Orbital floor reconstruction: a retrospective study of 21 cases

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Objective. The purpose of this retrospective study was to investigate the diagnostic methods, therapeutic principles, surgical approach, and materials used for orbital floor reconstruction.

Study design. This study consisted of 21 cases with orbital fractures treated at the Hospital of Stomatology, Sichuan University, China, between July 2002 and June 2006. Inclusion criteria were patients with fractures of the orbital floor with bone defects. Patients were retrospectively analyzed for gender, age, mechanism of injury, classification of fracture, and complications.

Results. CT scans were 100% accurate in diagnosing the fractures. Shaped autogenous bone, titanium mesh, and Medpor were respectively implanted under the periosteum of the orbital floor in 5 cases, 10 cases, and 6 cases. All the patients had good results including significant improvements in appearance and function after surgery. There were no severe permanent complications. Two cases had postoperative wound infections, and 1 case had temporary blindness that resolved completely.

Conclusions. CT scan is the first choice of investigation for an orbital floor fractures. The objectives of treatment for an orbital floor fracture with a bony defect are reduction of the prolapsed orbital contents and reconstruction of the orbital floor with repair materials, to restore the normal orbital floor and orbital capacity. A subciliary incision was adopted in our surgery. At present, porous polyethylene and titanium mesh are considered to be the ideal orbital floor repair materials. Titanium mesh was used in fractures with large defects that were not easy to fix without obvious enophthalmos. Porous polyethylene can be used in fractures when there is a need to restore the orbital volume. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:324-30)**

The orbits are pear-shaped pyramids at the center of the craniofacial region, in which the eyes are protected by the bony orbital walls. Zygomatic bone, maxilla, frontal bone, ethmoid bone, sphenoid bone, lacrimal bone, and palatine bone are all parts of the walls. The axis of the eyeball divides the orbital floor into anterior and posterior parts. The anterior part of the orbital cavity lies anterior to the axis. The lateral and posterior orbital walls lie posterior to the axis.

The orbit is particularly susceptible to fractures because of its exposed position and thin bones. External impact to this area can cause a blowout fracture or non-blowout fracture, both of which could be accompanied by orbital floor defects. Diplopia is the most complication caused by orbital defects. Others include limitation of ocular movement, infraorbital numbness, enophthalmos, and reduced vision. When the orbital floor is fractured, the enlarged capacity of the posterior part of the orbital bony cavity plays a major role in causing enophthalmos. The structures responsible for moving the eyeball are mainly located in the anterior part of the orbital cavity. Prompt therapy to restore the anatomic structure of the orbit and improve visual function and orbital appearance is therefore essential.[1,2]

The main treatment of orbital defects is surgical orbital reconstruction. At present, with the increase in traffic accidents, the incidence of orbital defects has risen substantially. At the same time, bone grafts and bone substitutes under barrier membranes have been increasingly utilized to optimize the treatment outcome of bone reconstructive therapy for defects in the orbital floor.

In recent years, many articles have explained that

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surgical treatment is the major method to manage these injuries. Surgical methods and diverse materials used in reconstruction were evaluated; for example, by using fervens bones, autogenous bones, and titanium mesh, as well as porous polyethylene. However, the therapeutic results are still not satisfactory and many complications exist after surgery. Many problems are still in dispute. Therefore, this study of 21 cases was initiated with the object to review and evaluate the diagnostic methods, therapeutic principles, surgical approaches, and selection of restoration materials to manage the orbital floor defects.

PATIENTS AND METHODS

Twenty-one patients fulfilled the following inclusion criteria: (1) clinical diagnosis of orbital floor defects; (2) imaging showing orbital floor defects, i.e., bony integrity of the orbital floor was destroyed and local soft tissue thickening or displacement in the maxillary sinus resulting in a teardrop appearance; and (3) surgical treatment had never been undertaken before our management.

Exclusion criteria include orbital floor fracture without bone defect or patients who had prior unsuccessful surgery.

Twenty-one patients treated in the Department of Traumatic and Plastic Surgery, West China Hospital of Stomatology, Sichuan University, were selected in this study from July 2002 to June 2006. All the patients were retrospectively analyzed for gender, age, mechanism of injury, classification of fracture, and complications.

RESULTS

Sex and age distribution

There were 12 males and 9 females, with a mean age of 34.1 years (range, 18 to 42 years).

