

Repair of Complex Orbital Fractures: Technical Problems, State-of-the-art Solutions and Future Perspectives

B Hammer,*^{MD, DMD}, C Kunz,**^{MD, DMD}, A Schramm,***^{MD, DMD}, R deRoche,****^{MD},
J Prein,†^{MD, DMD}

Abstract

Within the wide range of severity of orbital fractures, the small group of complex fractures causes most of the sequelae. Therefore identification of severe injuries and adequate treatment is of major importance. The introduction of craniofacial techniques made possible a wide exposure of even large orbital wall defects and their reconstruction by grafts. In spite of significant progresses, repair of complex orbital wall defects remains a difficult surgical problem even for the experienced. This paper outlines the specific technical problems concerning surgical anatomy, exposure and defect reconstruction of this type of injuries. A number of new developments providing interesting future perspectives for orbital wall reconstruction such as intraoperative navigation, endoscopic techniques and new materials are discussed.

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Introduction

Fractures involving the orbits are frequent among facial injuries, making up to nearly 40% of the total.¹ Within the wide range of severity, the small group of complex fractures (20% of the total*) is responsible for most of the sequelae. Identification of severe injuries (Fig. 1) and adequate treatment is therefore of major importance.

The aims of this article are to outline technical problems related to the repair of complex orbital injuries, to describe state-of-the-art solutions and possible future developments.

Technical Problems and State-of-the-art Solutions

The aim of reconstruction is to restore the pre-injury shape and volume of the orbit. Didactically and technically, two different steps can be identified:

- 1) three-dimensional reconstruction of the orbital frame,
- 2) orbital wall (internal orbit) reconstruction.

The Orbital Frame

The orbital frame is part of the facial buttress system,³ of which the correct three-dimensional reconstruction

defines the position of the bony orbit within the facial structures. In complex injuries, reconstruction of the facial buttress system using craniofacial techniques has become standard.^{4,5} The following discussion will focus on problems related to reconstruction of complex orbital wall defects as shown in Figure 2b.

Surgical Anatomy

The orbit is a four-sided irregular cone. From a surgical standpoint, it is important to note that the orbital floor can only be identified in the anterior half of the orbital cone, while posteriorly it blends into the medial wall (Fig. 2a). An orbital floor fracture extending posteriorly therefore always involves the oblique medial wall, which is important to keep in mind for the orientation of a graft reconstructing such a defect (Figs. 3 & 4). The inferior orbital fissure separates the floor and the lateral wall, creating a natural weak spot. Fractures extending posteriorly usually involve the inferior orbital fissure producing a considerable enlargement of the posterior orbit. Careful dissection and obliteration of the inferior orbital fissure is an essential part of complex fracture repair (see also below and Fig. 5). The anterior

* Associate Professor of Oral and Maxillofacial Surgery

** Senior Registrar

**** Associate Professor of Plastic Surgery

† Professor of Oral and Maxillofacial Surgery and Head

Clinic for Reconstructive Surgery

University Hospital Basel, Switzerland

*** Resident

Klinik und Poliklinik für Mund-Kiefer und Gesichtschirurgie

Albert Ludwigs Universität Freiburg, Germany

Address for Reprints: Dr B Hammer, Clinic for Reconstructive Surgery, University Hospital Basel, Spitalstrasse, CH-4031 Basel, Switzerland.

