A Prospective Study of Orbital Fracture Sequelae After Change of Surgical Routines

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Purpose: The present study was undertaken to investigate the circumstances surrounding the considerable increase in the number of orbital floor fracture repairs at the ORL Clinic at Sahlgrenska University Hospital at the end of the 1990s.

Patients and Methods: All the patients during a period of 1 year with a fracture involving the orbital floor were followed for 1 year using clinical assessments and questionnaires. Etiology, surgical methods, and the occurrence of long-term sequelae were investigated.

Results: Fifty-one patients were included. The main etiologies were assaults and falls. Surgery of the internal orbit was performed in 76%, often combined with a Gillies reduction. Porous polyethylene sheets (Medpor; Porex Surgical Inc, Newnan, GA) were used for the repair of large floor defects. Compared with previous results, the number of computed tomography investigations had considerably increased. The number of operations on the internal orbit due to fractures had doubled. The occurrence of diplopia was reduced compared with the situation when the floor was stabilized with an antral packing. Late enophthalmos developed in 11%. Despite fixation, the majority (67%) reported permanently affected sensibility.

Conclusion: The frequency and severity of diplopia decreased parallel to the introduction of Medpor implants and the termination of the antral packing technique. Tetrapod zygomatic fractures, possibly unnecessarily submitted for surgery of the internal orbit, were in part responsible for the increase in the number of orbital explorations, in spite of preceding computed tomography scans. This indicates inadequate diagnostic techniques. Studies evaluating alternative complementary diagnostic methods are in progress.

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Göteborg, with its population of approximately 500,000 inhabitants, is the second largest city in Sweden. The departments of otorhinolaryngology and head & neck surgery (ORL-HNS), plastic surgery, and oral surgery collaborate on handling the facial injuries within this area.[1] The ORL-HNS Clinic handled surgically approximately 20 internal orbital fractures a year in 1991 to 1995, the majority of which were due to low-energy trauma. In 1996 to 1999, the number of patients with internal orbital surgery due to trauma increased yearly to nearly double in the year of the present study.

Surgery for orbital fractures, which aims to produce an entirely successful functional and cosmetic result, is essential. Over the years, however, there has been much discussion and controversy about the patients who should be operated on and the timing of surgery.[2-5] Nevertheless, long-term sequelae following these fractures are still common, even if their severity and extent can vary.

The aim of the present study was to establish the circumstances behind the increase in the occurrence of orbital floor fracture explorations at the department. Furthermore, the purpose was to investigate

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Table 1. TYPES AND CAUSES OF FRACTURE

Type of Fracture	No. of Cases (%)	No. of Assaults (%)	No. of Falls (%)	No. of Vehicle Accidents (%)	No. of Sports Injuries (%)	No. of Accidental Blows by an Object (%)
Blowout	11 (22)	5 (29)	5 (28)	− (0)	− (0)	1 (50)
Zygomatico-orbital	24 (47)	9 (53)	6 (33)	4 (36)	1 (33)	1 (50)
Tetrapod zygomatic	14 (27)	3 (18)	5 (28)	7 (64)	2 (67)	− (0)
Le Fort II/III	2 (4)	− (0)	2 (11)	− (0)	− (0)	− (0)
Total	51 (100)	17 (100)	18 (100)	11 (100)	3 (100)	2 (100)
Male-to-female ratio	2.2:1	7.5:1	1:1.6	4.5:1	2:1	2:0

NOTE. Nine of 11 (82%) vehicle incidents were bicycle accidents. Four of the zygomatico-orbital fractures (sustained in 1 horseback riding accident and 3 vehicle accidents) were regarded as complicated because the zygoma had multiple fractures. Both Le Fort fractures were caused by high falls.

surgeons' methods of surgical repair and the long-term outcome. We also compare these cases with those of our prior study of orbital fractures.[6]

Patients and Methods

In the course of 1 year (September 1998 to September 1999), 83 patients visited the ORL-HNS Clinic in connection with an injury subsequently registered as a zygomatico-maxillary complex fracture. The inclusion criteria for the study were patients with a recent injury with 1) a zygomatic fracture involving the orbital floor (tetrapod zygomatic fractures included) or 2) a pure blowout fracture of the orbit. A third condition was that the patient was able to understand and fill in a questionnaire, along with appointments at which they were clinically assessed by an ORL consultant 5 times during a period of 1 year after the trauma.