Cause of injuries

The most common cause of fracture was motor vehicle accidents (16 cases, 76.2%), followed by falls (4 cases, 19.1%) and then fights (1 case, 4.7%).

Classification of the fractures

The fractures were recent (less than 4 weeks before surgery) in 5 cases and old (more than 4 weeks before surgery) in 16 cases. There were 16 fractures of the malar-maxillary complex, 10 of zygomatic-maxilla-complex, and 6 of the naso-orbital-ethmoid complex.

Complication of the fractures

Complications included diplopia in 20 cases, enophthalmos in 13 cases, limitation of ocular movement in 16 cases, reduced vision in 5 cases, and infraorbital numbness in 18 cases.

Treatment

On admission all patients underwent imaging examination, including axial and coronal computed tomography (CT), spiral CT, and 3-dimensional CT. Open reduction with rigid fixation and orbital floor reconstruction were undertaken in all cases. The plates were placed mainly on the midfacial buttresses, including the exterior margin of the orbit, zygomatic arch, zygomaticomaxillary suture, and edge of the anterior nasal aperture. This was in order to recover the normal height, width and profile of the midface. Autogenous bone, titanium mesh, or Medpor were used for orbital floor reconstruction.

Subciliary incisions were used in 16 cases, while incisions through the original infraorbital traumatic scar were used in 5 cases. Other incisions were also used as needed (coronal incision in 17 cases, intraoral vestibular incision in 15 cases). According to the "immobile-mobile, simple-complicated" sequence, anatomical reduction and rigid internal fixation were performed to reconstruct the vertical and horizontal bony buttresses of the face. When reducing and fixing the orbital floor, prolapsed orbital contents such as the inferior rectus and inferior oblique muscles were freed from the maxillary sinus to ensure that eye movement was not restricted. The infraorbital nerve was located and protected. The fracture site was exposed and visualized through the incision, and autogenous bone (5 cases), titanium mesh (10 cases), or Medpor (6 cases) were implanted under the periosteum of the orbital floor and fixed with titanium screws or Biogel.

In the 5 cases of naso-orbital-ethmoid fracture with avulsion of the medial canthal ligament, bilateral medial canthal ligament reduction and fixation were performed.[3] In the 3 cases of naso-orbital-ethmoid fracture with nasal deformity, concomitant augmentation rhinoplasty was performed.[4,5]

Postoperative patient care included intravenous fluids, analgesics, soft diet (according to the condition of accompanying other fractures), and strict hospital discharge instructions regarding hygiene, home care, and follow-up. Patients were examined in our clinic at 1, 3, and 6 months.

Examination criteria at baseline and at follow-up

1. Orbital floor reconstruction (judged by clinical examination and CT): yes or no.
2. Appearance recovery (symmetry, malformation and scars were considered): yes or no.

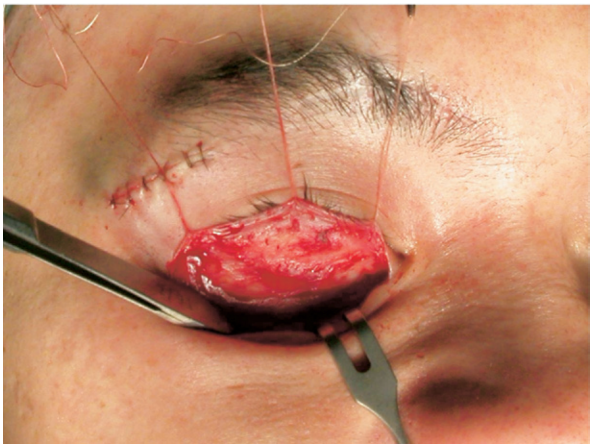

Fig. 1. The subciliary incision.

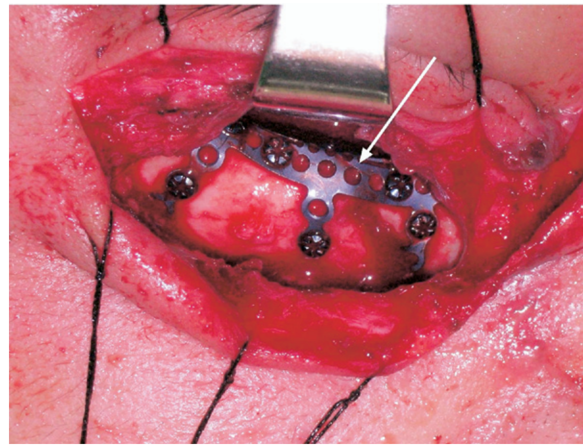

Fig. 2. Orbital floor defect is reconstructed with titanium mesh.

