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ORIGINAL ARTICLE

An innovative technique in orbital floor reconstruction avoiding complications: Temporary use of the silicone guide

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Summary *Background:* Orbital blowout fracture is a relatively common but challenging entity in the field of traumatology. Serious sequels may occur as a consequence of poor visualization or an inappropriate operative maneuver. We herein propose a modified technique featuring routine use of orbitotomy with temporary placement of a silicone shell as the guide template and soft-tissue barricade, thereby facilitating the mesh plate fashioning and expediting the implantation process.
Methods: Eleven patients underwent orbital floor open reconstruction with titanium orbital mesh plate implantation between January 2010 and December 2011. After thorough release of the herniated contents from entanglement, we tailored a silicone guide according to the size and shape of the defect and inserted it into the orbital cavity to hold up the soft-tissue contents. Another copy of silicone shell with exactly the same configuration was produced and taken as a reference to formulate the titanium plate. We removed this holding silicone guide after the placement of the orbital plate, avoiding incarceration between the plate and the herniated contents.
Results: Follow-up computed tomography scans 3 months after surgery demonstrated adequate reduction of the herniated contents. The patients were spared from complications such as diplopia or enophthalmos.
Conclusion: This innovative technique helps to simplify the operation, avoids complications, and is easily practicable.
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1. Introduction

Orbital trauma and the resultant orbital blowout fracture are relatively common but challenging disorders. Surgical repair of this fracture is straightforward; however, the secluded location of the pathology, the intricate regional anatomy, and the existence of numerous vulnerable vital structures near the fracture sites make reconstruction a daunting task.

The titanium orbital mesh gives this reconstruction a stable buttress to support the orbit, especially when two or more adjacent orbital walls are destroyed.[1,2] This mesh has to be tailored in accordance with the size and shape of the defect prior to insertion.[3] Impingement of soft tissue during deployment of this mesh may occur if the soft tissue is not held adequately by the instrument.[4] An appropriate retractor or barricade device is mandatory to facilitate the intervention process, and that device should be something with the size and shape similar to those of the defect, sturdy enough to hold up the herniated content while being flexible enough to be rolled up and set in through a limited incision.

Two identical customized silicone guides cut out from the suction drain bulb solve this problem. One serves to hold up the herniated contents, expediting the placement of metal implants, and the other one helps to fabricate a precise orbital plate for reconstruction. With this technique, we were able to successfully create a well-visualized operation field and effectively streamline the insetting maneuver of the orbital plate in 11 patients in the past 2 years.

2. Patients

A total of 11 consecutive patients underwent open orbital reconstruction with titanium orbital mesh plate implantation between January 2010 and December 2011 (Table 1). All reconstructions were performed by a single surgeon (J.-W.L.). This reconstruction series included six males and five females, and the mean age was 30 years. Prior to surgery, enophthalmos was noted in all but one of them (10 cases, or 91%), diplopia in seven cases (64%), and extraocular movement limitation in five cases (45%). Six of them had pure orbital blowout fracture (55%), three of them suffered from complex zygomatic fracture (27%), and the remaining two were diagnosed to have panfacial fracture. Seven of them underwent primary reconstructions within 1 month. The other four patients were referred to our clinic after failed primary surgeries. Among these four requiring secondary reconstructions, two patients arrived 2 months after their primary surgeries, whereas the other two patients came after more than 1 year.

Four patients had the floor or medial wall reconstructed with a titanium mesh alone, and another two patients had other bony problems corrected in addition. The remaining five patients had a cartilage graft implanted to correct enophthalmos in addition to the reconstruction work.

A comparative group of seven patients treated earlier (between 2006 and 2008) without using a silicone shell served as the control. The operative time and pre- and postoperative symptoms were recorded by reviewing the charts.

3. Surgical techniques

A subciliary or infraorbital incision was made, and then carried deep down by subperiosteal dissection to explore the fracture site. Upper blepharoplasty incision was added if medial orbital wall repair was indicated. An orbitotomy at the infraorbital rim was used to identify the route of the infraorbital nerve, and this step facilitated the freeing of the herniated orbital content from the enwrapped nerve. After thorough release of the herniated contents from entanglement, we tailored a silicone guide with the size and shape resembling those of the defect, but slightly wider on all periphery and inserted it into the orbital cavity to hold up the soft-tissue contents (Fig. 1). A clear operative field with distinct anatomy could be obtained by application of a retractor on this guide, allowing us to dissect the deepest fracture site free of obstacles imposed by the herniated content. The silicone guide was cut out from the suction drain bulb, which had a smooth edge for insetting with safety while also being sturdy enough to withhold the orbital content. Utilizing this technique, we could separate the orbital contents from the fracture site, preventing the orbital contents from reentering the fracture site during the subsequent repair work.