Patients were generally seen within the first 1 to 2 days after trauma. Preoperative radiology was performed according to the routines at the ORL Clinic, and the patients were operated on during the next week. Follow-up was undertaken after 1 week, 1 month, and 6 months, and a final evaluation was made 1 year after surgery.

INCLUDED, EXCLUDED, AND "MISSED" SUBJECTS

Fifty-one patients were included, and 32 of them were seen regularly according to the stipulated appointments, as described earlier. Thirty-two patients were excluded, of whom 14 had an isolated fracture of the zygomatic arch, 13 had a psychiatric disorder and/or serious drug abuse, three because they did not understand Swedish or English, and 2 did not wish to take part in the study. Fourteen only answered the final questionnaire by mail and clinical information could be satisfactorily completed using the patient's chart. Five patients could not be reached at all for the follow-up.

QUESTIONNAIRES AND PROTOCOLS

All of the patients who answered the questionnaire did so after informed consent had been obtained. The ORL consultant used another specific protocol to produce a uniform documentation of the clinical findings. A third, detailed protocol relating to the intraoperative fracture findings and surgical treatment was filled in by the surgeon immediately after the operation and compared with the radiologic findings.

The study was approved by the Ethics Committee at Göteborg University.

Results

GENERAL INFORMATION

The final questionnaire was answered by 86% of the included patients. The overall response rate for the separate questions was a minimum of 70%.

The male-to-female ratio was 2.2:1. The mean age of the study group was 43 years, with a range of 16 to 90 years.

The main reasons for the injuries were assaults and falls, closely followed by traffic accidents, particularly bicycle accidents (Table 1). Forty-one percent did not report the injury to any insurance company. The majority of the assaulted victims (13 of 17; 76%) reported the case to the police. Alcohol intake before the injury was denied by 51% and admitted by 14% of the patients. Among the assaulted patients, as many as 53% did not answer the question, whereas 41% denied having drunk alcohol. Three of the patients injured in traffic accidents (3 of 11; 27%) had drunk alcohol before the trauma.

In addition to the clinical assessment, the diagnosis was established by radiography in all patients. The majority (88%) had a computed tomography (CT) scan, preceded in most cases by a plain radiograph (51%). The remainder only had a plain radiographic examination.

Table 2. MATERIALS USED FOR ORBITAL FLOOR RECONSTRUCTION

Implant	1991	1992	1993	1994	1995	1998/1999
None	40	40	53	33	17	22.5
Lyoplant*	5	30	21	24	48	42.5
Medpor	0	0	0	0	9	3.5
Other (eg, Surgicel, Spongostan)	0	0	0	0	9	2.5
Cartilage	5	0	5	9.5	9.5	0
Bone	10	5	16	24	4	0
Balloon catheter/gauze tampon	40	25	5	9.5	13	0
Total (%)	100	100	100	100	109.5	102.5

NOTE. Forty orbits were explored (in 39 patients) in September 1998 through September 1999. One patient received 2 implants in the same orbit, Lyodura and Medpor, which is why the the sum exceeds 100%. Data for 1991 through 1995 were obtained from the surgery register. Values are given in percentage of patients.

*Lyoplant replaced Lyodura in 1998.

The types of fracture are shown in Table 1. The ratio of fractures of the zygomatico-orbital complex to pure blowout fractures was 4:1. In 4 of all of the cases (8%), there was an associated fracture of the medial orbital wall. One blowout fracture was combined with a medial wall fracture (1 of 11; 9%), otherwise blowout fractures in this study were isolated orbital floor fractures. The tetrapod zygomatic fractures were defined as the group of zygomatico-orbital fractures showing simple fracture lines at/next to the frontozygomatic suture, the inferior rim, the zygomatic arch, and at the lateral maxillary sinus wall/lateral pillar of the zygomatic corpus and across the orbital floor. A multifractured (ie, more than a single crack) orbital floor with or without a defect, along with one or more fracture lines across the zygoma and/or infraorbital rim are in Table 1 defined as the "zygomatico-orbital fractures." The distinction is made in this study as for tetrapod fractures a simple closed reduction is often enough, whereas for more extensive injuries open, orbital surgery to a greater extent might be indicated.

Eye motility was preoperatively estimated by an ophthalmologist in 78% of the patients. A forced duction test was carried out in 45% during general anesthesia in connection with the operation.