3. Function recovery (dysfunction completed disappear means recovered, less residual means improvement, no improvement means inefficacy): yes or no.
4. Complication existence: yes or no.

Result of the treatment

All 21 patients were enrolled. All the participants entered the result analysis with no loss along the way. Each patient had an orbital floor reconstruction to sustain the volume of the orbital cavity and the continuity of the orbital floor. CT scans provided a 100% accurate diagnosis in all 21 cases.

All patients had a significant improvement in esthetic appearance. The injured side and uninjured side or both sides were symmetrical and well formed. There was no case of enophthalmos and few scars.

Twenty-one cases had a noticeable improvement in function. Of the 20 cases with diplopia, 16 recovered completely during the 6 months after surgery, 3 improved, and 1 was insufficient. Of the 13 cases with enophthalmos, 11 recovered completely and 2 improved. The 16 cases with restricted eye movements all recovered. The 5 cases with reduced visual acuity all had significant improvement in their eyesight. Of the 18 patients with infraorbital numbness, 16 recovered completely during the 6 months following surgery and 2 were still numb 6 months postsurgery.

Common complications such as hemorrhage and infection did not occur in this study. One case lost sight in the operated eye 30 minutes postsurgery. Nitroglycerin was administered immediately and the patient was transfused with dextran-40, dexamethasone, clonitrate, and *Salvia miltiorrhiza*. Eyesight started to recover gradually after 30 minutes and had recovered completely after 3 days. All patients were satisfied with their therapeutic results.

DISCUSSION

Eye function should be examined routinely following midface fractures to avoid missing an orbital floor fracture. Symptoms such as diplopia, enophthalmos, restricted eye movement or reduced vision,[6] and abnormal extraocular muscle tests may indicate an orbital floor fracture.

Plain radiographs and CT scans are routinely used to investigate orbital floor fractures. Traditional radiographs can show conspicuous infraorbital border fractures, but the diagnosis can easily be missed, resulting in delayed treatment, because of the overlapping projection of various anatomical structures, and inadequate information being supplied to the radiologist. CT is the best imaging technique for identifying an orbital floor fracture, especially coronal CT of the orbit, which gives good views of the orbital floor.[7] The fracture pattern can be assessed with coronal and abscissa axis CT. Engorgement of the inferior rectus and inferior oblique muscles, and entrapment or herniation into the maxillary sinus can be determined, as well as orbital volume. Three-dimensional CT gives a stereoscopic view of the fractures.[3,8] The CT scan typically shows discontinuity and displacement of the infraorbital rim and orbital floor, and local soft tissue thickening or displacement in the maxillary sinus resulting in a teardrop appearance. CT can therefore confirm the fracture location, bone displacement and defects, and incarceration of orbital soft tissues. CT can also be used to estimate the volume of the orbital cavity, and to plan surgery.[9] It could enhance the correctness of the clinical diagnosis

Orbital floor fractures are often associated with craniocerebral injury, globe damage, or optic nerve

