	2
ZMB + FZ + IOR	4
ZMB + FZ + IOR + ZA	4
Total	22

Abbreviations: ZMB, zygomaticomaxillary buttress; FZ, frontozygomaticarea; IOR, infraorbital rim; ZA, zygomatic arch.

Adequacy of Reduction

The most important principle in treating fractures, especially those of the face, is proper reduction. If the bone is not placed into the correct position, stabilization becomes superfluous. Therefore, assessment of the fractures in this investigation that were treated by a variety of means for adequacy of reduction seemed mandatory. Recommendations in the literature for reduction of ZMC fractures range from "closed reduction" techniques[3-6] to three- or four-point surgical exposure.[6-9] Zingg et al[5] in reviewing 946 ZMC fractures treated by a variety of means, including 164 treated by "closed reduction," found a 13% incidence of malar asymmetry.[5] Their results are not significantly different than ours.

Five of the 48 ZMC fractures in this study (10.4%) were inadequately reduced as assessed in images taken immediately postoperatively. These five fractures were reduced by a variety of approaches. Fractures that were successfully treated also were reduced by a variety of means. This indicates that many techniques can produce favorable results, but when performed improperly, all can also result in poor reduction.

In many instances the areas identified as being poorly aligned in the postoperative images were areas that were directly exposed and, in some instances, stabilized. The first patient listed in Table 2 underwent exposure of the zygomaticomaxillary buttress and had a bone plate applied, yet the postoperative radiograph showed some medial rotation of the ZMC. This patient did not have a clinically observable asymmetry in the long-term photographic assessment. In the second patient, the inferior and lateral orbit was exposed in concert with the zygomaticomaxillary buttress. In spite of bone plates at the frontozygomatic and zygomaticomaxillary areas, rotation of the entire complex along its vertical axis was noted. This should have been noted on examination of the sphenozygomatic area during surgery, but apparently was not. This might have also been indicated by malalignment of the infraorbital rim, but that area is frequently comminuted. This patient did not have an apparent asymmetry on long-term photographic examination. These two cases indicate that some imprecision in reduction may be tolerable and clinically insignificant, depending on the magnitude, location, and soft tissue masking of the fracture. The third and fourth patients did not have exposure of the zygomaticomaxillary buttress, and medial rotation of the ZMC, resulting in posterior positioning of the malar eminence, occurred in both. These asymmetries were noted in the photographs.

These four cases show that clinically significant malar retrusion can be prevented by exposure and alignment of the zygomaticomaxillary buttress. This was not done in cases 3 and 4, and both were retruded. When this area is aligned, the malar eminence will be properly projected. However, as case 1 demonstrates, this concept is fallible. The zygomaticomaxillary buttress is often comminuted and, if segments of bone are missing, one often must estimate the proper position of the ZMC. In such cases, it is prudent to expose other areas and align multiple sites to obtain a proper reduction. It is also interesting that the cases with clinically apparent malar retrusion had a greater degree of medial rotation at the zygomaticomaxillary buttress than those that were not clinically perceptible.

The fifth case that was inadequately reduced had no preoperative CT scan done. Because of difficulty encountered with the reduction during surgery, a postoperative CT scan was obtained. The entire ZMC was found to have been bodily positioned laterally from where it should have been. The postoperative CT scan also showed a unilateral naso-orbito-ethmoid fracture, with the frontal process of the maxilla displaced laterally a few millimeters. This was unrecognized preoperatively during clinical examination. The ZMC was reduced to this laterally displaced segment of infraorbital rim, and the defect in the orbital floor was reconstructed. The result was a clinically noticeable widening of the face without perceptible enophthalmos or malar retrusion.

A Carroll-Girard screw was used to reduce and position most fractures. It was usually inserted transcutaneously through a 2- to 3-mm incision over the malar eminence. When a coronal approach was used, the Carroll-Girard screw was often placed directly after the flap was retracted below the eminence. The Carroll-Girard screw provided a "handle" on the ZMC, allowing accurate three-dimensional positioning. In our experience, instruments placed under the ZMC, such as a Dingman elevator, Rowe elevator, or bone hook, cannot provide this degree of control. The small stab incision through the skin of the face has never been a cosmetic problem. In fact, most of these incisions become invisible in several weeks.

Adequacy of Fixation

One of the most controversial topics in maxillofacial trauma is how much fixation is enough to prevent postreduction displacement of the fractured ZMC.[10-12] Recommendations for fixation have varied from none to the placement of three or four bone plates at different locations. The reason for this disparity is multifactorial and includes many intangibles such as experience and beliefs of the surgeon. Tangible factors include the type of injury being treated, ie, simple versus comminuted fractures, grossly displaced versus minimally displaced fractures, etc.

The masseter muscle has often been implicated as a primary cause of postreduction displacement of the fractured ZMC.[10,11,13-15] It is assumed to be capable of exerting sufficient inferiorly directed force on the fractured zygoma to cause movement, even after surgical insertion of fixation devices. However, this contention has never been proven. We have been unable to find any evidence in the literature that postreduction displacement of a ZMC fracture has occurred in patients. Previous clinical studies have simply evaluated patients clinically and radiographically months after surgery and noted some patients with poor ZMC position. It was assumed that because the fractures were simply elevated, or perhaps stabilized with wire fixation, that postsurgical displacement had occurred. Unfortunately, there are no published cases where the immediate postsurgical radiographs were compared with a radiograph taken months later to prove that postsurgical displacement had occurred. It is more likely that these ZMC fractures were never properly positioned at surgery.

The closest to determining if postreduction displacement occurs is a study by Kaastad and Freng.[3] They treated 159 ZMC fractures using a bone hook to reduce the ZMC into what appeared to be a stable position during surgery. One week later, after resolution of edema, patients were examined, and 32 (20%) were found to have malar asymmetry requiring open reduction and internal wire fixation. The one problem with that study, and others,[14] is that no postoperative images were used to prove that the ZMC had been properly reduced at surgery.