E-mail: ckunz@uhbs.ch

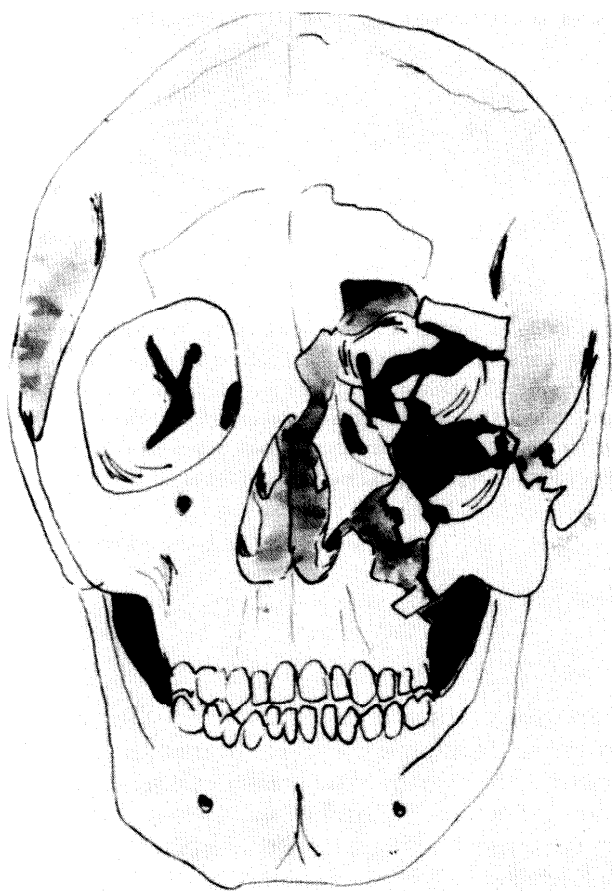


Fig. 1. A highly complex orbital fracture extending deep into the posterior orbit. If not adequately repaired, severe deformities will result.

and posterior ethmoidal arteries enter the orbit through the upper part of the medial wall. Transsection of the anterior ethmoidal artery (Fig. 2b, arrow), located at half distance between the orbital rim and the optic foramen, is routinely performed to get exposure for large medial wall defects, whereas the posterior artery is left intact to protect the optic nerve.

Exposure

Adequate exposure, far enough back to get a stable ledge, is the cornerstone of reconstruction for complex defects involving the medial wall and extending into the posterior part of the orbit (Fig. 2b). A coronal approach is combined with an anterior orbital approach. Dissection is strictly carried out in a subperiosteal plane, which may be difficult because in severe injuries the periorbit is often disrupted with herniating fat making exposure difficult. The use of loupes is recommended. Usually the lateral wall is not comminuted and offers itself as a starting point. The lateral canthal ligament is routinely detached and later reattached with a resorbable suture. In contrast, detachment of the medial canthal ligament should be avoided at any costs, its reattachment in a natural position being very difficult.



Fig. 2a. The orbit is a complex shaped cone, with the quadrangular cross section anteriorly changing into a triangular shape. This is due to the fact that in the posterior part, the orbital floor blends into the medial wall. The orbital floor is a relatively small structure and does not contribute to the anterior projection of the globe.

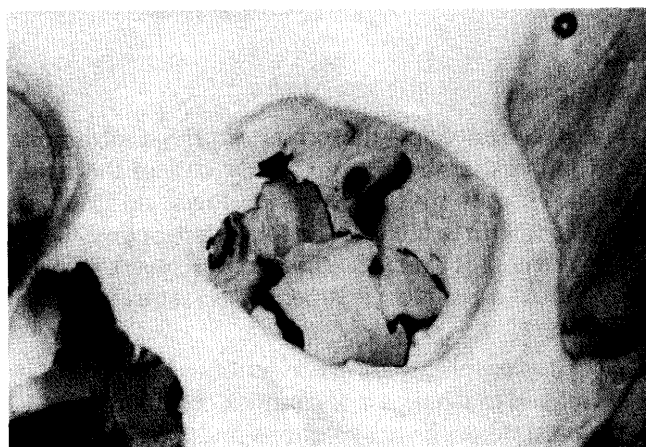


Fig. 2b. The posterior medial wall is a key area for the anterior projection of the globe. Repair of complex orbital wall defect involving the floor and the entire medial wall therefore requires an extensive exposure combining a coronal with an anterior orbital approach.

Exposure of the medial wall is started from the coronal incision. After transsection of the anterior ethmoidal artery, the coronal and anterior orbital approaches are connected. The dissection is completed with the transsection of the connective tissue in the inferior orbital fissure, and by separating the infraorbital nerve from the periorbit. This requires coagulation of several blood vessels between nerve and periorbit. Obliteration of the widened inferior orbital fissure is an essential part of orbital reconstruction (Tessier P, 1989—personal communication).

Visibility and Access

Visibility is enhanced and graft orientation facilitated by inserting a flexible sheet between periorbit and bone upon dissection.^{2,6} At the moment, resorbable 0.25 mm PDS sheet is used. After approval, polylactic acid (PLLA)

