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Do orbital floor plates adequately protect against serious secondary injury?

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Abstract

Reconstruction of the orbital floor is common in cases of trauma and a variety of alloplastic materials, including titanium, can be used. However, we know of no reports about what happens to these materials if there is a second injury to the surgical site. This pilot study on six human cadavers (12 orbits) was therefore designed to investigate the possible outcomes should this occur. A "blowout fracture" was created in each orbit, which was then repaired using a preformed titanium implant. In two orbits, two implants were placed without fixation. The remaining implants were secured to the anterior orbital floor with a single screw, which was placed laterally or medially. A second impact sufficient to fracture the zygomaticomaxillary complex was then applied and its effect on the implants noted.

Keywords: Orbit; trauma

Introduction

In recent years, surgeons have become increasingly aware of the importance of precise geometric reconstruction of defects in the orbital floor, as opposed to "volume correction", after trauma.[1] To achieve this, many types of flat and contoured implants have been tested, including porous polyethelene sheets, bone grafts, thermoplastic inserts, and titanium (precontoured plates and meshes), each with their own advantages and disadvantages.[2] Titanium is regarded by many to be a good option, and is now widely available.[3] It can be adapted and trimmed if necessary, and allows fluid to dissipate, and tissue to be incorporated through its perforations.[4] Implants must, however, be precisely placed and then secured to maintain their position.[5]

To our knowledge, the durability of titanium and its resistance to further injury is unknown, and further traumatic displacement of the zygomaticomaxillary complex (ZMC) after placement of an implant could result in several possible outcomes because of its rigidity. It could bend or buckle, risking a rupture of the globe, or displace posteriorly towards the orbital apex, injuring the optic and other nerves.[6,7] A secondary injury could also lead to the collapse of the ZMC and orbital rim around the fixed implant, and its leading edge could impinge on and tear the lower eyelid.[8] While these are the main concerns, the implant could, however, support and strengthen the ZMC.[9]

After placement, implants can be secured with one or more screws to either the orbital rim or the anterior orbital floor,[10] but the effects of the screws are also unknown. The main purpose of this pilot study therefore was to investigate the effects of a second impact on preformed titanium orbital implants and the surrounding bones, specifically, the effects on the entire zygomaticomaxillary-titanium complex

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after application of a force sufficient to displace the cheek. We were not able to find out whether the implant supported and strengthened the ZMC, as the entire complex with the implant was tested in such a way as to ensure that the fracture was displaced completely.

Method

We used six human "soft-fixed" cadavers: two male and four female, aged between 75 and 93 years. The surgical techniques were identical to those used on living patients. Each orbital floor and medial wall was approached through a retroseptal transconjunctival incision (the simplest approach in view of tissue fixation), and the floor of each orbit fractured into the maxillary sinus (approximately 1 × 1 cm) with a small blunt osteotome to create a "blowout fracture". In all cases, this was found to be medially sited and along the infraorbital nerve, which is common to most simple blowout fractures. The orbital soft tissues were then carefully raised and retracted to define and repair each defect as is normal practice. A preformed titanium implant was positioned to cover the orbital defect and secured to the anterior orbital floor just inside the inferior orbital rim, either with one screw medially or one screw laterally. The three preformed screw holes along the anterior edge were removed (as would be done routinely in vivo) to ensure that the entire implant was within the orbit with the anterior leading edge lying along the anterior orbital floor inside and below the edge of infraorbital rim. This prevented the implant from becoming exposed through the transconjunctival incision.

Results

We placed 12 orbital implants in six cadavers. The orbital plates that were fixed anterolaterally were displaced en bloc together with the ZMC (Fig. 1). Those that were securely fixed anteromedially tended to remain in place while the ZMC collapsed around them (Fig. 2). Plates that were not secured, or those in which the fracture propagated through the screw hole (with failed fixation), were displaced separately from the fracture but not en bloc. Comparison of each plate with the control plate showed that only one plate had been substantially deformed (Figs. 3 and 4). Closer inspection of all the plates showed that in a few there was only minor deformation along the medial or anterior lateral edges. The remaining plates were not affected (Table 1). It should also be noted that the bone in cadaver 2 (C2) was very strong, and several heavy blows were required to fracture the ZMC.

Discussion

We conducted this study to answer an important question regarding the placement of orbital plates: what happens if a

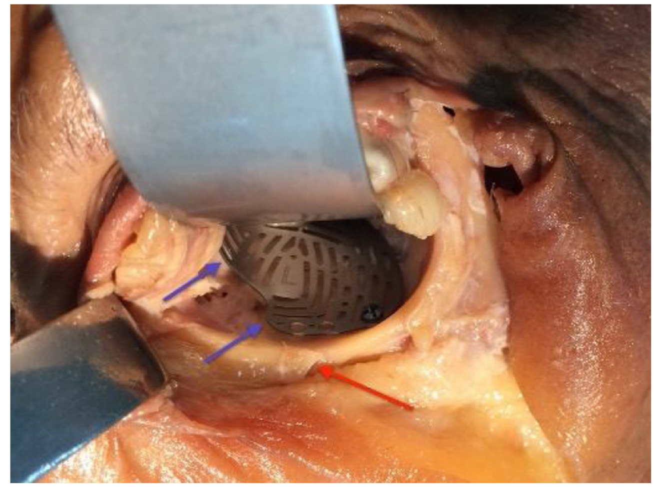

Fig. 1. Cadaver 1: left zygoma with superomedial displacement of the orbital plate (blue arrow). Red arrow highlights the fracture.