Another copy of silicone guide with exactly the same configuration was produced and taken as reference to formulate the titanium plate (Fig. 2). This plate was fashioned into normal orbit morphology and precisely positioned on the bony platform to restore the continuity of the orbital floor. With its superb pliability and smooth surface character, the silicone guide could be easily drawn out and inset repetitively during the tailoring process.

After placement of the orbital plate, we returned the previously orbitotomized bone back to its original location, and then removed the silicone guide (Fig. 3). A forced duction test was routinely carried out. If necessary, diced cartilage was harvested and instilled into the orbit socket to correct the enophthalmos.

After surgery, potential complications such as visual acuity impairment, extraocular muscle dysfunction, retrobulbar hematoma, infraorbital hypesthesia, or wound infection were monitored and recorded. Surgical results were followed up periodically with exophthalmometer, and computed tomography (CT) scan images were routinely obtained 3 months after surgery in all patients.

4. Results

The patients were followed up for 3–22 months (mean: 8 months). There was no visual impairment, new-onset extraocular movement limitation, or wound infection after surgery. The CT scan revealed that all patients had their mesh placed adequately without incarceration of orbital contents or impingement of vital structures (Fig. 4). All five patients who had preexisting extraocular movement limitation invariably had this problem solved. Almost every patient who had cartilage graft implantation experienced double vision shortly after the operation, but this always resolved within 3 months. All of the seven patients who had diplopia prior to surgery had definite improvement; however, two patients had residual diplopia and needed further strabismus surgery in the end. Among the 10 patients presenting with enophthalmos, five patients underwent cartilage graft implantation and all appreciated the aesthetic outcome that there was no discernible discrepancy between the operated eye and the fellow normal eye (Fig. 5). There was only one patient with persistent eye globe malposition even though the enophthalmos was corrected. The other five patients had reconstruction of the orbit without cartilage graft implantation revealing some degree of improvement in enophthalmos, but four of them still had residual enophthalmos. The discrepancy in exophthalmometer records prior to surgery was 3.5 mm, 3.5 mm, and 7 mm for Patient 1, Patient 3, and Patient 4, respectively, and after surgery, the discrepancy changed to 0 mm, 1 mm, and 0 mm, respectively.

The mean operative time for the pure blowout fracture patients undergoing titanium mesh reconstruction without the use of a cartilage graft was 143 minutes, whereas the surgical time for the control group was 155 minutes. There was no significant difference in operative time after using

Table 1 Patient list.

Case no.	Age	Sex	Side	Diagnosis	Previous surgery	Surgical timing (wk)	Preoperative symptom	Procedure	Postoperative symptom
1	17	F	L	Orbital floor and medial wall fracture	+	52	Enophthalmos, diplopia	Orbital floor and medial wall reconstruction [a]	—
2	31	M	L	Orbital floor fracture	−	4	Enophthalmos, diplopia, EOM limitation	Orbital floor reconstruction	Residual enophthalmos
3	17	M	R	Orbital floor fracture	+	52	Enophthalmos	Orbital floor reconstruction and cartilage graft	—
4	19	F	L	Orbital floor and zygoma fracture	+	8	Enophthalmos, diplopia, EOM limitation	Orbital floor and medial wall reconstruction and cartilage graft	Vertical diplopia
5	61	M	R	Orbital floor fracture	−	4	Diplopia, EOM limitation	Orbital floor reconstruction	—
6	28	M	L	Orbital floor with panfacial fracture	−	3	Enophthalmos	Orbital floor reconstruction and maxilla reduction and fixation	Residual enophthalmos
7	47	F	L	Orbital floor fracture	−	3	Enophthalmos, diplopia, EOM limitation	Orbital floor and medial wall reconstruction and cartilage graft	Low set eye globe position
8	39	M	R	Orbital floor and zygoma fracture	−	2	Enophthalmos, diplopia	Orbital floor reconstruction and cartilage graft and zygoma reduction and fixation	—
9	29	F	R	Orbital floor fracture	−	4	Enophthalmos	Orbital floor reconstruction	Residual enophthalmos
10	19	M	BIL	Orbital floor and panfacial fracture	−	2	Enophthalmos	Orbital floor reconstruction and mandible, maxilla, zygoma reduction and fixation	Vertical diplopia
11	27	F	R	Orbital floor and zygoma fracture	+	10	Enophthalmos, diplopia, EOM limitation	Orbital floor reconstruction and cartilage graft and zygoma reduction and fixation	—

EOM = extraocular movement; L = left; R = right.
[a] Staged operation, cartilage graft was implanted 1 year later.