Based on our experience and the data generated from this study, a variety of methods can be used successfully to stabilize ZMC fractures. These range from reduction without fixation to reduction with three- or four-point fixation using bone plates. Whether fixation devices were required and their locations were determined clinically during surgery. The Carroll-Girard screw served not only to disimpact and position the ZMC fracture, but to determine its stability when repositioned. If the fracture was stable, further fixation was not used (Fig 2). In only two instances was no fixation applied. However, 31% of fractures treated in this study required only one point of fixation, as determined by this method (Fig 3). No patients treated in this study showed evidence of postreduction displacement, regardless of the number of fixation devices applied.

This should not be surprising, given the results of a study by Dal Santo et al.[12] That study compared masseter muscle force in 10 male controls with 10 male patients who had sustained unilateral ZMC fractures. Calculation of muscle force was based on measured bite force, electromyogram, and radiographic determination of muscle vectors. It was found that the masseter muscle develops significantly less force in patients with a ZMC fracture than in controls. After fracture, the masseter force slowly increases, but at 4 weeks after surgery, most patients were still well below control levels. The results of that study cast doubt on the role of the masseter muscle in postreduction displacement of the fractured ZMC, and indicate that minimal amounts of fixation may be necessary for such injuries.

Others have used ZMC repositioning without fixation with good results,[3,5,6,16-18] confirming our opinion that fixation requirements are less than advocated by some. Intraoperative assessment of stability of the repositioned ZMC, as performed in our study, has also been advocated by others.[5,18] Zingg et al used digital pressure after reduction to determine the need for applying fixation devices.[5] Fixation with one bone plate, either at the zygomaticomaxillary buttress[12,19,20] or more commonly the frontozygomatic area,[5-7,18,21-24] as performed successfully in several of our patients, has been advocated by others in a certain percentage of ZMC fractures. Champy et al used a single bone plate at the frontozygomatic area in 342 isolated ZMC fractures and found that only 6 (1.8%) had an unsatisfactory result.[18] Tarabichi treated 17 consecutive low-velocity ZMC fractures by a transoral open reduction and internal bone plate fixation of the zygomaticomaxillary buttress with excellent results in all but two patients, who had comminution of the orbital rim.[20] Covington et al were able to stabilize 30% to 40% of ZMC fractures by one-point fixation.[6] We were able to use one-point fixation in 31% of ZMC fractures reported in this study. Restoring the zygomaticomaxillary or frontozygomatic buttresses by bone plate fixation is in keeping with the philosophies popularized by Manson et al[25] for treating midface fractures by reconstruction of the vertical and horizontal buttresses of the midface, and by Karlan and Cassisi[14] for treating ZMC fractures. Placement of fixation devices at the zygomaticomaxillary buttress has increased with the advent of bone plate fixation.[6] The frequent comminution in this area provided little opportunity for stabilization when wires were used. Using the zygomaticomaxillary buttress has the added advantage of an intraoral approach.

This discussion should not be misconstrued as a justification for using less fixation hardware. To the contrary, we believe in using as much hardware as is necessary to stabilize a fracture. This may range from no fixation to three or four bone plates and should be based on the characteristics of the ZMC fracture and the surgical procedure used in its treatment. One must also remember that this discussion is about isolated ZMC fractures. In such fractures, the zygomaticomaxillary buttress provides great mechanical advantage for stabilizing a ZMC fracture by the application of a bone plate. One plate can prevent medial rotation of the ZMC into the maxillary sinus. However, if the maxillary alveolus, the hemimaxilla, or the complete maxilla is unstable, a bone plate in this location will not provide support to the repositioned zygoma. In such instances, primary fixation of the frontozygomatic area will be necessary.

Orbital Reconstruction

Postsurgical enophthalmos usually results from not reconstructing the orbital floor/walls when indicated, or doing so inadequately.[5,9,26-30] Studies have shown that posttraumatic enophthalmos is most commonly caused by an increase in the size of the bony orbit.[31,32] Lateral positioning of the ZMC is one of the most common methods for increasing orbital volume because of the cross-sectional area of the orbit at the level of the displaced ZMC. However, concomitant fractures of the orbital floor or medial wall, which often accompany ZMC fractures, can also increase orbital volume.

Any patient with presurgical enophthalmos should be suspected of having orbital disruption. However, traumatic edema may mask the problem, making clinical examination difficult. CT has made preoperative assessment of the status of the bony orbit possible with a great degree of accuracy. When preoperative CT scans are available, it is no longer necessary to discuss whether the internal orbit should be explored. The CT scan allows one to predictably determine preoperatively whether the orbital floor or walls require reconstruction or not. Covington et al, in reviewing treatment of ZMC fractures over a 10-year period,