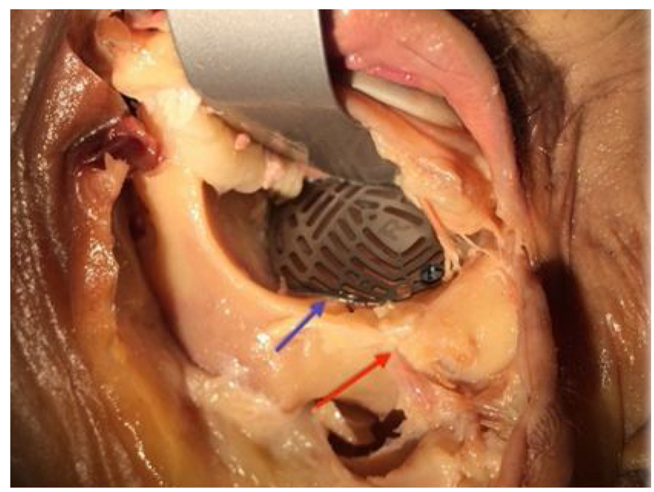

Fig. 2. Cadaver 1: plate remained in place while the fractured right zygoma was displaced beneath it. The anterior lateral margin of the plate was slightly deformed by the secondary impact.

Fig. 3. The removed orbital plate from Fig. 1 with deformed lateral edge.

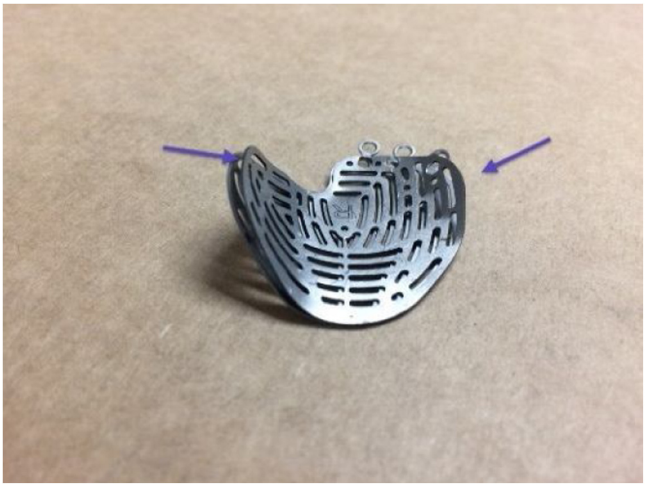

Fig. 4. The orbital plate from Fig. 2 was retrieved and placed on a normal plate for comparison. The deformed anterior lateral edge can be seen. There was also a minor degree of deformation along the medial edge.

patient with a previously repaired orbital fracture is injured on the cheek a second time? The answer could have several implications, which include the future design and choice of implant materials, consent, and advice for patients. Men and women who take part in contact sports professionally (such as rugby and mixed martial arts) may need to be counselled accordingly in view of their predisposition to sustain such injuries.[11,12]

There are a number of limitations in this study. The cadavers were not fresh but had been preserved (albeit very recently), so the supporting effects and resilience of the soft tissues were, to some extent, affected. Any cushioning effect of the globe was also negated because of its partial deflation. To attempt to counteract this, the retrobulbar tissues were lightly packed with fat to reproduce some support so, while this study cannot be used to draw any firm conclusions, we did note a few interesting findings.

The position of the retaining screw seemed to have some bearing on the displacement of the implant. When the screw was placed laterally, the ZMC and implant tended to move together, and the implant slid medially and upwards along

Table 1
Orbital plates after secondary injury to zygomaticomaxillary complex (ZMC).