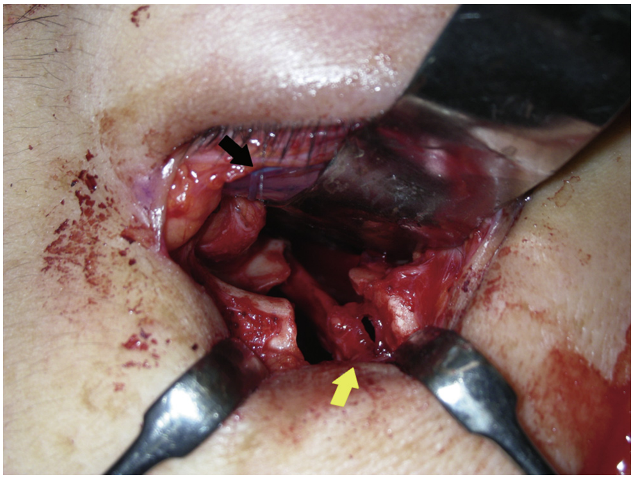

Figure 1 Herniated orbital content released from the enwrapped nerve. An orbitotomy was performed at the infraorbital rim to facilitate identification of the route of the infraorbital nerve, indicated by the yellow arrow. The orbital fat was held adequately by the silicone template (black arrow) and such an adjunct serves to separate the orbital content from the fracture site effectively.

the Mann–Whitney *U* test ($p = 0.732$). Diplopia improved from 6/7 to 2/7 for the control group, and from 2/3 to 0/3 for our current series.

5. Discussion

Orbital fracture is common in facial traumas, accounting for 2.5% of all trauma admissions, or 18–50% of all craniofacial traumas.[5,6] Orbital blowout fracture is caused by the traumatic force applied to the rim or soft tissue of the orbit and may occur as an isolated fracture of the internal orbit or in conjunction with the orbital rim disruption. The term "blowout" characterizes displacement of the orbital contents into the maxillary or ethmoid sinuses with destruction of the orbital floor and medial wall. The entrapment of either the extraocular muscle or the soft tissue adjacent to the muscles in orbital floor fracture frequently causes diplopia.[7] In our series, 64% of patients developed this symptom, which is slightly higher than in other studies with the prevalence ranging from 44% to 58%.[8,9] Sometimes the extraocular muscle imbalance could be caused by muscle contusion or nerve damage, and thus we should not attribute all the improvements of double vision to the surgical result.[10] Nevertheless, five of seven patients gained immediate postoperative improvement after thorough release of the extraocular muscle, and we regard this as significant.

Enophthalmos was the leading complication (91%) of orbital blowout fracture in our series, which accounted for 17.9% of orbital fractures in another study.[8] This posttraumatic enophthalmos is caused by reduction of the orbital soft tissue, which may come about as a result of relative volume deficiency due to bony-volume expansion or as absolute volume deficit resulting from loss of fat or cicatricial contraction.[11,12]

Surgical repair of orbital blowout fracture is straightforward but never an easy task. Reduction of herniated orbital contents and restoration of continuity of the orbital floor comprise the basis of orbital reconstruction. The anatomy of the orbital socket is intricate and encompasses numerous vulnerable vital structures. The infraorbital nerve runs in a canal in the anterior third of the orbit, travels in a groove in the posterior two thirds of the orbit, and enters the inferior orbital fissure. This architecture forms a weak point in the orbital floor and is frequently involved in orbital fractures. It is observed invariably that herniated orbital contents, fractured bony chips, and even extraocular muscles enwrap the infraorbital nerve in an orbital floor blowout fracture. Tugging these soft tissues through the restrictive fracture site without adequate visualization of this nerve may damage both of them. We routinely performed orbitotomy at the infraorbital rim to identify the whole route of the infraorbital nerve to facilitate the releasing of the herniated orbital contents.