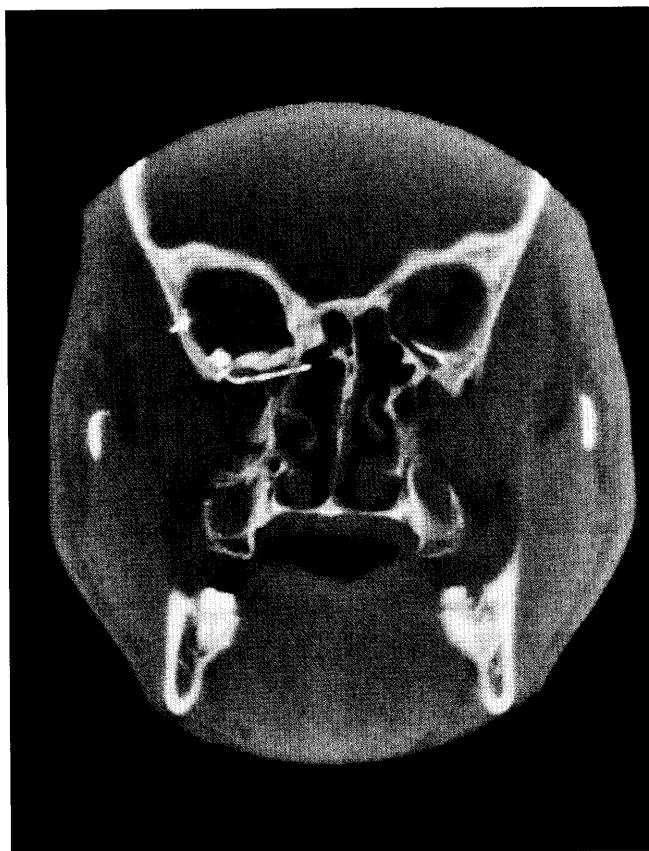


Fig. 3. As a consequence of the anatomy shown in Figure 2, a graft reconstructing the posterior part of the orbit must be orientated along the medial wall i.e. obliquely. The graft shown here was falsely orientated along the floor and leaves an enlarged posterior orbit.

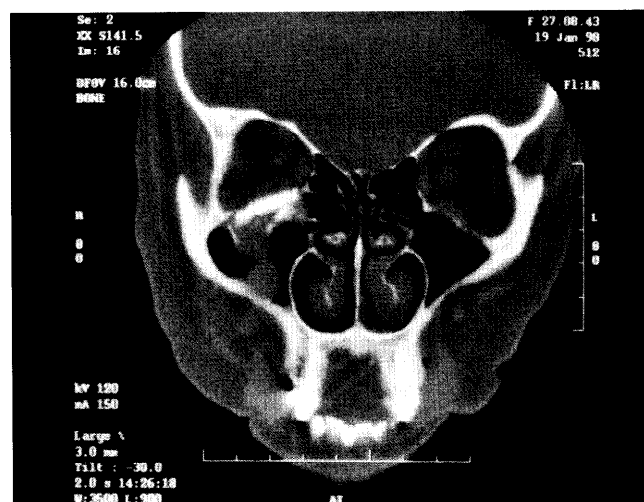


Fig. 4. Correctly oriented graft in a fracture involving orbital floor and lower part of the medial wall.

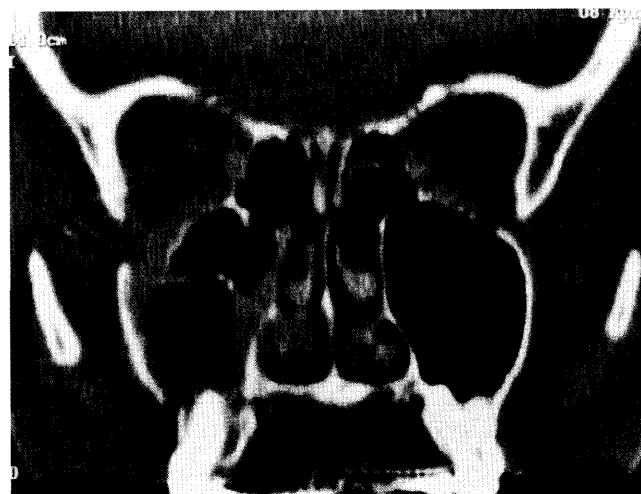


Fig. 5. Fractures extending into the posterior orbit produce a widening of the inferior orbital fissure. Obliteration of this fissure is an essential part of fracture repair.

membranes, showing osteoconductive properties, have to be recommended for larger defects.

Defect Reconstruction

Defects involving the floor and the lower part of the medial wall can be reconstructed with a single piece of cranial bone. Usually a graft of about 2.5 x 2 cm, slightly trapezoid shaped, is adequate (Fig. 4). Visualising the posterior bony ledge, the graft is wedged into the defect and, if necessary, stabilised with a small plate anteriorly.

