Trauma Case Reports 17 (2018) 23–28

Contents lists available at ScienceDirect

Trauma Case Reports

journal homepage: www.elsevier.com/locate/tcr

Case Report

Application of three-dimensional printing technology in orbital floor fracture reconstruction

Sherby Suet Ying Pang[a,*], Christian Fang[b], Jimmy Yu Wai Chan[a]

[a] Division of Plastic and Reconstructive Surgery, Department of Surgery, Queen Mary Hospital, The University of Hong Kong, Hong Kong
[b] Department of Orthopedics and Traumatology, Queen Mary Hospital, The University of Hong Kong, Hong Kong

ARTICLE INFO

Keywords:
Three-dimensional printing
Rapid prototyping
Orbital floor reconstruction
Blowout fracture

ABSTRACT

Importance: Orbital floor fracture is common among patients suffering from facial trauma. Open reduction and reconstruction of the orbital floor with Medpor is the treatment of choice in our centre to correct diplopia and enophthalmos.
Objective: Application of locally available 3D printing service in perioperative planning of orbital floor reconstruction with porous polyethylene.
Design: We present two patients who suffered from orbital floor fracture complicated by diplopia. Open reduction and orbital floor reconstruction with Medpor was performed with the guidance of a 3D printed customized model of the orbital floor defect.
Participants: Both patients were admitted through the Emergency Department to surgical ward after facial trauma. CT scan of the face showed orbital floor fracture with entrapment of inferior rectus muscle. Clinically patients also suffered from diplopia on extreme gaze.
Results: With the aid of 3D printed model, it shortened operative time and duration of anaesthesia. Defect-specific Medpor could be trimmed and molded easily from the model and thus reduced fatigue of the material. Furthermore, the model was helpful in patient education and explanation of the surgical procedure.
Conclusions and relevance: Application of 3D printing in medical specialties is rapidly developing in the past few years. In orbital floor fracture reconstruction, 3D printed model provides a customized solution, decreases operative time and duration of anaesthesia.

Introduction

Three-dimensional printing (3DP) technology, also termed rapid prototyping, has been widely applied in a variety of medical specialties especially in craniofacial, plastic and reconstructive and orthopaedic surgery. The number of publications focusing on medical applications of 3DP has increased exponentially over the past few years [1]. Compared to the technology in the 1980s when 3DP was first developed, nowadays it is considerably cheaper, easily accessible and less time-consuming. A great variety of printing materials allows for mechanical properties and appearance accustomed to specific applications. More importantly, accessibility of robust 3D modelling software and powerful computer processors enables 3D models to be created at ease with typical desktop workstations.

Orbital floor involvement is common in orbital blowout fracture (around 50%) [2,3]. Diplopia and enophthalmos are the

* Corresponding author at: T3, Office of Division of Plastic and Reconstructive Surgery, Department of Surgery, Queen Mary Hospital, 102 Pokfulam Road, Pokfulam, Hong Kong
E-mail address: sherbypang@hotmail.com (S.S.Y. Pang).

https://doi.org/10.1016/j.tcr.2018.09.006
Accepted 18 September 2018
Available online 24 September 2018

