Technical Experiences
Reconstruction of Traumatic Orbital Floor Fractures With Resorbable Mesh Plate

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Various materials such as autogenous bone, cartilage and alloplastic implants have been used to reconstruct orbital floor fractures. A new material is needed because of disadvantages of nonresorbable alloplastic materials and difficulties in harvesting autogenous tissues. In this study safety and value of the use of resorbable mesh plate in the treatment of orbital floor fractures are discussed. Between 2002 and 2004 a total of 17 maxillofacial trauma patients complicated with orbital floor fractures were treated with resorbable mesh plate through subciliary or transconjunctival incisions. Pure blow-out fractures were determined in 6 patients and 11 patients had accompanying maxillofacial fractures. Resorbable plate was easily shaped to fit to the orbital floor by cutting with scissors. Patients were evaluated clinically and with computed tomography scans preoperatively and at 3-, 6- and 12-month intervals postoperatively. Twelve patients had preoperative enophthalmos. Two patients had diplopia that was corrected postoperatively. In all 17 cases there was no evidence of infection, diplopia and gaze restriction postoperatively. Scleral show appeared in three patients by the second postoperative week but resolved totally within 3 to 6 weeks except one patient. In this patient anterior displacement of mesh was evident which caused ectropion and enophthalmos and required re-operation. No any other mesh related problems were seen at 15 months mean follow-up time. The advantage of the resorbable mesh system in orbital floor fracture is the maintenance of orbital contents against herniation forces during the initial phase of healing and then complete resorption through natural processes after its support is no longer needed. Our experience represents that resorbable mesh is a safe and effective material for reconstruction of the selected, non-extensive orbital floor fractures.

Key Words: Orbital floor fracture, resorbable plate, diplopia

B]lunt peri orbital trauma or more often fractures of the upper part of the face particularly, the zygomatico-orbital complex, impair the three-dimensional (3-D) structure of the bony orbit at the weakest vulnerable areas especially in the orbital floor. Orbital floor fractures present with varying degree of severity and extension. However, even simple, isolated orbital blow-out fractures may cause functional and cosmetic problems like residual dystopia, diplopia and enophthalmos due to herniation of the orbital soft tissue content into the maxillary sinus together with extraocular muscle entrapment between bony fragments.

Two mechanisms are accepted to be the cause of the orbital floor fractures. In the buckling mechanism it is suggested that traumatic force is transmitted by bony conduction through the orbital rim to the orbital floor while in the hydraulic mechanism, elevated hydrostatic pressure inside the orbital cavity causes a disruption of the orbital floor which is known to be the weakest region. Clinical findings of the orbital floor fractures include periorbital bruising and edema, limitation of the vertical and horizontal ocular movements which cause diplopia, enophthalmos and in some cases decreased sensation in the distribution of the infraorbital nerve. A characteristic ‘teardrop’ appearance can be seen in the maxillary antrum at conventional X-rays but blood inside the maxillary sinus may mask this diagnostic sign. In the diagnosis of blow-out fractures and any orbital volume change which might cause enophthalmos, computed tomography (CT) is the most accepted tool. Axial and coronal CT scans not only provide the data of the location and size of the fracture but also can be used for improved surgical planning.
In the treatment of blow-out fractures it is important to reconstruct and maintain the accurate anatomical structural support of the orbit against herniation forces during the initial phase of healing to obtain functional and aesthetic result. Joining and stabilization of small, thin and delicate bone fragments is usually impossible that autogeneous or alloplastic materials have been used to span the floor defect. A wide variety of materials have been preferred for this purpose with their own advantages and disadvantages, but there is still no consensus on any of them. To call a material ideal or at least close to ideal for orbital floor fracture, it should be non-carcinogenic, noninfectious, biocompatible and easy to sculpture and anchor into the defect. It should also provide enough support during the healing phase and continue the orbital integrity safely in the long term.

Recently, absorbable plate-screw systems have attracted attention as an efficient fixation system for the cranio-maxillofacial region, started to be used more commonly for various indications. In this series, the safety and the value of the use of biodegradable mesh plate in the treatment of the orbital floor fractures are discussed.