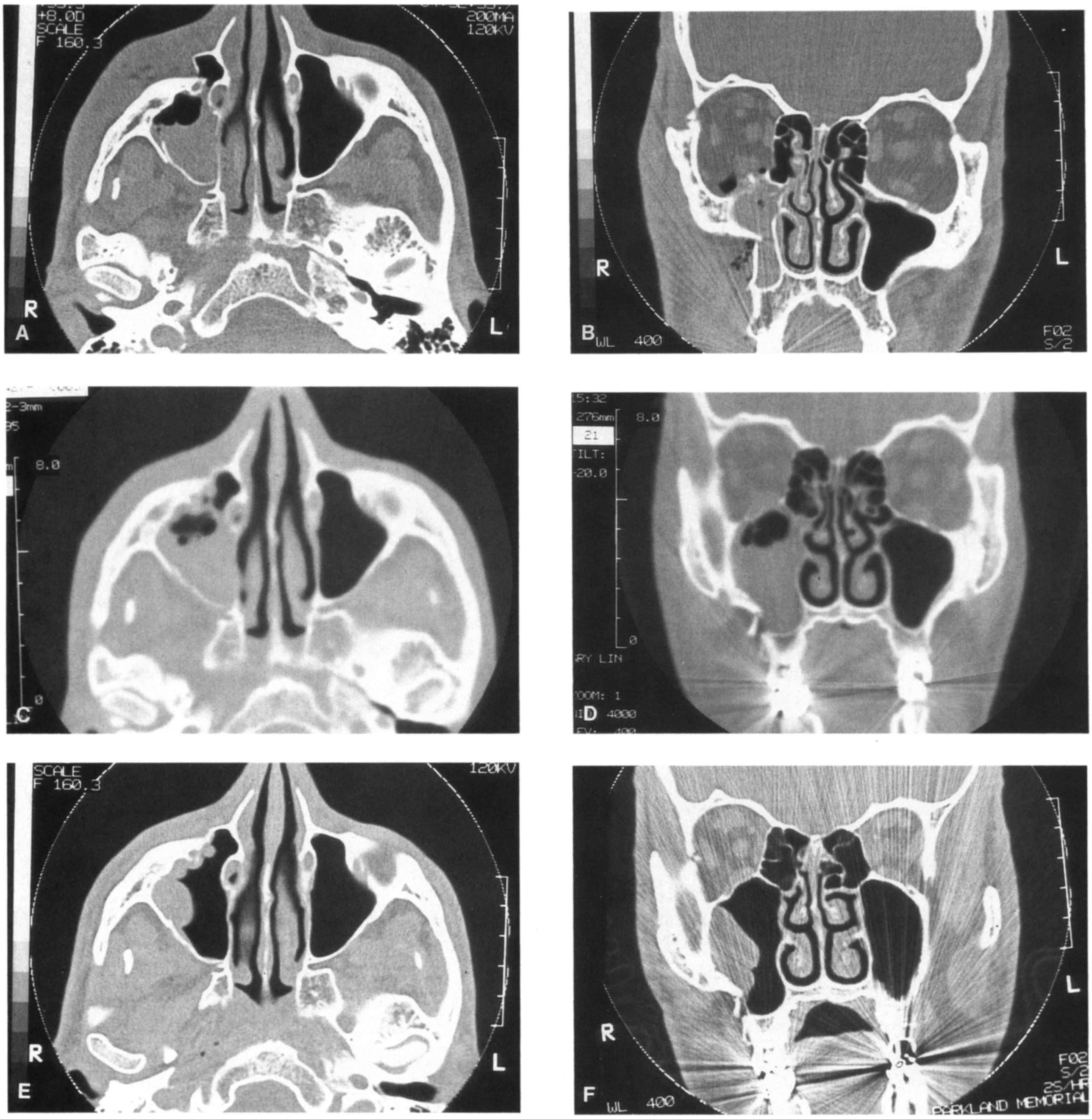


FIGURE 2. CT scans of patient treated by reduction without any means of fixation. Preoperative axial (*A*) and coronal (*B*) scans show displacement. Immediate postoperative axial (*C*) and coronal (*D*) scans showing satisfactory reduction (within 2 mm). Axial (*E*) and coronal (*F*) scans taken 6 weeks after reduction showing no postsurgical displacement.

found a reduction in orbital exploration from 90% in 1985 to 30% in 1989 because of the increasing use of preoperative CT scans.[6]

In this study, three patients showed perceptible enophthalmos on their latest follow-up visit. Two of these were in patients in whom orbital floor/wall disruption was not recognized clinically, no CT scans were obtained preoperatively, and no internal orbital reconstruction was done during surgery. Both patients had unrecognized orbital floor/medial wall disruption resulting in an increase in orbital volume in spite of an adequate reduction of the ZMC. In the third patient, it was recognized on preoperative CT scans that the internal orbit required reconstruction. This was performed, but inadequately. The dissection and reconstruction did not extend posteriorly an adequate amount, resulting in herniation of orbital contents into the maxillary sinus in the posterior/medial orbit.

It is clear from this study and others that orbital reconstruction, when indicated, is a vital component of treating ZMC fractures. In fact, the complications of ZMC fractures most difficult to correct secondarily