Reconstruction of defects involving the orbital floor and the entire medial wall (two and three wall defects) (Fig. 2b) are rendered difficult by the following reasons:

- 1) It is not possible to overlook the entire defect at one time, the coronal as well as the anterior orbital approach always exposing only about half of the defect.
- 2) Reconstruction cannot be done with a single graft, as the size and complex shape of the graft would not allow it to be inserted without injuring the orbital contents.

The basic concept for reconstruction of these defects has been developed by Manson and coworkers,⁶⁻⁸ involving the use of a titanium mesh plate lined with bone grafts (Manson has developed a variety of mesh plates,

which are available through Synthes, USA). The plate transforms a large defect into several smaller ones and, at the same time, serves as a rigid scaffold for the bone grafts to achieve correct volumetric proportions of the posterior orbit, a key area to prevent enophthalmos.⁹⁻¹¹ This technique has considerably improved the quality of orbital reconstruction. When using the plate, shaping and placement again are the critical points. Initially, we tried to insert too large plates, a time-consuming procedure often resulting in malposition and/or soft tissue impingement. Our present technique of shaping and insertion of orbital plates is shown in Figure 6. A flag-shaped orbital plate [Synthes Nr.446.440 (left), Nr.446.450 (right)] is cut and bent into a graft small enough to allow insertion and big enough to give adequate support to additional bone grafts. The plate only reconstructs a portion of the posterior orbit but it ensures continuity between the lateral wall and the medial part of the roof.

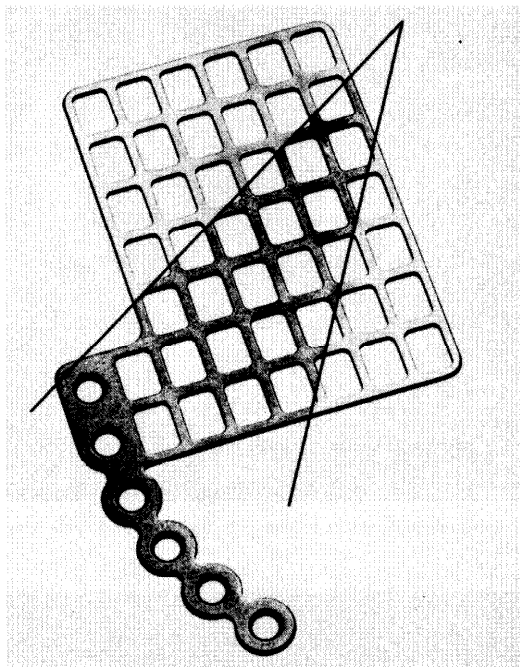


Fig. 6a. The first author's preferred mesh plate for orbital reconstruction. The plate cut as shown.

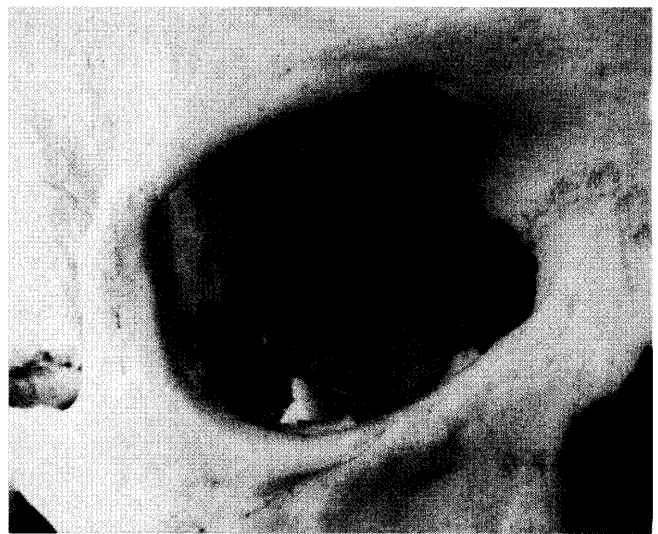


Fig. 6b. The plate is oriented along and fixed at the lateral orbital wall. It is lined with chips harvested from the calvaria.

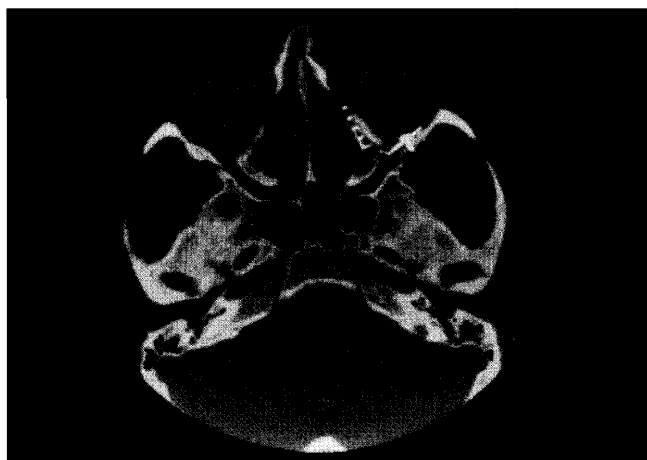


Fig. 7a.

