Re-establishing Facial Aesthetics - Patient-specific Orbital Implant for Post-traumatic Deformity

Sujeeth Kumar Shetty, Revati Kale, Abhinav Kathuria, Sonakshi Prakash, Prajwal Makam

Department of Oral and Maxillofacial Surgery, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysore, Karnataka, India

Abstract

Rationale: Complex fractures of the maxillofacial region can require staged interventions to achieve optimal outcomes. A significant example of this are complex fractures of the orbital floor, which may be difficult to restore during primary treatment. The secondary correction is often required which can be using stock- or customised implants. **Patient Concerns:** A previously operated case of panfacial trauma presented with an aesthetic concern regarding the asymmetrical appearance of his eyes. **Diagnosis:** On clinical and radiological evaluation, the patient was diagnosed with enophthalmos of the left eye secondary to orbital floor fracture. **Treatment:** A patient-specific implant (PSI) was fabricated and placed for orbital floor reconstruction. **Outcomes:** Postoperatively, aesthetic and functional outcomes were satisfactory. **Take-away Lessons:** This case report highlights the use of PSIs in orbital floor reconstruction, made possible due to the advent of virtual surgical planning and three-dimensional printing in the field of oral and maxillofacial surgery.

Keywords: Orbital fractures, patient-specific implant, post-traumatic deformity, reconstruction, titanium implant

Introduction

Residual post-traumatic facial deformities can persist even after primary treatment,[1] leading to functional and aesthetic compromise, which may require secondary correction to overcome the functional and psychological impact that such deformities entail. Factors influencing such residual deformities are the extent of fractures, inappropriate treatment or inadequate resources at the time of initial treatment.[2] The successful treatment of such deformities depends on the surgeon's skill to break down the disfigurement into its individual components.[3] Depending on the extent of the deformity, the treatment may involve simple camouflage procedures or more extensive surgeries, which may require refracturing, recontouring or reconstruction.[3] The integration of modern technology in the field of medicine has presented the boon of virtual surgical planning (VSP) and three-dimensional printing (3DP). These technologies allow surgeons to use patient scans to virtually plan the surgical steps and design customised implants by mirroring the healthy side onto the unhealthy side.[4] We present a case of post-traumatic deformity of the orbital floor causing enophthalmos. The orbital floor was reconstructed using a patient-specific implant (PSI). This report aims at highlighting the advantages of using VSP and 3DP in maxillofacial reconstruction. It sheds light on the superiority of PSIs over traditional reconstructive modalities in being objective, precise and time-efficient.

Case Report

A 22-year-old male presented to the outpatient department with aesthetic concerns due to an altered position of the left eye compared to the right. The patient has a history of open reduction and internal fixation for multiple facial bone fractures secondary to a road traffic accident. Clinical examination revealed a noticeable disparity between the right and left pupils, accompanied by hooding of the left upper eyelid [Figure 1a and b]. On ophthalmologic evaluation, no diplopia

Access this article online

Quick Response Code:

Website: https://journals.lww.com/aoms

DOI: 10.4103/ams.ams_22_24

Address for correspondence: Dr. Revati Kale, Department of Oral and Maxillofacial Surgery, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysore - 570 015, Karnataka, India.
E-mail: revati1507@gmail.com

Received: 15-02-2024 **Last Revised:** 11-06-2024
Accepted: 17-06-2024 **Published:** 26-08-2024

How to cite this article: Shetty SK, Kale R, Kathuria A, Prakash S, Makam P. Re-establishing facial aesthetics - Patient-specific orbital implant for post-traumatic deformity. Ann Maxillofac Surg 2024;14:221-3.

or restriction of eye movements was noted. A computed tomographic (CT) scan was done, which revealed a residual left orbital floor defect, with herniation of fat into the maxillary sinus [Figure 2a and b].

The patient was presented with various surgical options and after a comprehensive discussion regarding his expectations from the surgery and the financial implications of the procedure, an ambiguous decision was made to opt for PSI. This decision was also justified in light of the patient's requirement for both floor and lateral orbital rim augmentation, a requirement that could not be addressed using standard titanium meshes.

Digital Imaging and Communications in Medicine data from the preoperative CT scans were analysed through a Materialise Mimics software [Figure 3a]. Analysis revealed the orbital volume of affected side to be approximately 32 cubic centimetre (cc) and healthy side volume to be 26.5 cc. A custom-made implant was designed using a mirror-image overlay derived from the anatomically sound features of the patient's contralateral intact orbit. The designed PSI included medial and lateral extensions to correct orbital position [Figure 3b and c], with posterior limits defined by Hammer's key area, which is at the highest point on the posteromedial aspect of the floor. Multiple holes were incorporated in the implant to reduce weight and prevent tissue fluid collection. The finalised design achieved a corrected orbital volume of 26.08 cc [Figure 3d]. The design was then transferred onto a 3-dimensional model and the final implant was fabricated using medical grade alloy containing Titanium, Aluminium and Vanadium extra low interstitial (Ti 6Al 4V ELI).