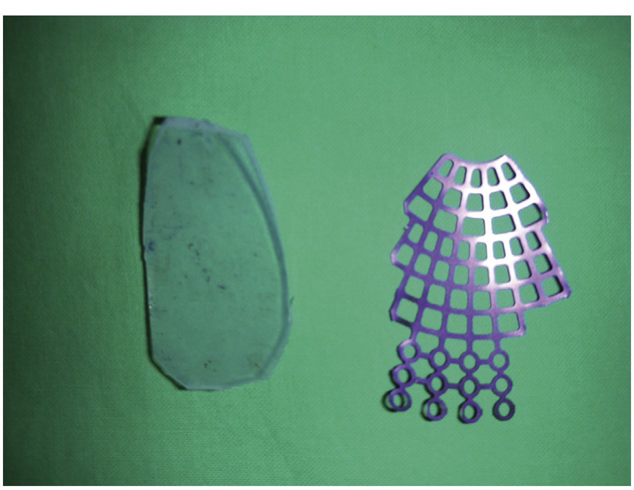

Figure 2 Another silicone shell served as a template to fabricate the titanium mesh.

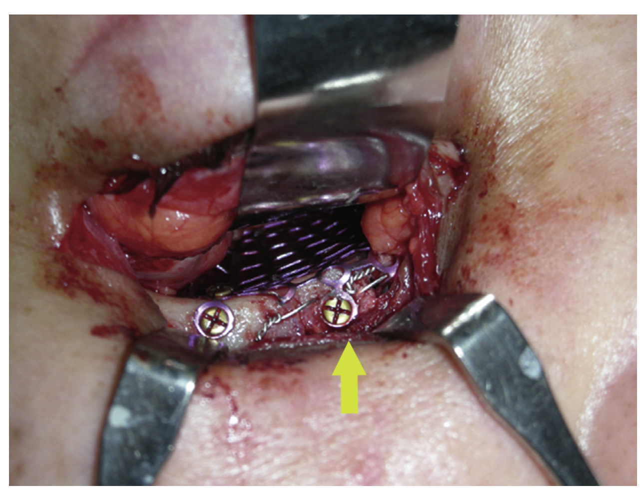

Figure 3 The titanium plate was deployed properly and the orbitotomied bone was then placed back to its original location (arrow). Note that if the silicone guide was removed, the orbital content would herniate back, and any attempts to retrieve the mesh for fine-tuning would become difficult.

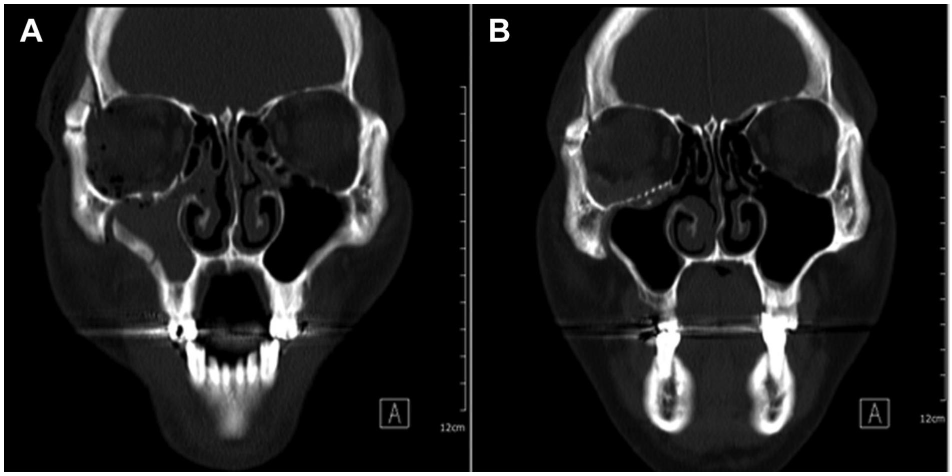

Figure 4 Reduction of right zygoma and right orbital floor reconstruction with concomitant cartilage grafting was performed. (A) The right-side bony-volume expansion and low set eye globe position could be seen in the preoperative computed tomography (CT) scan. (B) After restoration of orbital floor continuity with titanium mesh and orbital volume replenishment with a cartilage graft, a proper restoration of the globe position was achieved, as illustrated on the postoperative CT scan image.

Further dissection should be conducted until the posterior ledge of the remnant orbital floor is reached, thereby assuring thorough identification of the whole extent of the orbital defect. Misjudgment of the actual bony defect could lead to either undercorrection or inadvertent neuromuscular damage due to the oversized implant.

Prior to the middle of the year 2009, we used a malleable retractor to hold back the orbital contents. It was necessary that the retraction be gently applied and free of pressure on the ocular globe. However, considering the conformation of the orbital socket, which is more like a cone in shape, the precise retraction of deepest orbital soft tissue with a single configuration retractor was difficult. When a larger defect was encountered, especially in the case of involvement of both orbital floor and medial wall fractures, a single retractor usually failed to hold the soft tissue steadily. Besides, the fear of traumatizing the ocular globe, extraocular muscles, and even lid margin of the incision wound all work together to bring forth such an innovation.