Fig. 7. State-of-the-art repair of a complex orbital fracture.

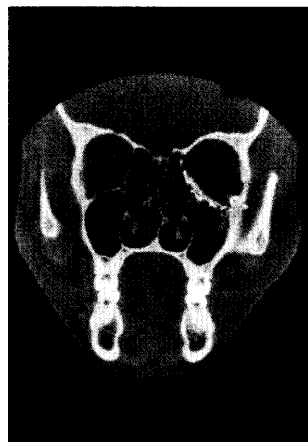


Fig. 7b.



Fig. 7c

Figs. 7a & b. Axial and coronal CT scans showing orientation of the plate, which is lined with bone grafts.

Fig. 7c. The patient, 6 months after the accident, with normal binocular vision. The correct three-dimensional orientation of the grafts in the deep orbit requires a long learning curve, and even the experienced surgeon often is frustrated when looking at the postoperative CT scans.

The correct orientation of the plate can be verified along the lateral and, from the coronal view, the medial wall. Figure 7 shows the repair of a complex orbital fracture using an orbital mesh plate lined with calvarian bone grafts.

Soft Tissue Reattachment

After extensive dissection, soft tissue resuspension is essential to prevent sagging.¹² It includes repositioning of the periosteum overlying the zygomatic body as well as reattachment of the lateral canthal ligament. We also perform a meticulous refixation of the periosteum at the supraorbital rim to prevent eyebrow malposition (Hammer B-unpublished data).

Discussion and Future Perspectives

In spite of significant progresses, repair of complex orbital wall defects remains a difficult surgical problem requiring a long learning curve. The extensive exposure may result in visible deformities and unfavourable long-term effects.¹³ The search for improvements giving better results with less morbidity goes on. A number of new developments provide interesting perspectives.

Intraoperative Assessment of Graft Position

The use of an intraoperative CT-based navigation system which is now introduced into clinical practice will provide an immediate assessment of the graft position allowing necessary corrections to be performed.

Endoscopic Techniques

Endoscopic techniques have been used for diagnosis, reduction and repair of small and middle size orbital wall fractures under certain conditions.¹⁴⁻¹⁹ It is difficult to predict whether repair and reconstruction of large defects using exclusively endoscopic techniques is possible. Dissection of large defects with the endoscope will certainly become standard technique and in the AO research laboratory in Davos, Switzerland, instrumentation for this purpose is presently under development.

New Materials

Titanium plates are considered to be the most biocompatible implants presently available.²⁰ However, they still remain in place as a foreign body which in rare cases may be the source of infections, requiring a technically difficult removal (Manson P-personal communication; Hammer B-unpublished data).

Resorbable polydioxanone membranes are used since 1991²¹ to repair small orbital wall defects, but they proved not to be suitable for large defects, the reason being their rapid degradation.²² However, animal experiments conducted in our institution,^{22,23} as well as in other places,^{24,25} using membranes composed of polylactic acid (PLLA) have demonstrated a much slower degradation, allowing them to be used as an osteoconductive scaffold for the reconstruction of large defects. In the experiments conducted in our institution, defects of 3 x 2 cm in sheep orbits were reconstructed using a small but strong PLLA plate as a scaffold supporting a 0.25 mm PLLA sheet lining the entire defect. Ossification of the entire defect was observed after 3 months.

In the last 15 years, the management of complex orbital fractures has undergone significant changes. The introduction of craniofacial techniques has allowed to radically expose large defects and to reconstruct them with the help of specially designed plates. Further improvements are to be expected in the near future by the possibility to intraoperatively assess the graft position, by endoscopic techniques allowing minimally invasive exposure of the defects and probably by the introduction of osteoconductive resorbable membranes replacing metal plates and bone grafts.

All these improvements are still based on today's principles for fracture repair: exposure of the defect and reconstruction with a graft. It should however not be forgotten that these techniques are compromised by a certain morbidity. Dissection of a large defect, even if performed endoscopically, is not possible without a certain amount of injury to the orbital contents, adding additional damage to the already injured optical pathways.

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