SURGERY

Ninety-two percent (47 of 51) of the patients underwent surgery. An operation on the internal orbit was performed in 39 cases. A Gillies reduction alone was performed in the remaining 8 cases. One patient with a Le Fort III fracture had both orbits explored.

Half of the isolated blowout fracture patients who underwent surgery (4 of 9) had diplopia; otherwise, the indication for the operation was based on the CT findings. In 13 of 19 cases, the surgeon thought that the CT scans did not provide a true representation of the fracture. In most of these cases (n = 11), the fracture was thought intraoperatively to be considerably more extensive than the CT indicated.

Fifty-one percent of the patients qualifying for surgery were operated on within 1 week, none later than 14 days after trauma. The hospitalization period for the majority (53%) of the patients was 2 days or less.

IMPLANTS AND MICROPLATES

Orbital surgery was performed through a subciliary incision combined with an intraoral approach and/or an incision at the lateral eyebrow when needed. Only in 2 cases was a coronal incision used.

An implant was used in 78% of the orbits. Soft lyophilized collagen sheets (Lyoplant; Braun Aesculap, Tutsingen, Germany) were most frequently used, followed by the use of 0.85-mm porous polyethylene sheets (Medpor; Porex Surgical Inc, Newnan, GA) (Table 2). Lyoplant was used for "mosaic" fractures (defined here as a multifractured orbital floor with a retained periosteum and/or mucosa of the maxillary sinus) of the orbital floor up to an approximate size of 600 mm^2 and, in cases with only small defects, that is, less than 100 to 150 mm^2, or to cover a narrow crack in the floor.

Medpor was mainly used when defects were larger than 200 mm^2 and in most cases of soft-tissue herniation (10 of 14; 71%), when a stable implant was needed. When there were defects of approximately 100 to 150 mm^2, either of the 2 materials was used.

Microplates for fixation at the infraorbital rim and/or at the frontozygomatic suture were used in 29 of the 47 operations (62%). Plate fixation of the lateral pillar of the zygoma, to obtain a third fixation point, was not routinely performed.

It was decided that none of the 8 fractures reduced by the Gillies procedure alone needed further fixation. However, in 4 of these cases, the fracture was not satisfactorily rigid after repositioning, resulting in asymmetric cheek prominences at follow-up.

Of the patients undergoing internal orbit surgery 77% received perioperative antibiotics, usually followed by 7 to 10 days of peroral treatment. When the porous material Medpor was used, antibiotics were

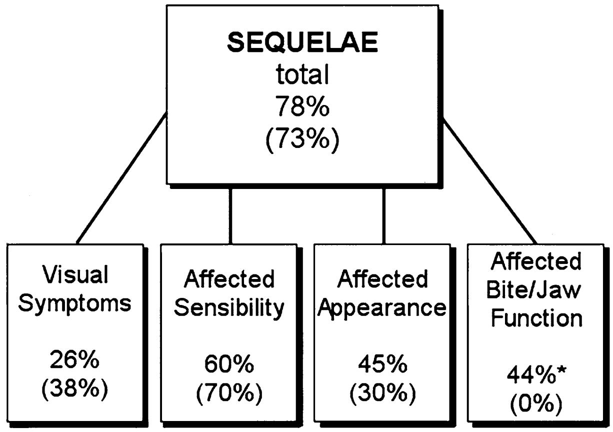

FIGURE 1. Long-term sequelae after orbital floor fractures. Corresponding frequencies for pure blow-out fractures alone within parentheses. The frequency of permanent diplopia and enophthalmos among the blowout fractures was 14% (1 of 7) and 29% (2 of 7), respectively compared with 9.5% (4 of 42) and 11% (6 of 43) in the entire patient group. *Blowout fractures excluded.

administered in most cases (77%). There were no cases of implant infections or rejections.

SEQUELAE

Seventy-eight percent of the 51 patients reported some kind of sequelae at the final follow-up, that is, 1 year after the trauma. The symptoms were divided into 4 main groups according to the questions on the questionnaire: 1) vision disturbances, 2) sensibility disturbances, 3) cosmetic consequences, and 4) reduced capacity of jaw opening and/or bite problems (Fig 1).

Vision Disturbances

Preoperatively, 17 patients (33%) had diplopia. Seven patients (16%) displayed restrained eye motility, and 5 of them had simultaneous diplopia.