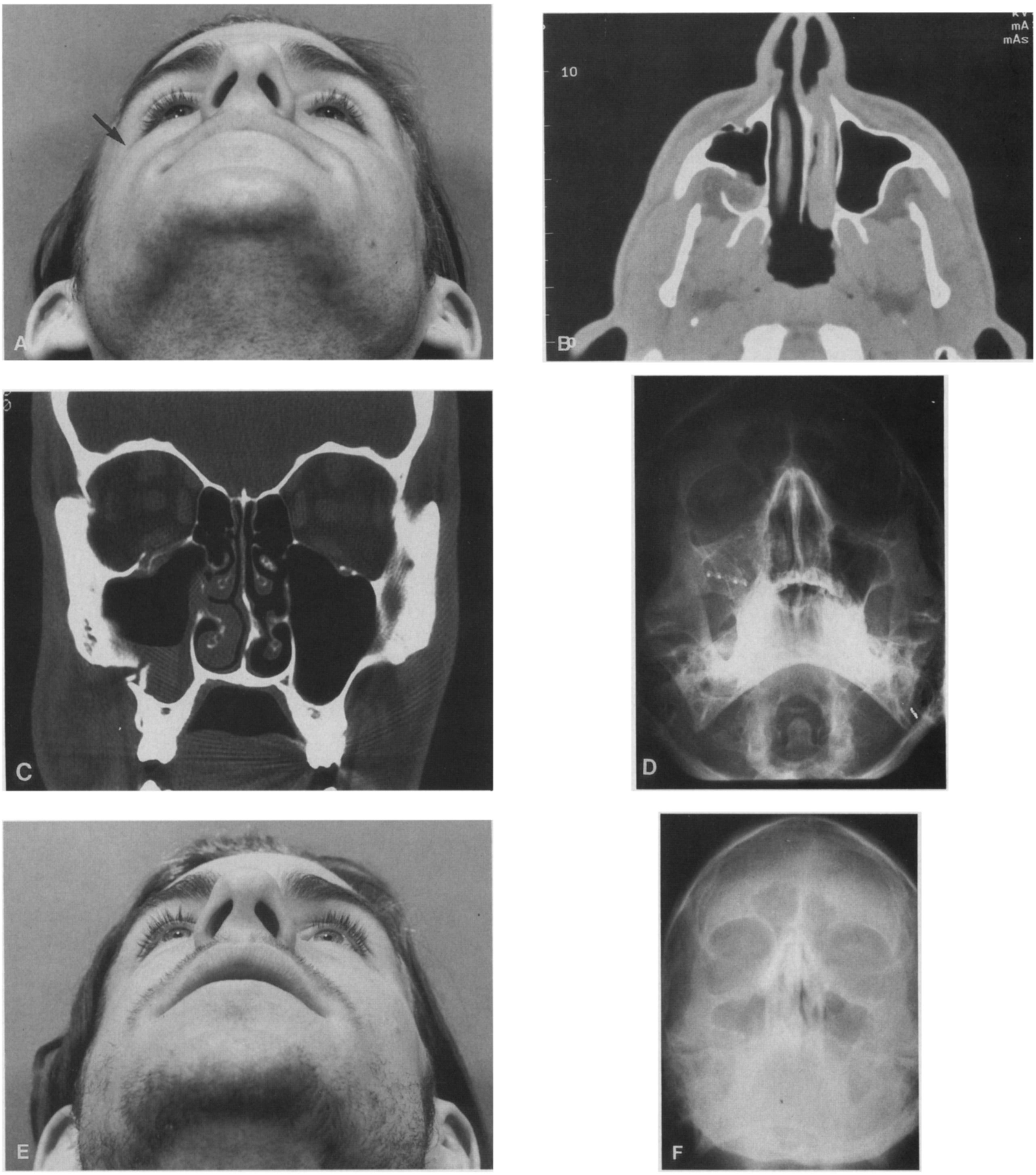


FIGURE 3. Patient treated for right ZMC fracture by reduction and fixation with a single bone plate at the zygomaticomaxillary buttress. Preoperative view showing loss of malar projection (*A*); axial (*B*) and coronal (*C*) CT scans showing medial rotation of ZMC. *D*, Immediate postoperative radiograph showing reduction. *E*, Appearance of patient at 5 weeks showing symmetrical result. *F*, Radiograph at 5 weeks showing no postreduction displacement.

are those of the orbit. When reconstruction is not performed when indicated, or is performed inadequately, postsurgical enophthalmos can result. In this study, the internal orbit was reconstructed in 21 of 48 cases (44%) using bone grafts that were stabilized with screws and/or plates. The necessity of performing internal orbital reconstruction, in all but a few cases early in the study, was based on the preoperative CT findings. However, it should be pointed out that the incidence of orbital reconstruction performed in this study (44%), and the

