Orbital Wall Reconstruction with Titanium Mesh: Retrospective Study of 24 Patients

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ABSTRACT

The aim of this study was to evaluate the efficacy and safety of traumatic orbital defect reconstruction with titanium mesh. A retrospective study was made. Evaluations were made after a minimum postoperative follow-up of 12 months, looking for the main complications. Twenty-four patients were included in this evaluation; 19 were male (79.1%) and 5 (20.8%) were female. The main injury etiology was vehicle accidents (50%) followed by other causes. Fourteen patients (58.3%) presented orbital floor fractures, and 10 had more than one wall fractured (41.6%). Permanent infraorbital nerve hypoesthesia was observed in two patients (8.3%), enophthalmos occurred in five patients (20.8%), and exophthalmos was found in two patients (8.3%). Four patients (16.6%) still presented evidence of residual prolapsed intraorbital content, and one of those needed further surgical correction; sinusitis occurred in one patient (4.1%). Titanium mesh is a reliable option for orbital reconstruction, despite some complications found in this sample.

KEYWORDS: Surgery, orbital reconstruction, titanium mesh

Orbital fractures are among the most common facial fractures, and high-energy trauma frequently results in need for multiple wall reconstruction. Successful treatment depends on correct planning, meticulous surgical dissection, and proper selection of type, size, and contour of the reconstruction material.¹

The choice of the ideal material for reconstruction of orbital floor and walls remains highly controversial. Many materials, from different sources, have been described for that task. The ultimate goals are the reconstruction of the bony orbital defect with restoration of anatomy, volume, function, and esthetics. Each type of material has advantages and disadvantages, but the most

important characteristic of a material is to allow those surgical objectives to be achieved.^{2,3}

Internal orbital reconstruction should isolate the orbital contents from the nasal cavity and paranasal sinuses while providing sufficient postoperative support to prevent enophthalmos and diplopia. Haug et al⁴ reported that the mean weight of orbital contents is 42.97 (± 4.05) g, and except in the instance of complete loss of the orbital floor, all materials tested in their study should provide adequate orbital support. However, fractures of the internal orbit can still cause several problems, including ocular muscle entrapment limiting extrinsic eye movements, diplopia, enophthalmos,

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Figure 1 Right orbital sketch: (1) anterior third orbital floor (zone 1); (2) middle-third orbital floor (zone 2); (3) posterior-third orbital floor (zone 3); (4) infraorbital fissure; (5) supraorbital fissure; (6) optical nerve; (7) lateral wall; (8) nasal-lachrymal duct; (9) medial border of the infraorbital fissure.

vertical displacements of the globe, sinusitis, and loss in visual acuity.

Development of late posttraumatic enophthalmos and diplopia does not depend only on orbital volume and loss of intraorbital contents, but also on precise anatomic reconstruction and the amount of fibrosis resultant from trauma and surgery. Titanium mesh is a very suitable reconstructive material that allows precise anatomic reconstruction, especially when more than one wall is fractured.² The purpose of this study was to evaluate efficacy and safety of orbital defects reconstruction with titanium mesh (Fig. 1).

MATERIALS AND METHODS

Twenty-four adult patients who had orbital fractures treated by reconstruction with titanium mesh were included in this study. All patients had initially presented with facial fractures that involved the orbital cavity and not only isolated orbital fractures. The records from those patients were reviewed looking for the most common complications described in the related scientific literature for that kind of facial injury. The inclusion criteria were presence of orbital fracture that required reconstruction, integrity of the eye globe, no preoperative loss of vision, minimum postoperative follow-up of 12 months, and availability of complete and thorough records by the assisting surgeon. All patients were treated for their facial injuries from January 2003 to October 2007.

Data collected included age, gender, etiology, time elapsed from the injury until surgical reconstruction, associated fractures, orbital walls reconstructed, visual acuity (before and after surgery), diplopia (before and after surgery), vertical displacement of the globe, anteroposterior displacement (enophthalmos and exophthalmos), type of surgical approach, motility restrictions,

sinusitis. Data were analyzed and organized in tables to illustrate the occurrence of these complications.

RESULTS

Reconstruction and postoperative follow-up of the patients were performed by the same team of surgeons. Clinical evaluations followed routinely the same orientation to minimize subjective errors during the assessment of clinical signs. The average follow-up was 38.4 months. Of the 24 patients evaluated, 19 were men (79.1%) and 5 were women (20.8%). The average age was 34.5 years, ranging from 18 to 61 years old. The etiology of trauma is listed on Table 1.

Time elapsed between trauma and surgery was also evaluated and scored; the average was 8.7 days. The most common orbital wall fractured was the floor, but combined wall fractures were frequent as shown in Table 2.

Orbital fractures were classified according to Jaquière et al⁵ (Figs. 2–6; Table 3).

The most commonly associated fracture was the zygomatic complex fracture (18), followed by maxillary (6); zygomatic arch, frontal sinuses and nasal-orbital-ethmoid fractures (5 frontal sinuses and nasal-orbital-ethmoid fractures), nose (4), mandible (2), and parietal bone (1), as shown in Table 4.