Twenty-six percent experienced some kind of change in eye function 1 year after the trauma. Four patients (9.5%) reported diplopia. In 2 of these cases, which were included in the group of the 30 patients examined, clinical assessments were able to verify diplopia at the outer parts of the visual field. None of the patients had diplopia in primary gaze or any detectable eye motility disorder. However, 1 had also developed a discrete enophthalmos.

Seventeen percent were still experiencing blurred vision 1 year after the trauma, but this did not interfere with their daily life.

Sensibility Disturbances

Before surgery, 82% of the patients had experienced some sensibility disorder in the distribution region of the infraorbital nerve. One year after the trauma, 60% of them still did, mainly in the form of numbness. The corresponding occurrence among the blowout fractures accounted for separately was 70% before and 1 year after trauma.

A non-negligible number of the patients had pain (21%) and/or a sense of pricking (29%) at the final follow-up. Thirty-six percent were still bothered about the lack or absence of sensibility along the upper front gum/teeth on the injured side, unlike patients with an upper denture, who were not troubled by this manifestation of disturbed sensibility.

Despite fixation, the majority (67%) reported permanently affected sensibility. Of the 8 patients reduced ad modum Gillies alone, with no fixation, 5 had normal sensibility, despite the postoperative redislocation of the fracture in 2 cases.

Cosmetic Consequences

Varying degrees of affected physical appearance were reported by 45%. Ten percent complained about the surgical scar. At examination, a permanent scleral show could be observed in 6 of 21 cases (29%) (Fig 2A). Long-term ectropion was established in 1 patient and reported in another one.

Enophthalmos was observed in 6 of 31 cases (19%) at final examination. This was obvious to the naked eye during a professional visual inspection without Hertel's instrument. However, only 3 of these patients had themselves noted the change in the face. In no case did enophthalmos show during the first month after trauma/surgery and it was not detected until after 6 months (Fig 2B).

Six cases ended up with a flattened cheek contour despite surgery. Four of them were plain tetrapod zygomatic fractures treated with a closed reduction, with no further fixation. Of the 6, the majority (67%) suffered cosmetically from the loss of cheek prominence.

Reduced Capacity of Jaw Opening and/or Bite Problems

Preoperatively, 71% experienced disturbed jaw function and/or did not think their bite fitted normally. In some cases, these symptoms did not disappear completely despite surgery and 18 patients (44%) ended up with persistent problems. Of these, the majority experienced an impaired ability to open their mouth (24%). However, at the last clinical examination, no patient was found to have less than 40 mm maximum interincisal opening.

OTHER SEQUELAE

Some patients spontaneously mentioned persistent symptoms such as hyperesthesia (12 of 45 patients; 27%) or increased sensibility to chill/cold and/or wind (13 of 45 patients; 29%) in the region supported by the infraorbital nerve, increased tear flow (8 of 45 patients; 18%) and/or, in some cases of injury due to assaults, a posttrauma negative impact on mental well-