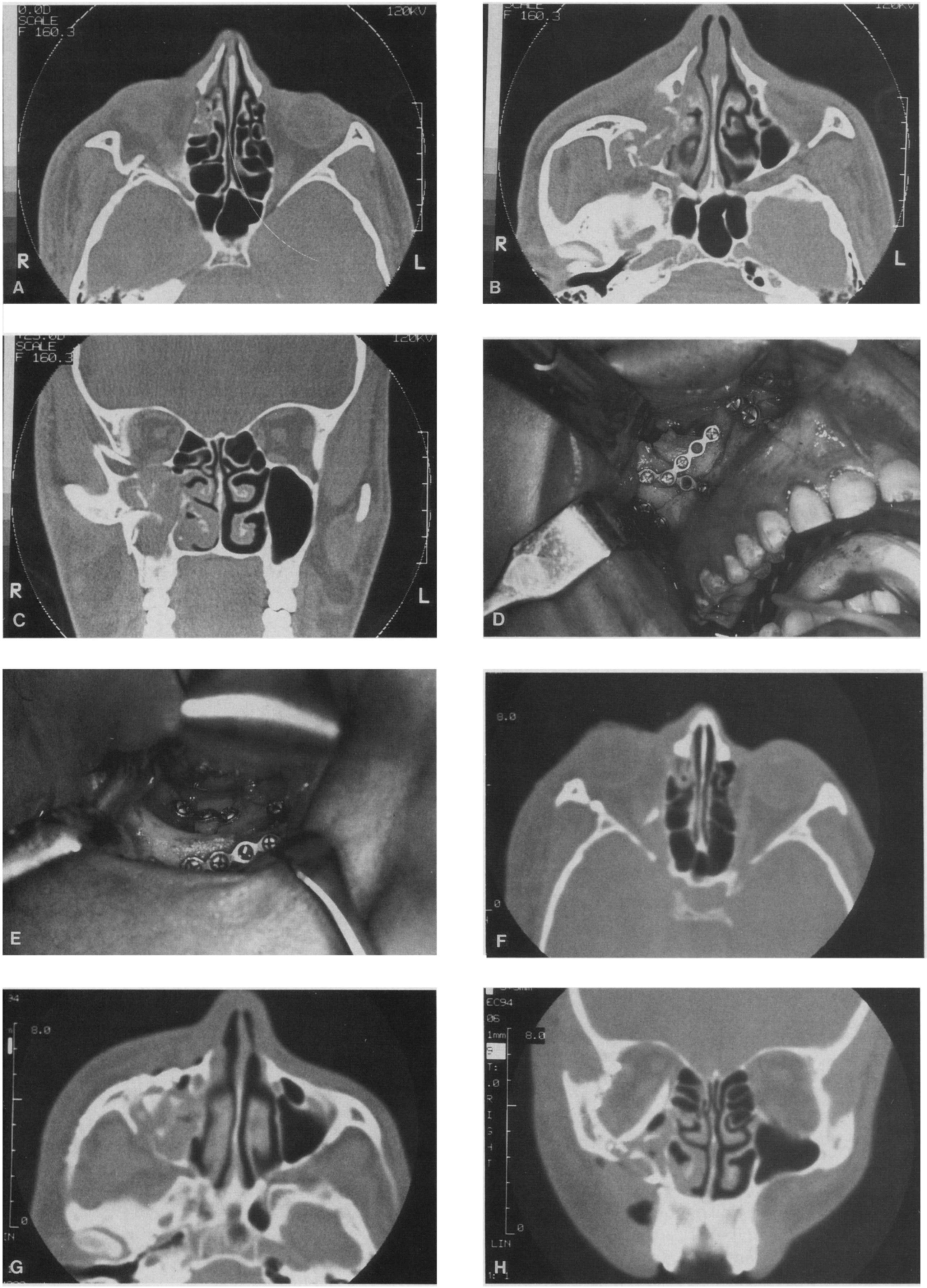

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FIGURE 4. Treatment of patient with high-energy ZMC fracture by maxillary vestibular, subciliary, and coronal approaches. *A-C,* CT scans before surgery. Note comminution of articulations along lateral orbital wall and zygomaticomaxillary buttress, disarticulation of zygomatic arch from temporal process of zygomatic arch, and significant displacement of malar eminence. *D,* Intraoperative view showing reduction and fixation of zygomaticomaxillary buttress, using fractured pieces of bone to reconstruct skeleton. *E,* Internal orbit reconstructed with two pieces of bone, one along medial wall, one along floor. All pieces were stabilized with plate and screw fixation. The lateral orbital wall was also reconstructed by replacing and stabilizing fractured segment of bone at sphenozygomatic junction. *F-H,* Immediate postoperative CT scans showing reduction. *I, J,* Appearance of patient 8 weeks after surgery.

number who had coronal approaches, may be inflated. Only those patients with good clinical and imaging follow-up were included in this study. Patients with more severe ZMC injuries were the ones who we had the most interest in following. A point was made to stay in contact with as many of these as possible for repeated examinations 6 months or more after injury.

Other Findings

One could argue that a shortcoming of this study was the subjective nature of assessing long-term clinical results with photographs. Most of the patients were difficult to follow, and recalling them for a clinical analysis by impartial examiners would have drastically diminished the sample size. Others have similarly used clinical photographs for assessing ZMC fractures.[9] Although not ideal, this method did provide some useful information.

This study showed that using approaches through the lower eyelid was not innocuous. Six patients had some observable problem with the lower eyelid, although only two were significant. The other four were very mild cases of lid shortening, exposing approximately 1 mm of sclera. Most patients who had approaches to the orbit through the lower lid, by either a transcutaneous or transconjunctival approach, had postsurgical suspension (Frost) sutures placed for approximately 4 days. In spite of this, 6 of 30 patients (20%) showed some observable deformity. This is consistent with studies in the literature. Pospisil and Fernando found a 37% transient ectropion in their patients who had subciliary approaches to the orbit.[33] All of their patients who developed this problem had a skin-only flap dissection to the orbital rim. Those that had a skin-muscle flap ($n = 7$) had no ectropion. They noted that older patients and those with edematous tissues were more likely to develop ectropion.

The incidence of ectropion/scleral show reported for subciliary incisions with skin/muscle dissection vary considerably. Heckler et al reported a 6% temporary incidence after a skin-muscle approach to the orbital floor.[34] Manson et al noted a 10% incidence of temporary ectropion or scleral show using a skin-muscle flap to approach the orbit.[35-37] They noted that sufficient resolution occurred with time that patients did not request corrective surgery. Wray et al compared the incidence of ectropion after subciliary exposure of orbital fractures versus the conjunctival approach and found an extremely high incidence of postoperative vertical lid shortening in the former.[38] After subciliary incisions, 19 of 45 eyelids developed ectropion, 15 of which were transient, and 4 of which required operative intervention. A prospective study by Lacy and Pospisil reported 55 skin/muscle dissections through the eyelid to perform zygomatico-orbital trauma surgery.[39] Ectropion occurred in 18% of their cases, being transient in all but two. They again noted an increased incidence in older patients and those with edematous lids during surgery. Bahr et al have confirmed that orbits operated after the onset of traumatic edema developed more complications.[40] They found that 3 of 16 patients (18.8%) developed ectropion after a subciliary incision with skin/muscle dissection to approach the orbit. However, the ectropion was permanent in only one patient. Antonyshyn et al found a scleral show frequency of 16.6% with this same approach.[41] Appling et al compared a subciliary incision with skin/muscle dissection to transconjunctival approaches to the orbit and noted a 12% rate of transient ectropion and a 28% rate of permanent scleral show after the subciliary approach.[42] No transient ectropion and only a 3% rate of permanent scleral show was found with the transconjunctival approach.

The literature and the findings of our study show that postsurgical ectropion/scleral show is common, especially when a subciliary approach is used to approach the orbit. In 1991, Phillips et al described a method of soft-tissue suspension of infraorbital and malar soft tissues before closing incisions after treating midfacial fractures.[43] They hypothesized that these soft tissues droop if not resuspended, resulting in facial asymmetry as well as providing traction on the lower eyelid, causing ectropion. Yaremchuk and Kim confirmed this and found a 20% incidence of scleral show when the facial soft tissues were not resuspended, but no scleral show when the tissues were resuspended.[44] Many of our patients had such suspension of the facial soft tissues, especially those that had extensive subperiosteal dissection to expose the fractures. In spite of this, scleral show occurred in some patients.