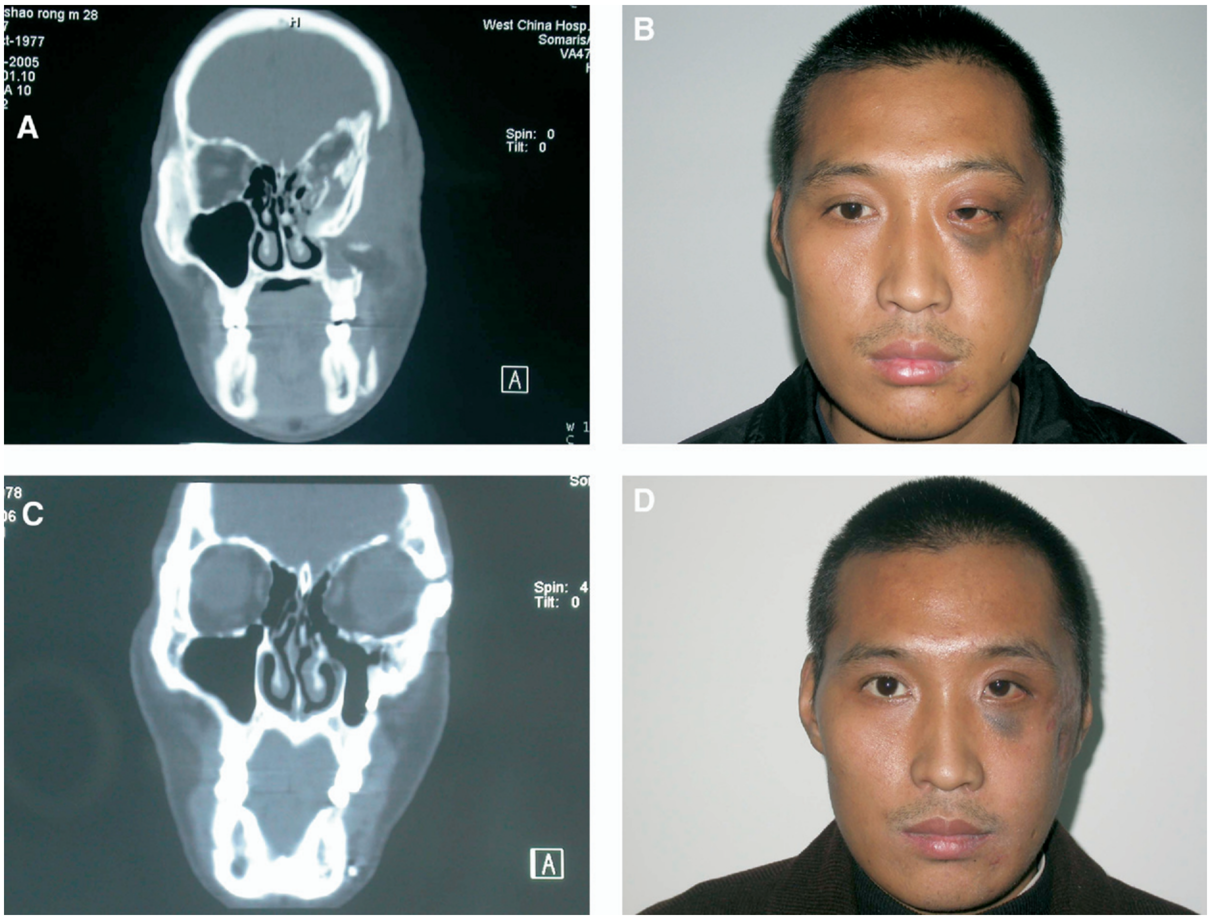

Fig. 3. **A,** Case 1 coronal CT shows a large orbital floor defects with insufficient contents. It was restored with the rib. **B,** Preoperative photo of case 1. **C,** Postoperative CT of case 1. *D,* Postoperative photo of case 1.

damage. Such cases often require multidisciplinary knowledge, and cooperation between oral and maxillofacial surgeons, neurosurgeons, and ophthalmologists to develop reasonable and complete treatment plans.[10] Orbital floor fractures should be individually treated according to the characteristics of the injury. If there is no orbital floor defect, soft issue incarceration, or eye dysfunction, conservative treatment is suggested. In cases without orbital floor defects, but with soft issue incarceration or eye dysfunction, surgery should be considered to free any incarcerated orbital contents and restore the infraorbital rim. When there is a bony defect, autogenous bone graft or biological materials should be used for orbital floor reconstruction.[11]

The most common complications of orbital floor fractures are diplopia and enophthalmos. Diplopia is usually caused by contusion and intramuscular hematoma of the inferior oblique and inferior rectus muscles. This is usually temporary, lasting no more than 2 weeks. However, if the diplopia is caused by the inferior rectus or the inferior oblique muscles being caught in the fracture, urgent surgery is required to free them within 3 weeks. If the surgery cannot be done in time, the incarcerated tissue becomes fibrotic and scarred. These factors, and wide adhesions to surrounding tissues increase the difficulty and reduce the effectiveness of surgery.[6,12]

Access to the infraorbital region can be via a subciliary incision or an incision through the traumatic scar.[13] There are 3 types of subciliary incision: subciliary nonstepwise incision, subciliary stepwise cutaneous muscle incision and the subciliary incision. The subciliary incision is our preference. The incision is made 2 mm inferior to the lower lid margin. To fully expose the bony defect, the subcutaneous tissue is dissected down to the infraorbital rim, muscles beneath the orbicularis oculi muscle are