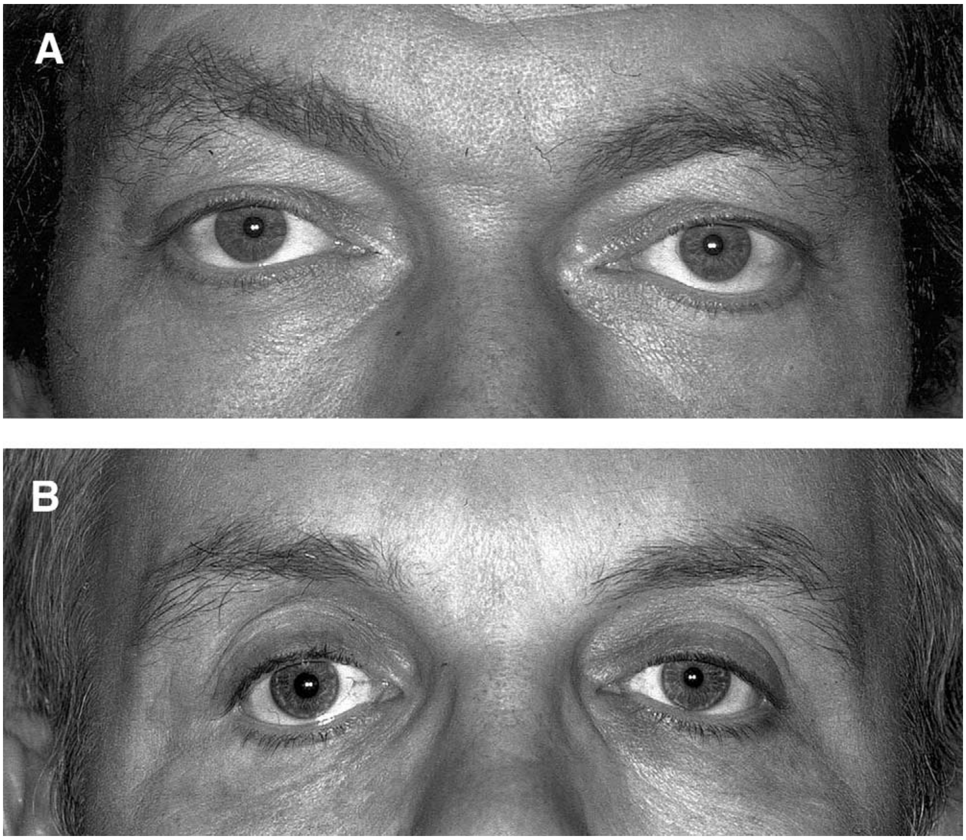

FIGURE 2. *A*, Permanent scleral show 1 year after subciliary incision for the exploration of the left orbital floor. *B*, Enophthalmos developing more than 6 months after surgery for a zygomatico-orbital fracture with a complete loss of the orbital floor (right orbit) despite reduction and a 0.85-mm Medpor implant.

being (10 of 45 patients; 22%). Three patients (7%) had noted episodes of lower eyelid tics first appearing postoperatively. A separate analysis of the blow-out fracture patients revealed equal frequencies, apart from a higher occurrence of tics (18%).

Discussion

Although it is difficult to make exact comparisons between the present study and our previous one, it appears that at the end of the 1990s, there was a considerable increase in the number of patients with an orbital floor fracture that were registered and operated on at the ORL-HNS Clinic at Sahlgrenska University Hospital.[6] In the course of 1 year, twice the number of operations on the internal orbit due to floor fractures were performed compared with those performed during a period of 1 year at the start of the decade.

It is a common belief that CT scans should be performed more or less routinely on all zygomatico-orbital fractures.[7] However, many experts also regard ordinary radiographs as being sufficient when diagnosing low-impact/energy zygomaticomaxillary complex fractures.[5,8]

In the present study, as many as 88% of the cases had a CT scan, although most fractures were low-energy injuries. This is a 50% increase in a period of less than 4 years. In this perspective, it is interesting to note that parallel to the increased number of CT investigations it appears that a larger number of tetrapod zygomatic fractures were included among the "orbital floor fractures" than in the first half of the 1990s. Further analysis indicates that there has been a tendency to perform orbital explorations in more tetrapod zygomatic fractures than before and the need for this should be discussed. There are many advocates of minimization of surgical treatment and avoidance of orbital floor reconstructions if not convincingly indicated.[3,5] In retrospect, the present study appears to contain 8 cases (17%) that were sent for an unnecessary operation on the internal orbit. This could suggest that there is a risk of misjudging the severity of a tetrapod zygomatic fracture when studied in detail on a CT scan (Fig 3).

In this context, it is interesting to note a commonly held view among surgeons that, in many cases, the CT images did not correspond very well to the fracture findings established intraoperatively. This has already been commented on.[9]

Sequelae after surgery for orbital fractures are known to be common. In the present study, effects on vision displayed an improvement, in that the frequency of diplopia had changed from 17% to 9.5% on a comparison made with our previous study.[6] Furthermore, the affected patients only experienced diplopia