Cadaver (C)	Side	Screw position	Direction of displacement	Deformation of plate
C1	Left	Lateral screw with moderate displacement of zygomatic bone	Plate and zygoma displaced medially as single unit, with medial wall of the plate shifted along medial orbital wall, resulting in obvious gap	Not deformed
C1	Right	Medial screw with moderate displacement of zygomatic bone	Plates remained in situ resulting in anterior lateral edge of plate standing proud of inferior orbital rim laterally	Potential impingement into lower eyelid, anterior lateral edge of plate also buckled but reminder of plate unchanged
C2	Left	Lateral screw, moderate displacement of zygoma	Both plate and zygoma displaced medially and posteriorly	Not deformed
C2	Right	Medial screw, ZMC fracture with fracture line passing through screw hole	Entire fracture complex displaced medially taking plate with it, and resulting in displacement along medial wall	Not deformed
C3	Left	Plate not fixed, moderately displaced zygoma	Anterior leading edge of the plate over-riding inferior orbital rim, potential impingement on lower eyelid	Not deformed
C3	Right	Plate not fixed, moderately displaced zygoma. Plate not deformed	Anterior leading edge of the plate over-riding inferior orbital rim, potential impingement on lower eyelid	Not deformed
C4	Left	Medial screw, ZMC fracture with fracture line passing medial to screw	Entire fracture plate complex displaced medially	Not deformed
C4	Right	Middle screw, fractured zygoma with fracture passing through screw	Fracture plate complex displaced medially	Not deformed
C5	Left	Lateral screw, ZMC fracture with fracture passing through screw hole	Fracture complex plus plate displaced medially	Not deformed
C5	Right	Medial screw, zygomatic fracture	Plate unchanged in position	Not deformed
C6	Left	Fixation with single screw along medial rim, zygoma displaced medially	Plate rotated around medial screw, eyelid potentially impinged	Not deformed
C6	Right	Fixation with single screw along lateral rim, fracture plate complex displaced medially	Second fracture through screw hole	Not deformed

the medial orbital wall and lifted away from the orbital floor (Fig. 1). This would, in theory, reduce the orbital volume and potentially raise the pressures within the eye and orbital contents. When the screw was placed medially, the implant tended to remain in its normal position while the zygoma collapsed below it (Fig. 2), potentially placing the lower eyelid at risk. In all cases except one, the implant seemed to retain its original shape, or at least undergo only minimal change. The issue as to whether the implants provided structural support to the ZMC and prevented its collapse could not be settled by this study, as we intended to test each "repair" to destruction and ensure that the ZMC collapsed completely.

Hypothetically, a repaired "metal floor" could prevent a further blowout fracture, whether it resulted from a buccal or hydraulic mechanism. The geometry of a closely fitting implant might therefore, in theory, provide a buttress-type effect if the implant is secured to the orbital rim. Whether these theoretical mechanical effects would also occur with other implants is unknown. One would imagine that the more rigid an implant is, the more likely this is to occur. For example, orbital repair using a thin flexible sheet of polydioxanone (PDS) would presumably offer no structural resistance against a second impact, but this of course, is speculative.

This study provides information that can help us when obtaining consent. While the data and conclusions are by no means robust, it seems that titanium implants retain their shape and do not buckle. Nevertheless, when a strong enough force is applied they can displace, although the positioning of the screws seems to give some control over this. The next logical step is to compare implants of different materials and designs, together with multiple points of fixation, to attempt to minimise displacement and limit the risk of injury.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

Not applicable.

References

1. Hazani R, Yaremchuk MJ. Correction of posttraumatic enophthalmos. *Arch Plast Surg* 2012;**39**:11–7.
2. Totir M, Ciuluvica R, Dinu I, et al. Biomaterials for orbital fractures repair. *J Med Life* 2015;**8**:41–3.
3. Gabrielli MF, Monnazzi MS, Passeri LA, et al. Orbital wall reconstruction with titanium mesh: retrospective study of 24 patients. *Craniomaxillofac Trauma Reconstr* 2011;**4**:151–6.
4. Schlittler F, Schmidli A, Wagner F, et al. What is the incidence of implant malpositioning and revision surgery after orbital repair? *J Oral Maxillofac Surg* 2018;**76**:146–53.
5. Neumann A, Kevenhoerster K. Biomaterials for craniofacial reconstruction. *GMS Curr Top Otorhinolaryngol Head Neck Surg* 2009;**8**:Doc08.
6. Foletti JM, Scolozzi P. Severe distortion of an orbital titanium mesh implant after recurrent facial trauma: a potential threat to the orbital contents? *Br J Oral Maxillofac Surg* 2017;**55**:836–8.
7. Scott R. The injured eye. *Philos Trans R Soc Lond B Biol Sci* 2011;**366**:251–60.
8. Lee EI, Mohan K, Koshy JC, et al. Optimizing the surgical management of zygomaticomaxillary complex fractures. *Semin Plast Surg* 2010;**24**:389–97.
9. van Hout WM, Van Cann EM, Muradin MS, et al. Intraoperative imaging for the repair of zygomaticomaxillary complex fractures: a comprehensive review of the literature. *J Craniomaxillofac Surg* 2014;**42**:1918–23.
10. Kim HS, Jeong EC. Orbital floor fracture. *Arch Craniofac Surg* 2016;**17**:111–8.
11. Bathgate A, Best JP, Craig G, et al. A prospective study of injuries to elite Australian rugby union players. *Br J Sports Med* 2002;**36**:265–9.
12. Zagelbaum BM, Starkey C, Hersh PS, et al. The National Basketball Association eye injury study. *Arch Ophthalmol* 1995;**113**:749–52.