Recommendations for Treatment

Based on our experience and the information presented in this study, we have developed a protocol for treating isolated ZMC fractures. It is based on several assumptions: First, all ZMC fractures do not have to be treated in the same manner. Some require less surgical intervention than others.[3,5,7,19] Second, ZMC fractures can be categorized by CT scans into those that require aggressive exposure and fixation and those that do not.[46] A preoperative CT scan is obtained to determine which fractures should be treated aggressively, and whether the internal orbit requires reconstruction. Third, approaches to the infraorbital rim, whether transcutaneous or transconjunctival, can frequently be avoided, precluding the possibility of postsurgical eyelid deformities. Because the infraorbital rim is comminuted in 60% of cases[14] and therefore provides a poor site for stabilization, if the internal orbit does not require reconstruction, exposure of the infraorbital rim can be avoided. Alignment of the infraorbital rim can be assessed through the maxillary vestibular approach. Fourth, the amount of fixation required for ZMC fractures can be determined at the time of surgery. The Carroll-Girard screw allows the clinician to readily determine the stability of the repositioned ZMC. Fifth, reduction can be assessed with less than four-point exposure. The ability to do so is based on several factors including the amount of edema and the experience of the surgeon.[45]

We classify isolated ZMC fractures with CT scans similar to the method presented by Manson and colleagues.[46] Those that are severely displaced, segmented, or have comminuted articulations are placed into a high-energy category. Such cases usually require extensive internal orbital reconstruction. We take an aggressive approach to such fractures and expose at least the zygomaticomaxillary buttress, infraorbital rim/orbital floor, and lateral orbital rim. In many such cases, the zygomatic arch is also exposed. Our approaches are usually maxillary vestibular, lower eyelid, and if necessary, coronal. We usually expose the infra-

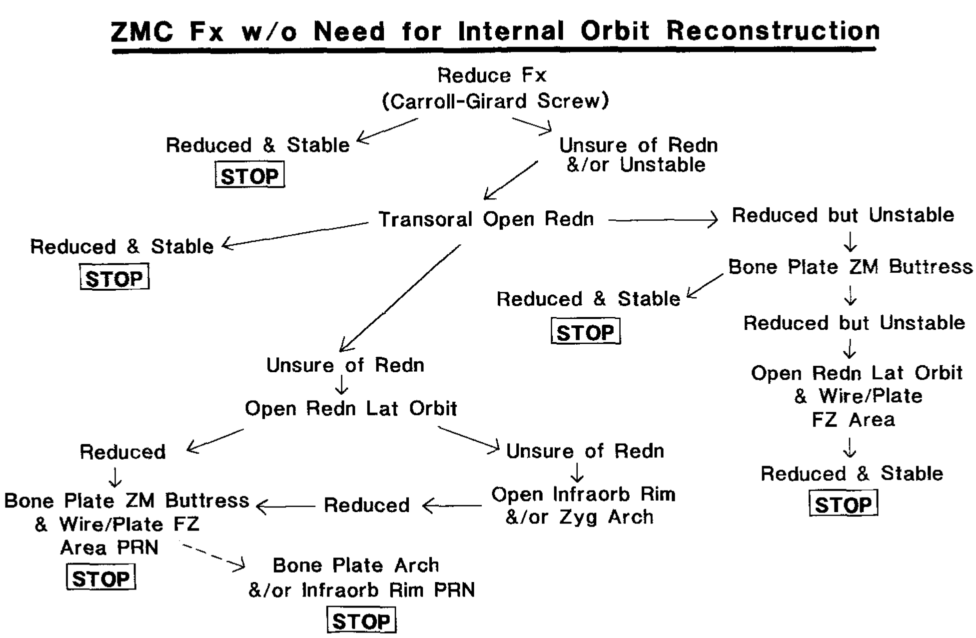

FIGURE 5. Flow diagram of treatment of low- to middle-energy ZMC fracture that does not require internal orbital reconstruction as judged by preoperative CT images.

orbital rim, frontozygomatic area, and entire orbital floor through the lower eyelid approach by stripping the lateral canthal tendon and dissecting superiorly along the lateral orbital rim.[35] Our decision to use a coronal approach is based on the amount of displacement of the ZMC posteriorly and laterally and comminution of the arch.[47,48] If the other articulations more anteriorly appear to be significantly comminuted, exposure and reconstruction of the arch provides another point for reduction and stabilization (Fig 4). A coronal approach for an isolated ZMC fracture is also used if a medial orbital wall fracture is present that cannot be reached and reconstructed from the lower eyelid incision.

We treat fractures that do not require reconstruction of the internal orbit by a progressive, step-wise approach. If the preoperative CT scans show that the internal orbit does not require reconstruction, the treatment proceeds as outlined in Figure 5. The first area of surgical exposure, if necessary for reduction or fixation, is intraoral. An incision in the lower eyelid is avoided, if possible, to minimize the chance of postoperative scleral show. Using this algorithm, one can frequently provide satisfactory treatment with less intervention than would be required to immediately open all articulations of the fractured ZMC.