Visual acuity was evaluated with the Rosenbaum Pocket Vision Card following the instructions printed on the card, which basically consists in holding the pocket card 30 cm from the observer and to asking him or her to look at the number and letter sequence with both eyes separately each time, recording the best results obtained at every checked time. Ophthalmologic

Table 1 Cause of Injury

Cause	n	Percentage
Traffic	12	50.0
Interpersonal violence	5	20.8
Work	3	12.5
Sports	2	8.3
Gunshot	1	4.2
Fall	1	4.2
Total	24	100

Table 2 Site of Fracture

Site	n	Percentage
Isolated floor	14	58.3
Floor + medial wall	2	8.3
Floor + lateral wall	2	8.3
Floor + medial + lateral walls	2	8.3
Isolated roof	2	8.3
Roof + medial wall	1	4.1
Isolated medial wall	1	4.1

Figure 2 Orbital wall defects, category I: isolated defect of the orbital floor or medial wall (1 to 2 cm²) within zones 1 and 2.

Figure 5 Orbital wall defects, category IV: defect of the entire orbital floor and the medial wall extending into the posterior third (zone 3), missing bone ledge medial to the infraorbital fissure.

Figure 3 Orbital wall defects, category II: defect of the orbital floor and/or medial wall (>2 cm²) within zones 1 and 2, preserved bone ledge at the medial margin of the infraorbital fissure.

Figure 6 Orbital wall defects, category V: defect of the entire orbital floor and the medial wall extending into zone 3 and into the orbital roof.

Figure 4 Orbital wall defects, category III: defect of the orbital floor and/or medial wall (>2 cm²) within zones 1 and 2, missing bone ledge medial to the infraorbital fissure.

evaluation was requested when there was suspicion of significant eye lesions. Every patient was evaluated before and after the surgical procedure, and in all cases recorded visual acuity improved after the acute phase of trauma and surgery. There was no record of complete or partial loss of vision in the studied population.

Six patients (25%) had vertical dystopia of the globe preoperatively, and one (4.1%) presented postoperative vertical displacement after the surgical procedure. Seven patients (29.1%) presented with preoperative

Table 3 Classification of Orbital Fractures

Category	n	Percentage
I	5	20.8
II	9	37.5
III	4	16.6
IV	3	12.5
V	3	12.5

Table 4 Site of Fracture

Site	n	Percentage
Zygomatic complex	18	75.0
Maxilla	6	25.0
Zygomatic arch	5	20.8
Frontal sinus	5	20.8
Nasal-orbital-ethmoid	5	20.8
Nose	4	16.6
Mandible	2	8.3
Parietal	1	4.1

diplopia, which resolved in all cases after reconstruction. Four patients (16.6%) continued to relate diplopia in the immediate postoperative period but in all it resolved spontaneously with no further treatment being necessary. The average time for resolution was 2.2 months. Eighteen patients (75%) presented pre- and immediately postoperative hypoesthesia related to the infraorbital branch, which was still present after 15 months in two patients (8.3%). Twelve patients had surgical approaches through the skin surface of the lower eyelid, and 12 had a combination of coronal and lower eyelid approaches for the orbits. Patients who presented other fracture sites received additional surgical approaches to those areas. Three patients (12.5%) had mild ectropion, which resolved with clinical measures and time within 6 months.

Preoperative enophthalmos was observed in five patients (20.8%) despite the presence of edema. Two patients (8.3%) required secondary procedures after 6 months. The other three patients maintained a very mild degree of enophthalmos perceived by the examiner, without need of further correction. Postoperative exophthalmos was found in two patients (8.3%) in a very low degree; however, none required surgical correction, and the patients did not present any associated symptoms. Five patients (20.8%) presented limitation of eye movements preoperatively. True muscle entrapment was found in four patients (16.6%). After reconstruction, one patient (4.1%) still presented limitation of superior vision and had to be surgically corrected in a secondary surgical procedure, which consisted of a new surgery with replacement of the titanium mesh. Although the patients included in the study had other associated facial fractures, only one presented postoperative sinusitis (4.1%), which was treated clinically (Table 5).

As described, one patient presented limitation in upper gaze, vertical displacement of the globe, and minor enophthalmos; one patient presented sinusitis infraorbital hypoesthesia and exophthalmos; two patients presented hypoesthesia and enophthalmos; and one patient presented minor exophthalmos, totaling 7 (29.1%) patients who presented nine long-term complications. Three patients (12.5%) needed secondary surgical procedures.