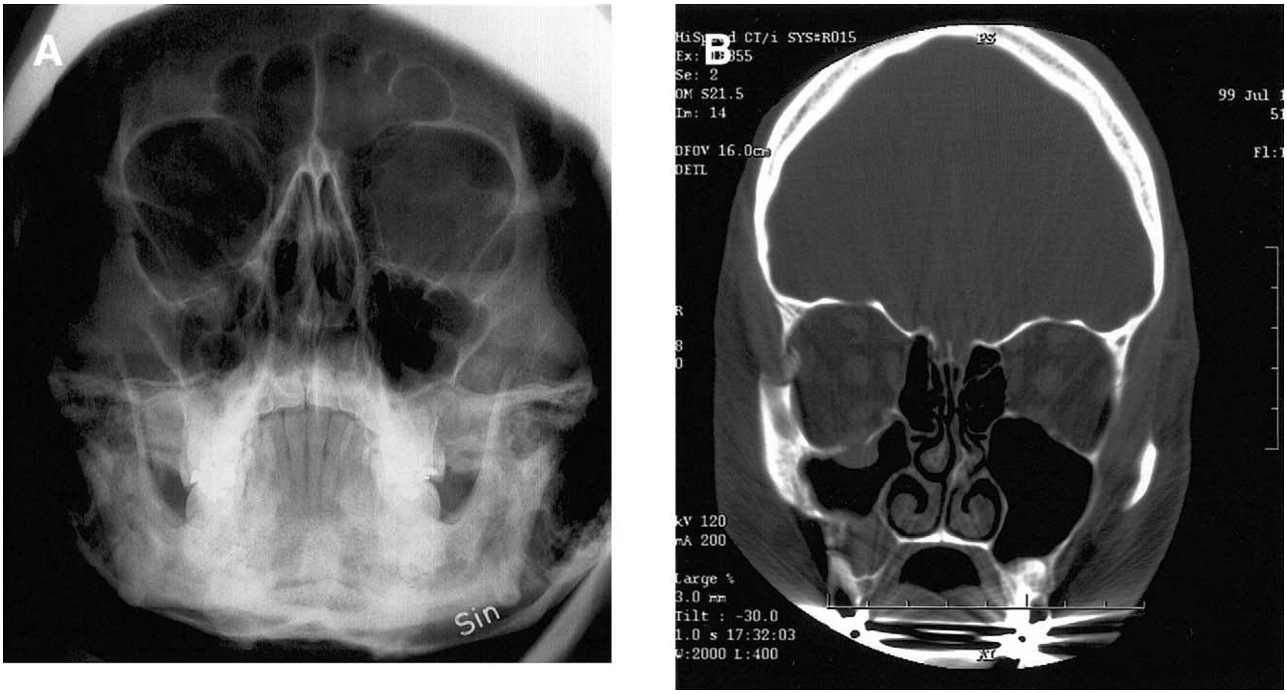

FIGURE 3. How often is an operation on the internal orbit performed unnecessarily? *A,* A plain radiograph showing a zygomatico-orbital fracture involving the right orbital floor (tetrapod zygomatic fracture). *B,* Radiography was supplemented with a CT scan indicating a possible herniation, but in retrospect was diagnosed as a hematoma in connection with the orbital floor. At surgery, when an orbital exploration was performed, it was verified that the floor was completely reduced and rigid after a Gillies procedure without fixation. The periorbita was intact, and there was no incarceration of soft tissue. The operation on the internal orbit could therefore be regarded as unnecessary.

at extreme gaze and were not bothered by the symptom in daily life, unlike some of the patients in the previous study with disabling double vision. The direction of a diplopia could not be correlated to any particular type or size of orbital floor fracture.

However, there was no change for the better in terms of sensibility disturbances and no significant improvement was seen in the effects on physical appearance on a comparison made on our previous results.[6]

In this study, as many as 60% of the patients still had a sensibility disorder 1 year after the trauma. It has been shown in previous studies that rigid fixation also improves the results when it comes to sensibility.[10-12] In the present study, 67% had disturbed sensibility, despite rigid fixation. Five of the 8 patients who underwent a closed reduction without fixation reported normalized sensibility at the final follow-up. This again raises the questions of whether and to what extent the sensibility disorders are due only to the trauma or also to the tissue manipulation during open surgery.[5,10,13,14]

Parallel to the improved effects on vision, Medpor had entirely replaced the use of balloon catheters or gauze tampons in the maxillary sinus as a temporary (5 to 7 weeks) support for the floor fracture. Neither bone nor cartilage was used as an orbital implant after the introduction of Medpor. However, the occurrence of enophthalmos was still high. In six cases of 31 (19%) "follow-ups," a cosmetically obvious enophthalmos was established. None of the "missed" cases reported any enophthalmos in the dispatched questionnaire, resulting in an occurrence of 11% (6 of 43). However, as patients sometimes appear to overlook the presence of an enophthalmos, there might be a number of unrecorded cases.[4]