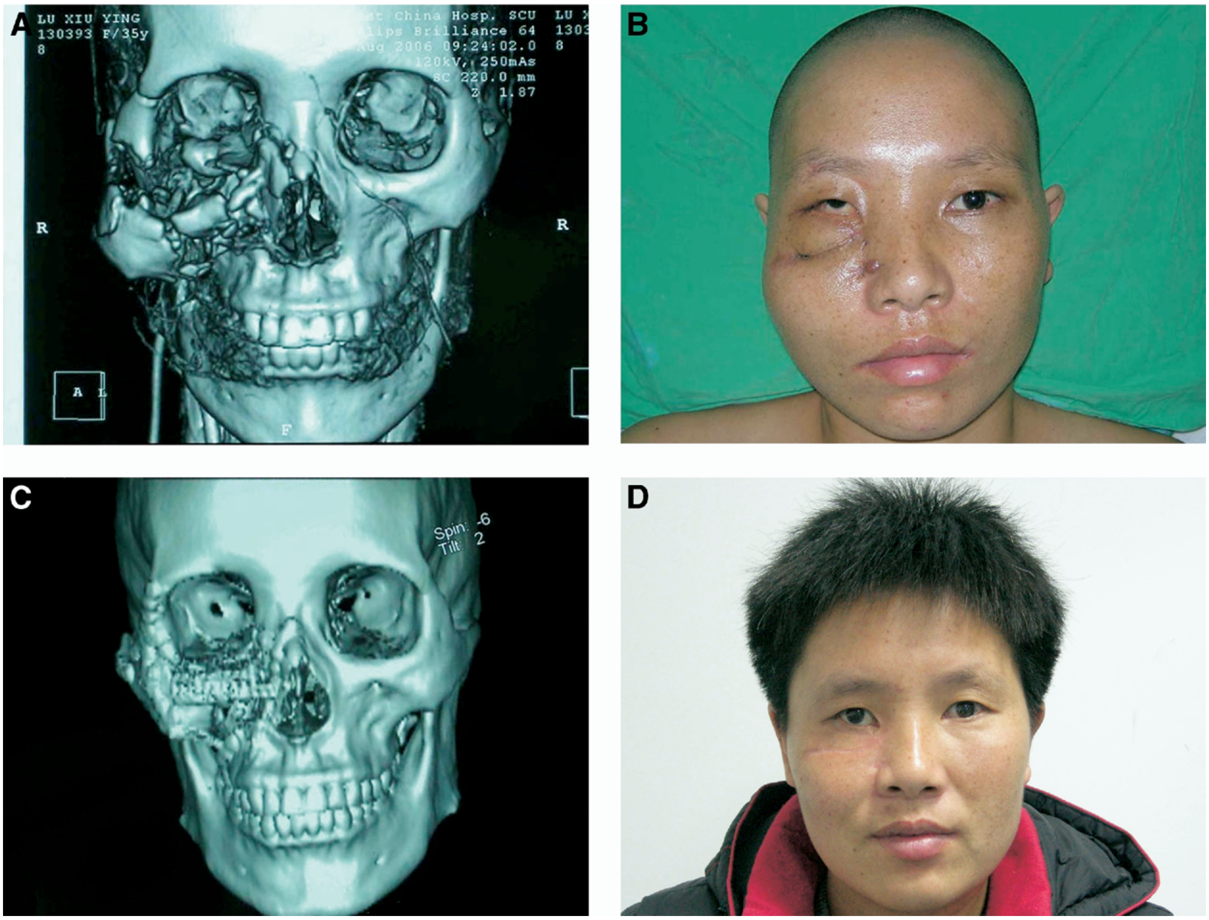

Fig. 4. **A,** Case 2 3-D CT shows orbital floor defects that were difficult to fix. **B,** Preoperative photo of case 2. **C,** Postoperative CT of case 2. **D,** Postoperative photo of case 2.

bluntly dissected, and the periosteum is incised to the infraorbital foramen. The orbital conjunctiva is not injured by this incision and there is little scarring after 3 months (Figs. 1 and 2).