Figure 1: (a and b) Pre-operative photographs, with yellow line showing the discrepancy in pupillary level. (c and d) 3-month postoperative photographs, with yellow line showing the marked improvement in pupillary level. (e and f) 1-year follow-up photographs, with yellow line depicting pupillary level

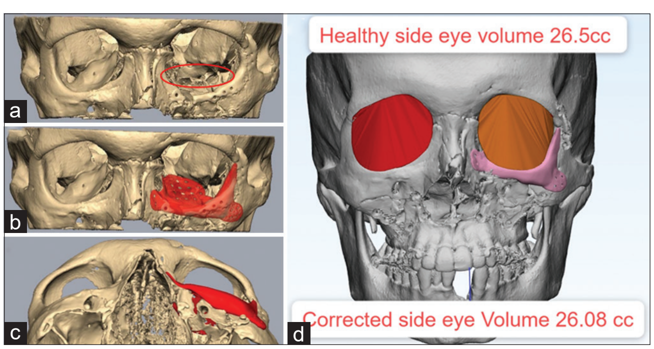

Figure 3: (a) Three-dimensional reconstruction of scans, circle showing defect. (b) Frontal view of proposed design for the orbital floor implant obtained by mirroring of healthy side. (c) Worm's view of proposed design for the orbital floor implant. (d) Software generated image showing orbital volume of intact side and corrected volume of affected side as per proposed design of the patient-specific implant

The surgical approach used involved infra-orbital and lateral eyebrow incisions. Blunt dissection was done to expose the previously fixed plates, which were then removed, to facilitate PSI placement. Subsequently, PSI was meticulously positioned [Figure 4a and b], and soft-tissue contour was assessed. Once the intraoperative fit of the implant was deemed satisfactory, the PSI was securely affixed using six titanium screws of 1.5 mm diameter, and closure was achieved in layers. Postoperatively, facial asymmetry improved significantly, along with a gross reduction in pupillary level discrepancy [Figure 1c and d]. A post-operative ophthalmologic evaluation revealed no diplopia or restriction of eye movements. At 1-year follow-up, it can be appreciated that the correction of globe position and bony contour, in turn, led to enhanced soft-tissue appearance [Figure 1e and f]. The post-operative CT scan shows the orbital floor contour symmetrical to the healthy contralateral side [Figure 5a and b].

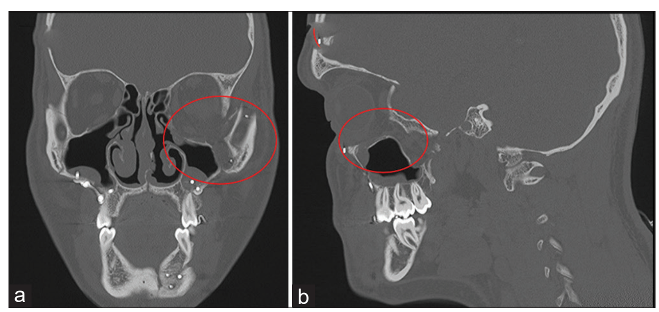

Figure 2: Preoperative Computed Tomographic (CT) images of patient with red circle showing (a) lateral wall and (b) orbital floor fracture with fat herniation

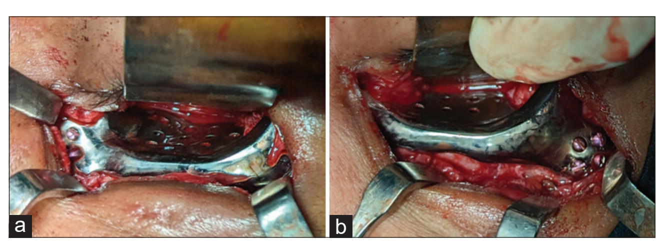

Figure 4: Intra-operative photos showing implant in place with (a) medial and (b) lateral fixation

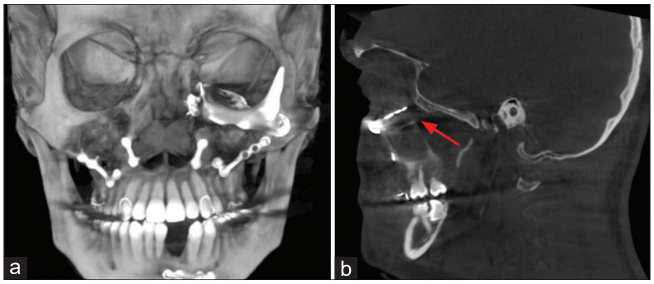

Figure 5: (a) Post operative CT showing orbital implant in place and (b) Red arrow showing improved orbital floor contour.