One customized silicone guide cut out from the suction drain bulb solved the aforementioned problem. With this, we can fabricate the silicone guide into any size and shape according to the specific condition of a given defect. This silicone guide is sturdy enough to hold up the orbital contents, and works perfectly well with the application of a retractor on this guide. It also has a smooth edge and surface, making the deployment into the orbital socket free of impingement or entanglement of the orbital soft tissue. During the surgical procedure, it could be rolled up to pass through a limited incision wound and then spread out to resume its maximal coverage dimension. We believe that the suction drain bulb is a wonderful material to meet our requirement and is available in most medical institutions. Moreover, the natural curve of the suction drain bulb makes this guiding template an ideal option because it possesses a concave surface, which closely resembles the native contour of the inner orbital floor.

Another issue for orbital reconstruction is restoration of continuity of the orbital floor. A multitude of autogenous and alloplastic materials have been used, and the complications have been reviewed.[13] The alloplastic implants can do without donor site morbidity and save operation time, but their complications including infection, migration, and

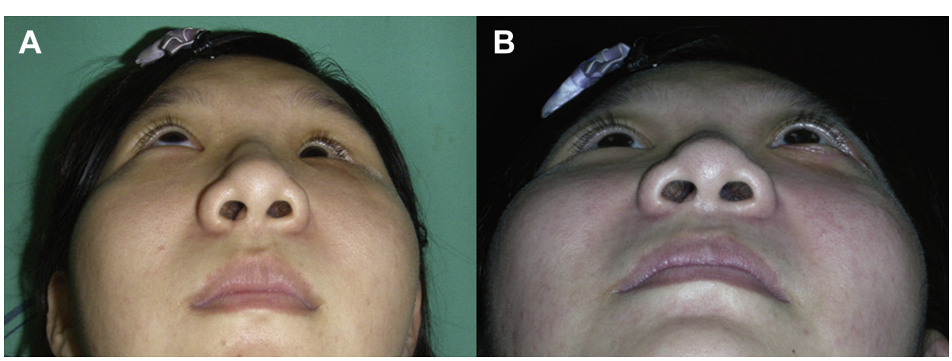

Figure 5 (A) Preoperative photograph showing enophthalmos up to 7 mm discrepancy on Hertel's exophthalmometer. (B) After orbital floor and medial wall reconstruction with concomitant 4 mL cartilage grafting, the postoperative photograph shows no discernible differences between the operated eye and its fellow normal eye.

protrusion are a major concern.[14–16] Nevertheless, the biocompatibility and safety of the titanium use was proven in the literature.[3,17,18] It cannot be overemphasized that the titanium orbital mesh gives this reconstruction a stable buttress to support the orbit, and has become our preference, especially when two or more adjacent orbital walls need to be fixed.[1,2]

The mesh has to be tailored in accordance with the size and shape of the defect; fortunately, the malleability of the titanium material facilitates restoration of symmetric orbital socket conformation in three dimensions. It is still necessary to move the mesh plate in and out repetitively from the orbital socket before an ideal contour has been reached. Although there is only one case report in the literature, the impingement of the orbital contents or infraorbital nerve did occur if the soft tissue was not held adequately.[4] With this technique, a silicone guide becomes the barricade of orbital soft tissue, clarifying the boundary between the fracture site and orbital contents. Another silicone shell with identical size and shape is fabricated as a guide template. The titanium mesh can be fashioned according to this template, and then it will become much easier and safer to be repetitively drawn out for fine-tuning its contour and reinserted, because at this moment the orbital content was held and retracted adequately.

The treatment of enophthalmos consists of restoration of the original bony anatomy and return of orbital soft-tissue volume. The high incidence of residual enophthalmos following orbital wall reconstruction has been observed.[13] The details of this procedure were described in our previous study.[19]

A somewhat better improvement of diplopia in the current series (from 67% to 0%) was identified as compared with the control group (from 86% to 29%). Admittedly, the severity of injury may not be perfectly identical among those two groups. Besides, the surgical skill may become more proficient as experience accumulates with time, which may possibly be a bias factor affecting the overall outcome. In addition, we noticed some degree of simplification of the whole procedure.

Some authors shared their experience about the use of Freer periosteal elevator or spoon, and a host of specially designed orbital retractors were invented and commercialized, but so far there has been no report mentioning the temporary use of a silicone shell. Since the time this technique was brought forth, we have routinely used it in orbital reconstruction, and it is considered a useful and safe maneuver. We believe that it is easily practicable and deserves popularization.

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