**Patients and Methods**

Between September 2002 and December 2004, 17 patients who underwent reconstruction of orbital floor fracture using two different biodegradable mesh (Biosorb™, Bionx Implants Tampere, Finland and Inion®, Inion Ltd. Tempere, Finland) were included in the study. Patients’ ages ranged from 9–65 with a mean age of 34.2 years. Eleven of the patients were male and 6 were female. The most common cause of fracture in this series was motor vehicle accidents (70.5%). Other causes included fist blows, sports injuries and falls on face. Pure blow-out fractures were determined in 6 patients and 11 patients had accompanying maxillofacial fractures. All patients received a thorough maxillofacial examination at their first presentation to the emergency department. Existence of obvious enophthalmos, diplopia, limited eyeball motility, visual acuity and orbital dystopia were carefully evaluated. Patients with suspicious findings were referred to an ophthalmologist in order to rule out any probable globe injury. None of the patients showed impaired visual acuity however, there was one significant gaze restriction preoperatively. Although all patients were evaluated with plane radiographs and physical examination findings, axial, coronal plane and 3-D CT evaluations were carried out for accurate diagnosis. Impaired orbital floor integrity and soft tissue herniation into the maxillary sinus were accepted to be absolute indications for surgical intervention. Early surgical treatment within 48 hours was preferred for all maxillofacial trauma patients except existence of any contraindication due to multiple trauma. All patients received prophylactic intravenous antibiotics preoperatively which was continued orally for seven days postoperatively.

**Surgical Procedure**

Surgical procedures were carried out under general anesthesia. Subciliary muscle-splitting incision was used in 14 patients, and transconjunctival approach without lateral canthotomy was used in 2 patients and lateral canthotomy in another one. Other surgical incisions were added in complex maxillofacial fracture patients to reach related fractures. Bicoronal approach was carried out in three patients, two for frontal sinus fracture and another for supraorbital rim fracture. Upper gingivobuccal incisions were performed in 10 patients to correct fractures of maxillary buttress and anterior wall of maxillary sinus. Once the infraorbital rim was exposed through preferred incision, orbital floor was dissected superiostrally to reach the fracture area.Extent of the fracture was the determining criteria for using resorbable mesh plate. Limited fractures with small soft tissue herniation were ideal candidates for biodegradable plate reconstruction. Amount of the orbital floor defect was determined after the soft tissue was freed and small bony fragments were taken away. In most instances, associated fractures involving the zygomatic bone and infraorbital rim were apparent. First these fractures were fixed via titanium or resorbable plate-screw systems. Then a template fitting the orbital floor defect was prepared using a suture package. The resorbable mesh was easily shaped by cutting with scissors and molded by hand to give a curved shape in order to fit the anatomical shape. Then the implant was inserted over the orbital floor defect and careful attention was given to leave it 0.5 cm posterior to the inferior orbital rim, so that it would not be palpable and placed posterior enough to support the whole globe. No fixation was performed, but periosteal edges were brought together on the infraorbital rim so as to prevent implant displacement. Surgery was ended with skin or conjunctival closure and confirmation of orbital soft tissue release with forced duction test. Postoperatively patients’ physical appearance, existence of enophthalmos, diplopia, gaze restriction and
eyelid deformities were evaluated. Postoperative CT imaging was performed to visualize orbital integrity and compare volume changes.

**RESULTS**

Patients who underwent surgical reconstruction with resorbable mesh plate had a hospitalization time ranging between 2–10 days (mean 3 days). Associated injuries due to multiple trauma or complex maxillofacial fractures lengthened the hospitalization period. Patients were followed-up for 3–28 months (mean 14.6 months) (Figs 1–3). CT studies were performed at 1 week, 3 months and 12 months postoperatively to visualize the orbital integrity.

Of the 17 patients, 2 had clinically evident diplopia (11.7%) and 12 of them had enophthalmos (70.5%) (Table 1). Preoperatively detected diplopia was corrected in these two patients and 11 of the 12 patients with enophthalmos were corrected successfully. However one patient showed persistent enophthalmos with lower eyelid retraction and the mesh plate was palpable just anterior to the infraorbital rim. Resorbable mesh which was prepared longer in anteroposterior dimension had been blamed for this outcome. Mesh plate was replaced with a unicortical cranial bone graft to correct
enophthalmos and a canthopexy was performed to correct ectropion. Scleral show appeared in three patients by the second postoperative week but totally resolved within 3–6 weeks postoperatively. Subciliary approach was the preferred incision for these patients. No evidence of infection due to the resorbable mesh on the orbital floor was detected in any of the patients. One patient showed a delayed foreign body reaction on postoperative month nine against resorbable plate which was used in zygomatic fixation. Surgical debridement of the partially resorbed plate and screws on the infraorbital rim was performed (Fig 4). At that moment orbital floor was explored and no evidence of reaction or infection was detected. Except the patient who had a cranial bone graft replacement all 16 patients were treated successfully using biodegradable mesh plate. Postoperative functional and aesthetic results were satisfactory.