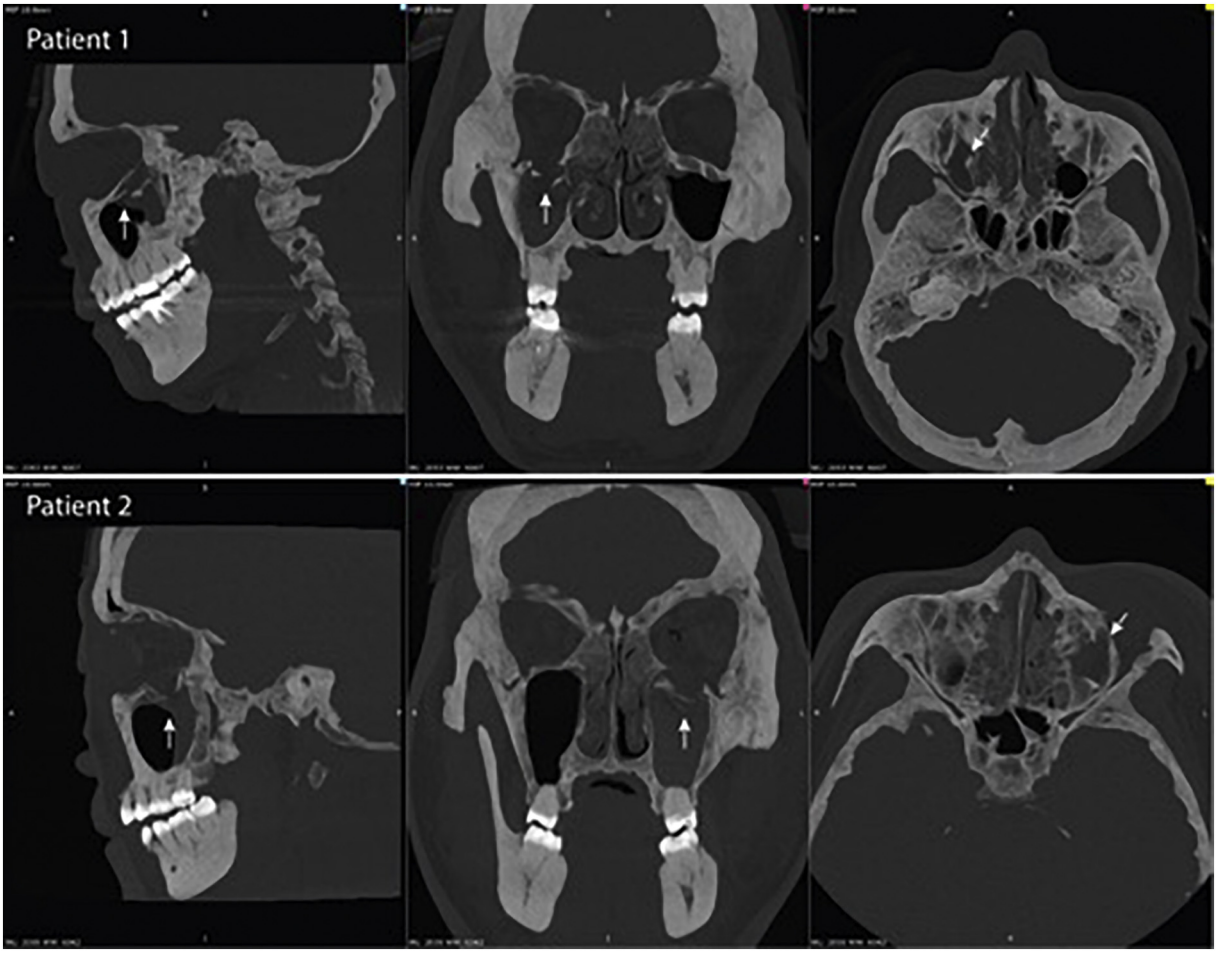

Fig. 1. CT scan with 10 mm maximum intensity projection (MIP) views in three planes showing (Patient 1) right sided fractured orbital floor in first patient and (Patient 2) left sided fracture in second patient. Both having caudal herniation of orbital contents.

indication for surgical reconstruction of floor defect. Autologous calvarial bone grafts, porous polyethylene, and polydioxanone are most widely used for orbital floor reconstructions [4]. In our centre, porous polyethylene sheets (MEDPOR®, Stryker, MI, USA) is the treatment of choice for orbital floor reconstructions via a transconjunctival approach after reduction of orbital contents. In this technique, it is imperative that the implant is precisely shaped to securely seal off the orbital floor defect.

3DP provides customized patient-specific solutions to surgical challenges. In this article, we describe two patients with orbital floor fracture managed by porous polyethylene reconstruction precisely shaped with the aid of 3DP bone models.

Patients and methods

Two patients suffering acute blunt facial trauma were included. The first patient was a 37 years old male who received a direct blow to the face by a glass bottle during an assault. He presented with diplopia and restricted extraocular muscle movements. Computer tomography (CT) scan revealed right orbital floor fracture with herniation of inferior rectus muscle (Fig. 1-Patient 1). The second patient was a 50 years old female presented with diplopia on upward gaze after falling on her face at level ground. CT scan showed isolated left orbital floor fracture with muscle herniation (Fig. 1-Patient 2). Both patients have consent to publishing their results in this article.

Digital imaging and communications in medicine (DICOM) data of the CT scans were obtained in 0.5 mm layer thickness and region of interest (ROI) resolution of 512 × 512 corresponding to a voxel size of 0.331 × 0.331 × 0.5 mm. The skull bone was segmented from DICOM volumetric data using 3DSlicer software [5] (Version 4.62, http://www.slicer.org) by Hounsfield unit thresholding. A 3D skull model was created in standard triangle language (STL) format (Fig. 3-A) and refined with 3D modelling software Meshmixer (Version 3.2, Autodesk, CA, USA) by following techniques previously described for other medical applications [6]. The relevant area including the orbital floor defect and the contralateral intact orbital floor was cropped from the skull (Figs. 2-A, 3-B). Afterwards, mesh reduction (decimation), smoothing and defect filling techniques were applied to the 3D models to reduce its triangular complexity (Figs. 2-B, 3-C). These mesh optimization steps were aimed at reducing the computational burden and time