References

1. Ellis E, El-Attar A, Moos K: An analysis of 2,067 cases of zygomatico-orbital fracture. J Oral Maxillofac Surg 43:417, 1985
2. Burcal RG, Laskin DM, Sperry TS: Recognition of profile change after simulated orthognathic surgery. J Oral Maxillofac Surg 45:666, 1987
3. Kaastad E, Freng A: Zygomatico-maxillary fractures. J Craniomaxillofac Surg 17:210, 1989
4. Ogden GR: The Gillies method for fractured zygomas. J Oral Maxillofac Surg 49:23, 1991
5. Zingg M, Laedrach K, Chen J, et al: Classification and treatment of zygomatic fractures. J Oral Maxillofac Surg 50:778, 1992
6. Covington DS, Wainwright DJ, Teichgraeber JF, et al: Changing patterns in the epidemiology and treatment of zygoma fractures: 10-year review. J Trauma 37:243, 1994
7. Holmes KD, Matthews L: Three-point alignment of zygoma fractures with miniplate fixation. Arch Otolaryngol Head Neck Surg 115:961, 1989
8. Rumsey C, Sargent LA: Zygomatic fractures. Trauma 9:76, 1992
9. Rohrich RJ, Hollier LH, Watumull D: Optimizing the management of orbitozygomatic fractures. Clin Plast Surg 19:149, 1992
10. Rinehart GC, Marsh JL, Hemmer KM, et al: Internal fixation of malar fractures: An experimental biophysical study. Plast Reconstr Surg 84:21, 1989
11. Davidson J, Nickerson D, Nickerson B: Zygomatic fractures: Comparison of methods of internal fixation. Plast Reconstr Surg 80:1, 1990
12. Dal Santo F, Ellis E, Throckmorton GS: The effects of zygomatic complex fracture on masseteric muscle force. J Oral Maxillofac Surg 50:791, 1992
13. Dingman RO, Natvig P: The zygoma, *in* Surgery of Facial Fractures. New York, NY, Saunders, 1964, p 219
14. Karlan MS, Cassissi NJ: Fractures of the zygoma: A geometric, biomechanical, and surgical analysis. Arch Otolaryngol 105:320, 1979
15. Wavak P, Zook EG: Immobilization of fractures of the zygomatic bone with an antral pack. Surg Gynecol Obstet 149:587, 1979
16. Larsen OD, Thomsen M: Zygomatic fractures. Scand J Plast Reconstr Surg 12:59, 1976
17. Balle V, Christensen PH, Greisen O, et al: Treatment of zygomatic fractures: A follow-up study of 105 patients. Clin Otolaryngol 7:411, 1982
18. Champy M, Lodde JP, Kahn JL, et al: Attempt at systematization in the treatment of isolated fractures of the zygomatic bone: techniques and results. J Otolaryngol 15:39, 1986
19. Eisele DW, Duckert LG: Single-point stabilization of zygomatic fractures with the minicompression plate. Arch Otolarngol Head Neck Surg 113:267, 1987
20. Tarabichi M: Transsinus reduction and one-point fixation of malar fractures. Arch Otolaryngol Head Neck Surg 120:620, 1994
21. Champy M, Gerlach KL, Kahn JL, et al: Treatment of zygomatic bone fractures, *in* Hjorting-Hansen E (ed): Oral and Maxillofacial Surgery: Proceedings from the 8th International Conference of Oral and Maxillofacial Surgery, Chicago, IL, Quintessence, 1985, pp 226-231
22. Wangerin K, Busch HP, Conrad HG: Complication incidence of zygomatic bone fractures using different operations methods, *in* Hjorting-Hansen E (ed): Oral and Maxillofacial Surgery: Proceedings from the 8th International Conference of Oral and Maxillofacial Surgery. Chicago, IL, Quintessence, 1985, pp 236-240
23. De Man K, Bax WA: The influence of the mode of treatment of zygomatic bone fractures on the healing process of the infraorbital nerve. Br J Oral Maxillofac Surg 26:419, 1988
24. Schilli W: Treatment of zygoma fractures. Oral Maxillofac Clin North Am 2:155, 1990
25. Manson PN, Hoopes JE, Su CT: Structural pillars of the facial skeleton: an approach to the management of Le Fort fractures. Plast Reconstr Surg 66:54, 1980
26. Stanley RB, Mathog RH: Evaluation and correction of combined orbital trauma syndrome. Laryngoscope 93:856, 1983
27. Pearl RM, Vistnes LM: Orbital blowout fractures: An approach to management. Ann Plast Surg 1:267, 1978
28. Pearl RM: Surgical management of volumetric changes in the bony orbit. Ann Plast Surg 19:349, 1987
29. Wolfe SA: Treatment of post-traumatic orbital deformities. Clin Plast Surg 15:225, 1988
30. Mathog RH, Hillstrom RP, Nesi FA: Surgical correction of enophthalmos and diplopia. Arch Otolaryngol Head Neck Surg 115:122, 1989
31. Bite U, Jackson IT, Forbes GS, et al: Orbital volume measurements in enophthalmos using three-dimensional CT imaging. Plast Reconstr Surg 75:502, 1985
32. Manson PN, Grivas A, Rosenaum A, et al: Studies on enophthalmos: II. The measurement of orbital injuries by quantitative computed tomography. Plast Reconstr Surg 77:203, 1986
33. Pospisil OA, Fernando TD: Review of the lower blepharoplasty incision as a surgical approach to zygomatic-orbital fractures. Br J Oral Maxillofac Surg 22:261, 1984
34. Heckler FR, Songcharoen S, Sultani FA: Subciliary incision and skin-muscle flap for orbital fractures. Ann Plast Surg 10:309, 1983
35. Manson PN, Ruas E, Iliff N, et al: Single eyelid incision for exposure of the zygomatic bone and orbital reconstruction. Plast Reconstr Surg 79:120, 1987
36. Manson PN, Iliff NT: Orbital fractures. Facial Plast Surg 5:243, 1988
37. Dufresne CR, Manson PN, Iliff NT: Early and late complications of orbital fractures. Clin Plast Surg 15:239, 1988
38. Wray RC, Holtmann B, Ribaudo JM, et al: A comparison of conjunctival and subciliary incisions for orbital fractures. Br J Plast Surg 30:142, 1977
39. Lacy MF, Pospisil OA: Lower blepharoplasty post-orbicularis approach to the orbit: A prospective study. Br J Oral Maxillofac Surg 25:398, 1987
40. Bahr W, Bagambisa FB, Schlegel G, et al: Comparison of transcutaneous incisions used for exposure of the infraorbital rim and orbital floor: A retrospective study. Plast Reconstr Surg 90:585, 1992
41. Antonyshyn O, Gruss JS, Galbraith DJ, et al: Complex orbital