DISCUSSION

Various autogenous or alloplastic materials have been used in the treatment of orbital floor fractures. The extent of the disruption of the orbital floor is important in choosing the appropriate surgical procedure. Most commonly, complete destruction of the floor without any bony support is encountered and utilizing a graft material either alloplastic or autogenous is required. On the other hand, on some occasions, only a trapdoor defect may be present and the only treatment in this group is the repositioning of the trapped tissues from the linear fracture to their original site without any

Fig 2 Preoperative appearance of a male patient with left orbitozygomatic fracture (upper left); during the surgery the fractured lower orbital rim and the orbital floor was reconstructed by using resorbable plating system and mesh (upper right); preoperative coronal section CT demonstrating the fracture (lower left); and a similar CT section at one year postoperative (lower right).
reconstruction. Autogenous bone graft is one of the widely preferred alternatives especially for the reconstruction of severely disrupted orbital floors. Various donor sites were advocated for autogenous bone like calvarium, antral wall, mandibular symphysis, lateral and lingual ramus of mandible, and rib. These bone grafts can be used safely with no or minimal risk of infection and foreign body reaction. Although these autogenous bone grafts are excellent sources for bony reconstruction of the orbital floor, they are difficult to shape and undergo an undetermined amount of resorption. It is generally accepted that calvarial bone survives much more than grafts taken from endochondral sources but harvesting calvarial bone grafts may cause donor site complications some of which are life threatening such as cranial contour deformity, dural tear, meningitis and epidural hematoma. Pediatric patients are much more susceptible to these complications, because the human cranium cannot reach its terminal thickness before the age of 17. With the harvesting techniques in experienced hands, rate of such devastating complications are rarely seen. Autogenous cartilage grafts have also been used for orbital floor reconstruction with their easy harvesting techniques and excellent fitting by their malleable structure. However the enophthalmos rates were found to be higher.

Cadaveric allografts of various tissues, such as fascia, dura and bone have been used for the reconstruction of orbital floor fractures. These materials show a similarity to host tissues and avoid harvesting autogenous grafts. On the other hand, transmission of infectious diseases had been a severe

### Table 1. The Data of 17 Patients With Orbital Floor Fractures

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age</th>
<th>Sex</th>
<th>Fracture Type</th>
<th>Preoperative Findings</th>
<th>Follow up (months)</th>
<th>Early</th>
<th>Late</th>
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<td>Enophthalmos</td>
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<td>Enophthalmos</td>
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<td>Ectropion mesh displacement</td>
<td>Enophthalmos</td>
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problem in some cadaveric substances before the development of the current preservation processes. Some reports of slow viral infections caused by lyophilized dura and fasciae latae used in neurosurgery and otorhinolaryngology limited the widespread use of these materials. Lyophilization also damages the biomechanical structure of the allograft and weakens it against various forces. Later on, new human originated allogenic materials gained popularity with developments in allograft processing. In a recent study of our group the successful use of solvent preserved cadaveric bone graft in the treatment of orbital floor fracture was reported. Disease transmission by solvent-preserved bone grafts has not been reported yet; however, due to the rigid and nonmalleable structure of the material, proptosis was a problem in the early postoperative period. But it still serves a good alternative for the treatment of extensive orbital floor fractures which may cause enophthalmos in long term follow-up.

Several resorbable and nonresorbable alloplastic materials have also been used to reconstruct orbital floor in order to decrease operating time, increase the sculpture to fit the defect and obtain precise 3-D reconstructions. Among these materials, porous polyethylene implants and hydroxyapatite are the most commonly used materials. Their open-pore structure allows vascularization as well as soft tissue and bone ingrowth which stabilize the implant in the defect and eliminates stabilization with screws and sutures. Villarreal et al used ultra-thin porous polyethylene sheets for orbital floor reconstruction in 32 patients and achieved a 62.5% enophthalmos correction rate. The disadvantage of the porous polyethylene implant is the high infection rate before the implant is completely vascularized and become resistant to bacterial contamination. If extarocular muscle is encountered in the surgical field the use of the porous polyethylene implant is not recommended; a non-porous alloplastic implant or an autogeneous nasal septal cartilage between the implant and the extracocular muscle should be used instead.

Reasonable results have been obtained with artificial hydroxyapatite ceramics for orbital floor coverage with fixation of the material; however fixation of the material is required since they show migration.