All 6 cases of enophthalmos were diagnosed at a control at postoperative visit at or more than 6 months after surgery, indicating that risk cases should be followed for a longer period than uncomplicated cases. Methods of measuring orbital volume preoperatively at CT scans and postoperative radiologic check-ups of surgical restoration of the bony orbit have the potential to reduce the occurrence of long-term enophthalmos.[15] However, early Hertel's measurements have not proved to correlate with the computer volumetric values or with subsequent late enophthalmos.[16]

The fact that enophthalmos did not manifest itself until several months after trauma/surgery could indicate that not only the resolution of edema, emphysema, and/or hemorrhage but also an alteration in the soft tissues was responsible for reduced orbital content that revealed the increased orbital volume. Posttraumatic degeneration of the intraorbital fat tissue is, however, not commonly accepted as an explanation.[14,17]

It is suggested that the change in surgical routines involving the replacement of the former technique of antral packing as a support for large orbital floor fractures with the use of porous polyethylene sheets in the orbit has improved surgical results in terms of long-term diplopia, the frequency and severity of which have decreased.

Patients at risk of developing enophthalmos must be followed for 6 months or more to provide feedback on surgical techniques at the very least.

Tetrapod zygomatic fractures, possibly unnecessarily submitted for surgery on the internal orbit, were in part responsible for the increase in the number of orbital explorations, in spite of preceding CT scans. This indicates inadequate diagnostic techniques. Studies evaluating alternative complementary diagnostic methods are in progress.

References

1. Gewalli F, Sahlin P, Guimaraes-Ferreira J, et al: Orbital fractures in craniofacial trauma in Goteborg: Trauma scoring, operative techniques and outcome. Scand J Plast Reconstr Surg Hand Surg 37:69, 2003
2. Putterman AM, Stevens T, Urist MJ: Nonsurgical management of blow-out fractures of the orbital floor. Am J Ophthalmol 77:232, 1974
3. Shumrick KA, Campbell AC: Management of the orbital rim and floor in zygoma and midface fractures: Criteria for selective exploration. Facial Plast Surg 14:77, 1998
4. Hartstein ME, Roper-Hall G: Update on orbital floor fractures: Indications and timing for repair. Facial Plast Surg 16:95, 2000
5. Kovacs AF, Ghahremani M: Minimization of zygomatic complex fracture treatment. Int J Oral Maxillofac Surg 30:380, 2001
6. Folkestad L, Westin T: Long-term sequelae after surgery for orbital floor fractures. Otolaryngol Head Neck Surg 120:914, 1999
7. Ellis E 3rd: Imaging of zygomatico-orbital fractures. Compendium from International Course in Advanced Cranio-Maxillofacial Surgery, University of Glasgow, October 9-10, 1999
8. Moos KF: Imaging of zygomatico-orbital fractures: Plain film. Compendium from International Course in Advanced Cranio-Maxillofacial Surgery, University of Glasgow, October 9-10, 1999
9. Ilankovan V, Hadley D, Moos K, el Attar A: A comparison of imaging techniques with surgical experience in orbital injuries: A prospective study. J Craniomaxillofac Surg 19:348, 1991
10. Vriens JP, van der Glas HW, Moos KF, et al: Infraorbital nerve function following treatment of orbitozygomatic complex fractures: A multitest approach. Int J Oral Maxillofac Surg 27:27, 1998
11. 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
12. Westermark A, Jensen J, Sindet-Pedersen S: Zygomatic fractures and infraorbital nerve disturbances. Miniplate osteosynthesis vs. other treatment modalities. Oral Surg Oral Diagn 3:27, 1992
13. Peltomaa J, Rihkanen H: Infraorbital nerve recovery after minimally dislocated facial fractures. Eur Arch Otorhinolaryngol 257:449, 2000
14. McNab AA: Orbital and optic nerve trauma. World J Surg 25:1084, 2001
15. Whitehouse RW, Batterbury M, Jackson A, et al: Prediction of enophthalmos by computed tomography after 'blow out' orbital fracture. Br J Ophthalmol 78:618, 1994
16. Raskin EM, Millman AL, Lubkin V, et al: Prediction of late enophthalmos by volumetric analysis of orbital fractures. Ophthal Plast Reconstr Surg 14:19, 1998
17. Schuknecht B, Carls F, Valavanis A, et al: CT assessment of orbital volume in late post-traumatic enophthalmos. Neuroradiology 38:470, 1996