Discussion

Fractures of the midfacial skeleton, especially those involving the orbital floor, pose complex challenges to maxillofacial surgeons due to potential complications such as enophthalmos, diplopia, reduced infra-orbital nerve sensation, retinal trauma and vision loss. Orbital reconstruction during primary surgery aims to restore orbital anatomy, preserve soft tissue, remove unstable fragments and identify stable bone platforms for fixation.[5] However, the arduous nature of orbital reconstruction often leaves a residual deformity after primary treatment, which require a secondary surgery, which is in turn complicated by altered anatomic landmarks and delayed soft-tissue changes.[6] The primary objective of the secondary surgery is to rectify alterations in orbital volume, reinstate symmetry of the globe and restore overall facial aesthetics.

Traditional orbital floor reconstructive procedures have utilised either auto-grafts or prefabricated orbital-mesh implants. Reconstruction using these methods is highly arbitrary in the absence of proper bony landmarks and, therefore, left to the surgeon's subjective discretion. These methods often led to increased oedema, implant fatigue, excess tissue handling and increased intraoperative time.[7] Advancements in diagnostic imaging, VSP, 3D printing, and material science have facilitated the development and utilisation of PSIs, which have emerged as an efficacious treatment modality owing to their ability to overcome the drawbacks of traditional methods.[8] PSIs are designed based on mirroring the healthy side, allowing for precise and objective restoration of anatomy providing superior functional and aesthetic outcomes.

Various materials have been employed for orbital reconstruction, including autologous bone and alloplastic materials such as polytetrafluoroethylene, glass bioceramic implants and porous polyethylene implants. The choice of material is multifactorial based on resource availability, fracture geometry and surgeon's preference. A titanium alloy was chosen in this case, owing to its biocompatibility, corrosion resistance and high fatigue limit.

PSIs have been employed in a variety of intricate scenarios, including orbital fractures with enophthalmos, secondary orbital deformities or postenucleation socket syndrome.[9] Fan *et al*., in 2017, conducted a comparative study between traditional methods and 3D technique-assisted surgical reconstruction with 56 patients and observed that 3D printing models allowed for a 'true-to-original' orbital reconstruction with shorter surgical time than traditional methods.[8]

A volumetric analysis of patients experiencing late enophthalmos without surgical intervention revealed that orbital fat loss further aggravated enophthalmos.[6] Consequently, achieving additional volume restoration, extending beyond mere bony reduction, becomes imperative.[10] In regard to this case, it was observed while sufficient supero-inferior correction was obtained, a mild antero-posterior deficit remains appreciable, which can be attributed to a lack of over-correction to compensate for fat atrophy. This serves as a significant learning for future cases. This case report serves as a testament to the benefits of VSP and 3DP in the medical field and adds to the literature in favour of PSIs, encouraging further research for these treatment modalities allowing for a cost-effective and efficient solution in future.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Liokatis P, Malenova Y, Fegg FN, Haidari S, Probst M, Boskov M, *et al.* Digital planning and individual implants for secondary reconstruction of midfacial deformities: A pilot study. Laryngoscope Investig Otolaryngol 2022;7:369-79.
2. Jimson S. Residual deformities of the maxillofacial Region. In: Oral and Maxillofacial Surgery for the Clinician. Bonanthaya K, Panneerselvam E, Manuel S, Kumar VV, Rai A (eds). Springer: Singapore; 2021. [Doi: 10.1007/978-981-15-1346-6_61].
3. Ranganath K, Hemanth Kumar HR. The correction of post-traumatic pan facial residual deformity. J Maxillofac Oral Surg 2011;10:20-4.
4. Jansen J, Schreurs R, Dubois L, Maal TJ, Gooris PJ, Becking AG. Orbital volume analysis: Validation of a semi-automatic software segmentation method. Int J Comput Assist Radiol Surg 2016;11:11-8.
5. Ordon AJ, Kozakiewicz M, Wilczynski M, Loba P. The influence of concomitant medial wall fracture on the results of orbital floor reconstruction. J Craniomaxillofac Surg 2018;46:573-7.
6. Smeets M, Snel R, Sun Y, Dormaar T, Politis C. Late reconstruction of extensive orbital floor fracture with a patient-specific implant in a bombing victim. J Korean Assoc Oral Maxillofac Surg 2020;46:353-7.
7. Pang SS, Fang C, Chan JY. Application of three-dimensional printing technology in orbital floor fracture reconstruction. Trauma Case Rep 2018;17:23-8.
8. Fan B, Chen H, Sun YJ, Wang BF, Che L, Liu SY, *et al.* Clinical effects of 3-D printing-assisted personalized reconstructive surgery for blowout orbital fractures. Graefes Arch Clin Exp Ophthalmol 2017;255:2051-7.
9. Chepurnyi Y, Zhukovtseva O, Kopchak A, Kanura O. Clinical application of automated virtual orbital reconstruction for orbital fracture management with patient-specific implants: A prospective comparative study. J Craniomaxillofac Surg 2022;50:686-91.
10. Habib LA, Yoon MK. Patient specific implants in orbital reconstruction: A pilot study. Am J Ophthalmol Case Rep 2021;24:101222.