Fig 4 CT scan showing right orbitozygomatic fracture (upper left); the fractured floor was spanned by using a resorbable mesh and the lower orbital rim was reconstructed with resorbable plate and screws (upper right). The patient showed a delayed foreign body reaction on the ninth month postoperative. (lower left); the remainder of the partially resorbed plate and screws that were taken out from infraorbital rim (lower right).
Among the nonporous alloplastic materials, metal meshes such as vitallium and titanium have been used to reconstruct the orbital defects but they have to be fixed with mini-plate systems because they don’t allow tissue ingrowth and capsule formation occurs around them. These materials should be considered for extensive fractures with large, multiple-wall defects in the posterior orbit, where resorption of the material may cause problem.

Bioactive glass which is osteoconductive, bacteriostatic and rigid have been used in the treatment of the orbital floor defects successfully. But its permanence and nonavailability in some countries are the disadvantages. Other nonporous alloplastic materials which have been used were silicone, teflon, tantalium and methyl methacrylate but primary concern with their use has been the risk of infection with extrusion.

Resorbable bone fixation materials have been clinically available and widely used in cranio-maxillofacial region. They are polymers consisting of varying compositions of polylactic acid and polyglycolic acid copolymers. These materials are completely biocompatible, and has adequate biomechanical resistance and can be eliminated from the body without causing any foreign body reaction. The use of resorbable materials which are completely eliminated from the body, appear to be appropriate in the treatment of orbital floor fractures. In an animal study, 0.4-mm poly-L-lactic acid implants were used to reconstruct the artificial orbital floor defects approximately 15 mm in diameter. It was observed that the implant was fully encapsulated by connective tissue after 3 weeks, a bony plate was progressively formed at the 19th week and at 78 weeks new bone had fully covered the plate on the antral and orbital site without inflammation or rejection. Tissue reaction on the orbital side had propensity to have been denser due to the eye movement and gravity and minimum load bearing function of the antral side. These implants are fully resorbed in about 3.5 years.

Poly-L-Lactic acid is hydrophobic and resistant to degradation whereas polyglycolic acid is hydrophilic and undurable. Composition of these two different resorbable materials in a unique combination, PLLA-PGA (82%/18%; LactoSorb, Walter Lorenz Surgical, Jacksonville, FL), results a copolymer which has enough strength and resorption properties with minimal foreign body reaction. Its strength persists up to 6 weeks and complete resorption occurs between 9 and 15 months. The safety and long term value of resorbable PLLA-PGA plate and screw fixation in pediatric patients without restriction of growth with fewer potential complications compared to traditional metal plates, screws, and wires, encourage their widespread use in all age groups. Although the temporary support they provide until their resorption is usually sufficient, we do not recommend their use in extensive orbital floor fractures where some volume replacement is also necessary. Ultimate resorption and replacement by fibrosis may not support orbital structure and persistent enophthalmos can not be corrected.

In a recent study 12 orbital floor fractures were treated with a resorbable 0.25-mm sheet. Enophthalmos was observed in two patients due to technical errors in placement of the implant. Only one patient developed delayed foreign body reaction which necessitated removal of the excessive portion of the mesh, and securing with an absorbable screw at infraorbital region. In another study, successful use of the 25 × 25 mm, 0.65-mm thick resorbable perforated plate through an access of 1-cm³ antral bone flap to the maxillary sinus and infraorbital floor in five patients was reported. None of the patients developed enophthalmos and no infection occurred in 3- to 12-month follow-up.

Timing of the operation for blow-out fractures is also controversial. Early surgical intervention is suggested by a number of authors. Postoperative complication rates are significantly low when an immediate or early operation is performed. In our treatment protocol, we prefer to operate on the patients within days after the trauma. In cases of late reconstruction, fibrous healing of the soft tissues may limit the dissection of the orbital floor and reduction of prolapsed orbital contents, and the soft-tissue changes may be even more severe.

In our study with 17 cases there was no evidence of infection. In one patient anterior displacement of the mesh plate caused ectropion and required re-operation. Persistent enophthalmos was also determined in this patient. In two patients diplopia due to the fracture dissolved postoperatively. One delayed foreign body reaction related to infraorbital rim plate required debridement. Biodegradable plate on orbital floor was safe and secure in this patient. No other mesh-related problems were seen at a mean follow-up of 15 months.

Resorbable mesh plate used for orbital floor reconstruction has many advantages. It is easy to sculpt to fit to the defect and operative time is significantly decreased. The implant’s low profile prevents postoperative proptosis and globe dystopia. Radiolucency of the system allows postoperative imaging without metallic artifact. The main superiority of the use of a resorbable mesh system in
orbital floor fracture is the maintenance of orbital contents against herniation forces during the initial phase of healing and complete resorption from the region after it is no longer needed. Our experience represents that resorbable mesh is a safe and effective alternative for reconstruction of orbital floor.

REFERENCES

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