fractures: A critical analysis of immediate bone graft reconstruction. Ann Plast Surg 22:220, 1989
42. Appling WD, Patrinely JR, Salzer TA: Transconjunctival approach vs subciliary skin-muscle approach for orbital fracture repair. Arch Otolaryngol Head Neck Surg 119:1000, 1993
43. Phillips JH, Gruss JS, Wells MD, et al: Periosteal suspension of the lower eyelid and cheek following subciliary exposure of facial fractures. Plast Reconstr Surg 88:145, 1991
44. Yaremchuk MJ, Kim W-K: Soft-tissue alterations associated with acute, extended open reduction and internal fixation of orbital fractures. J Craniofac Surg 3:134-140, 1992
45. Rich JD, Zbylski JR, LaRossa DD, et al: A simple method for rapid assessment of malar depression. Ann Plast Surg 3:151, 1979
46. Manson PN, Markowitz B, Mirvis S, et al: Toward CT-based facial fracture treatment. Plast Reconstr Surg 85:202, 1990
47. Stanley RB: The zygomatic arch as a guide to reconstruction of comminuted malar fractures. Arch Otolaryngol 115:1459, 1989
48. Gruss JS, Van Wyck L, Phillips JH, et al: The importance of the zygomatic arch in complex midfacial fracture repair and correction of posttraumatic orbitozygomatic deformities. Plast Reconstr Surg 85:878, 1990

J Oral Maxillofac Surg
54:400-401, 1996

Discussion

Analysis of Treatment for Isolated Zygomaticomaxillary Complex Fractures

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This report is another study by Ellis et al on the fractured zygoma. It addresses the amount of stabilization and approaches that were used and their long term follow-up. In a fashion that has been characteristic for Ellis, he has 1) reviewed the literature, 2) developed a clinical philosophy, 3) supported it with experimental work, and 4) followed his patients. This pattern of investigation serves as a model for investigators in honestly evaluating the outcome of our treatment.

The questions that he raises have been also raised by others; they reflect a growing concern with identifying the minimal treatment appropriate for a particular set of characteristics of an injury. The enthusiasm for extensive open reduction and rigid fixation techniques recently surpassed that for more limited approaches such as closed reduction and the use of wire interfragment fixation. In the 1970s, more extensive degloving approaches were applied to the midfacial skeleton with a dramatic increase in the accuracy of reduction. The introduction of plate and screw fixation in the 1980s required broader exposures, which improved reductions because of the dual mechanisms of better visualization and increased 3-dimensional stability.

However, recently the adverse effects of wide subperiosteal exposure have begun to receive comment in the literature. Clinicians with significant experience in facial injuries, having experienced a number of complications directly related to plate and screw fixation, such as increased lower eyelid ectropion, have begun to suggest that we avoid extensive exposures. Techniques of repositioning the soft tissue (following extensive exposure) and for the correction of soft tissue deformity after open reduction have arisen from complications of these exposures.[1-6] We are now aware that wide surgical exposure has risks as well as benefits. Scarring, soft tissue displacement, soft tissue disorganization, ectropion, and soft tissue atrophy are seen. It is only natural, therefore, that certain fracture patterns be identified for less extensive treatment. The two principal objections to extensive exposure are soft tissue slippage and resorption of bone. Curiously, the possibility of bone resorption (that we know in bone grafts affects at least one third of the volume even under ideal circumstances), has never been studied after wide subperiosteal dissections for fracture reduction.

The literature on zygoma fractures offers a wide variety of treatment options, including closed reduction. Closed reduction which fell out of fashion in the 1980s but is recently receiving some support, is most appropriate for fractures that are noncomminuted, treated early, and that are incomplete at one or more buttress articulations. The incomplete fracture should preferably be at the zygomatico-frontal suture. Laedrach and Raveh[7] have had an extensive experience with closed as well as open reduction and prefer closed reduction in many cases, and count on both the incomplete fracture and "wedging" as techniques of achieving stability in closed reduction.

Ellis has followed a group of patients with facial trauma (the follow-up is notoriously difficult in this population of predominately young males) and produced a good study with some thoughtful recommendations. Even in his hands, 11% of the patients had an unsatisfactory reduction. None of these were after closed reduction. Interestingly, 60% of those reductions identified as unsatisfactory had no significant physical asymmetry determined by the observers. (The normal asymmetry in the face masks a fair amount of post-traumatic zygomatic malposition, as has been noted by others). Six of his patients showed enophthalmos and 20% had lid abnormalities following lower lid incisions. Thirteen percent of lower eyelid skin incisions and 16% of conjunctival incisions were troubled by lid shortening. Despite the fact that a coronal incision was used in 24%, only 10% of his patients required "four point fixation", whereas 24% were described as having arch reduction. Thirty-five percent of patients had either closed reduction or one point fixation, and 85% of zygoma fractures could be managed with three or less points of fixation. Ellis has therefore dealt with the two major considerations in zygomatic fracture treatment: 1) how much exposure is required for alignment? and 2) how much exposure is required for fixation? The two needs are different! He correctly identifies the computed tomography (CT) scan as the single best preoperative and postoperative assessment (it is the "Gold Standard".) Essentially, all patients evaluated for zygomatic fractures of significance ought to have an axial and coronal CT scan with bone and soft tissue windows for analysis. If one wants to improve results (and despite the concern about cost and the fact that I will probably receive some angry letters to the editor by this endorsment), I would say that one should obtain postoperative CT scans. In my experience, they are the single best teaching tool in determining midfacial fracture reduction accuracy.

One evening I was standing outside an operating room where I had just finished a midfacial fracture reduction. Andy Burgess, Chief of Orthopedics at the University of Maryland Shock Trauma Unit was standing outside an adjacent room