Materials may be implanted in different places when reconstructing the orbital floor. If the aim is to adjust the downward movement of the eyeball, material should be implanted inferiorly at the axis of the eyeball. If the aim is to adjust for enophthalmos, material should be implanted posterior to the axis.[14] The implanted material should fully cover the bone-loss region, be closely attached to the surface of the orbital bone, and be in close contact with the edge of the bone plate posterior to the bone loss. The posterior extension should be no more than 3 cm to avoid damaging the optic nerve and ophthalmic artery,[15] and there should be an infraorbital nerve buffer. The exophthalmometer should be used to measure protrusion of the eyeball and adjust the thickness of the filling material so that the injured eye is aligned to within 1 to 2 mm of the other eye. The vertical and horizontal alignment of the globe should also be checked.

The proper selection and use of materials will usually ensure the success of orbital floor reconstruction. Prosthetic materials include autogenous bone, allograft bone, and biological materials. Autogenous bone takes easily and may vascularize, and has the advantage that there is no immunologic rejection; but there have been problems with donor site bone lesions, laborious molding, and unpredictable absorption. Bones frequently used for autogenous grafts include the lamina externa cranii, ribs, and ilium. Compared with the rib and ilium, the lamina externa cranii has slight advantages. There is less absorption, the bone can be harvested through 1 coronal incision, there is little or no pain after surgery, and the scar is inconspicuous.[16] It is the most widely used donor site for the reconstruction of small orbital floor defects (Fig. 3, *A-D*). Titanium mesh has good

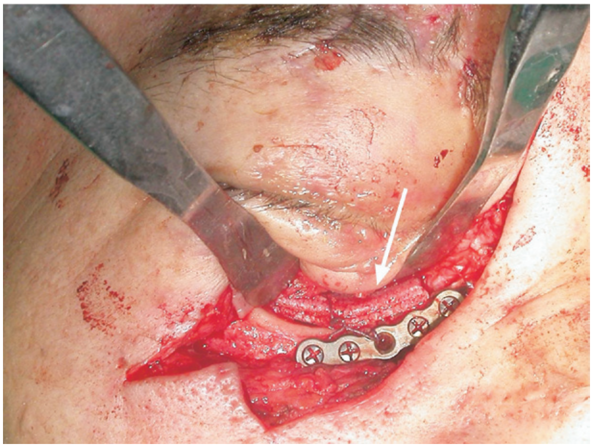

Fig. 5. The orbital floor defect that was reconstructed with Medpor through traumatic scar incisions.

biocompatibility and is easily adjustable.[17] It can be reliably fixed with screws in areas such as the infraorbital border, but cannot be multi-filled to reduce the volume of the orbital cavity,[18] and can therefore only be used when there is no obvious enophthalmos, especially in fractures with large defects that are not easy to fix[19] (Fig. 4, *A-D*). The advantages of porous polyethylene include good biocompatibility, mild rejection reactions, and easy molding. (Fig. 5). Autogenous tissue can grow into the porous material, biologically integrating the material with the soft tissues and orbital floor.[14,20] Advantages include decreased operative time, reduced pain, avoidance of donor site complications, and the ability to adjust the volume of filling as needed, particularly in cases of enophthalmos.[20,21] Nowadays, porous polyethylene and titanium mesh are considered to be significantly better reconstruction materials than autogenous bone, and are the main materials used.

There were no cases of hemorrhage, lower eyelid ectropion, implant shifting, rejection, or other serious complications. One patient had sudden blindness 30 minutes after the operation. Central retinal artery spasm was suspected, and the patient was treated with dextran-40, dexamethasone, clonitrate and *Salvia miltiorrhiza*. Eyesight improved after 30 minutes and was fully recovered after 3 days.

CONCLUSION

This study was performed to investigate the diagnostic methods, therapeutic principals, surgical approach and materials of orbital floor reconstruction. The results showed that CT scan should be the first choice of investigation for an orbital floor fractures. The results showed that also the objectives of treatment for an orbital floor fracture with a bony defect are reduction of the prolapsed orbital contents and reconstruction of the orbital floor with repair materials to restore the normal orbital floor and orbital capacity. A subciliary incision was adopted most in our surgery. At present, porous polyethylene and titanium mesh are considered to be the ideal orbital floor repair materials. Titanium mesh was used in fractures with large defects that were not easy to fix without obvious enophthalmos. Porous polyethylene can be used in fractures when there is a need to restore the orbital volume.

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