Table 5 Pre- and Postoperative Complications

Signs and Symptoms	Preoperative		Postoperative	
	n	Percentage	n	Percentage
Movement restriction	5	20.8	1	4.1
Diplopia	7	29.1	0	0
Vertical dystopia	6	25.0	1	4.1
Enophthalmos	5	29.1	5	29.1
Exophthalmos	2	8.3	2	8.3
Infraorbital hypoesthesia	18	75	2	8.3
Ectropion			3	12.5

DISCUSSION

Although isolated orbital fractures are considered rare, it is estimated that 1 to 9% of facial bone fractures significantly involve the orbital walls.^{4,6-8} A similar rate is found in our hospital settings. Adults who sustain orbital roof fractures are generally between 20 and 40 years of age, and there is a very high male predilection.^{6,7,9,10} The same was found in the studied population for orbital fractures in general with a much higher incidence in males than females.^{6,7,9-12} Those fractures are associated with high-energy trauma, and motor vehicle collisions are the most frequently reported cause. Results showed motor vehicle accidents to be the etiology in 37% of the studied cases. This is partially due to the increase of violent assault as the cause of facial fractures in this country. Many other causes have been identified, including tire explosions, ruptured garage door springs, chainsaws, high-voltage electric shocks, swinging objects, falls from high places, and objects that crush, to name a few.^{4,12-14} Also, 13% were isolated orbital fractures in this study and 87% were associated with other facial fractures.

The literature describes the safe limits for orbital dissection.¹⁵ However, to correctly reconstruct the orbital cavity, the orbital walls have to be dissected internally as far as needed, within safe limits of the optic nerve. Dissection has to be performed under direct visualization until the areas to be reconstructed are exposed and a suitable posterior ledge is obtained to position the reconstruction material.

Careful subperiosteal dissection prevents injury to the musculature and ensures complete release of the soft tissues from the osseous segments during bone reconstruction. Care must be taken to prevent entrapment of the soft tissues, especially when using metallic mesh systems, but also when using nonresorbable polymers or bone. Entrapment is avoided by eliminating sharp edges when contouring the mesh and not letting intraorbital tissue escape or be trapped by the mesh borders. It is useful to perform a forced duction test at the completion of the procedure to verify unrestricted movement.^{5,6,8,16}

The restoration of the orbit to its pretraumatic volume and anatomy is one of the most difficult surgical tasks. There is no doubt that the most important component of orbital reconstruction is restoration of the pretraumatic anatomy and volume of the internal orbit. This can be achieved by many means. However, volume is not so easy to measure; it is not easy, either, to know if the surgical procedure had reestablished the primary volume during surgery. On the other hand, it is important to point out that not only volume is important, but also the restoration of pretraumatic anatomy, especially in the key area. In that sense, intraorbital navigation and preformed meshes, stock or custom-made, may be the next valuable and widespread tools for orbital reconstruction.^{2,14,17}

Quite a few complications can occur after the treatment of traumatic orbital wall defects. They differ in the severity and treatment difficulty. Five patients had postoperative enophthalmos of some degree, and two needed secondary correction. The cause for that kind of complication probably was the failure to reestablish the previously existent orbital volume and anatomy, added by some degree of intraorbital muscular and fat content fibrosis. It is important to point out that enophthalmos was observed in those patients preoperatively, despite the presence of edema. Probably the incidence of enophthalmos would be higher if not masked by edema at the preoperative evaluation or if the patients had not received early reconstruction. One patient presented vertical displacement at the postoperative evaluation; however, neither the patient nor the surgeon thought about a secondary correction because it was clinically almost imperceptible. Two patients presented postoperatively with a small degree of proptosis, not requiring further treatment.

Postoperative infections are rare, but prophylactic use of antibiotics could be indicated, mainly in the cases where other facial fractures are associated or in cases of immunosuppressed patients. Fractures of the orbital roof and lateral and medial walls can communicate directly with the neurocranium and can be potentially lethal. The only infection seen in the present group of patients was maxillary sinusitis in one patient who sustained multiple facial fractures that was not related to the implant material and who was treated clinically. When used in contact with the oral-nasal pharyngeal area or paranasal sinuses, titanium mesh seems to be incorporated with soft tissue, which is then resurfaced by indigenous cells, including respiratory epithelia and goblet cells.^{6,8,15,18}

Blindness is one of the most devastating problems associated with internal orbital surgery. It may be associated with the trauma, excessive edema, uncontrolled instrumentation, pre- or postoperative hemorrhage, or bony fragments displaced into or about the optic nerve. Intraoperative steroids are effective in reducing edema. The orbit is well adapted

to trauma; the extraocular muscle, the intraconal fat, and the very resilient annulus of Zinn protect the optic nerve.^{1,14} Although dissection of the orbital walls for reconstruction was usually extensive in the population studied, no blindness or loss of visual acuity occurred. Diplopia was found in four patients postoperatively and regressed spontaneously without further intervention, suggesting a reversible cause such as edema, hematoma, or motor nerve or muscle reversible damage.

CONCLUSIONS

Reconstruction of orbital walls defects is a very delicate surgery and difficult to perform, especially if high-quality imaging is not available. Orbital dissection should carefully be extended to completely expose the defect and allow proper positioning and support to the reconstructive material. Titanium mesh is a suitable material for reconstruction of orbital fractures, and complications are mainly due to difficulties in restoring anatomy and volume.

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