# Innovative Solutions in Orbital Fracture Management: The Role of Computer-aided Design and Computer-aided Manufacturing Technology


## Abstract

Being the intricate architecture of the maxillofacial region, rehabilitation of maxillofacial abnormalities is relatively hard for most maxillofacial surgeons. Orbital roof fractures are among the most uncommon craniofacial abnormalities. The fact that these fractures "grow" makes treatment challenging. An encephalocele can form as a result of a hemorrhage or swelling caused by a dural rupture. These "growing" fractures are prevalent in children. The etiology of these fractures is uncertain; however, a dural laceration usually occurs along the fracture line. After a latency period, clinical signs and symptoms of an expanding fracture of the orbital roof are observed. During this latent time, the fracture expands in size during the growth stage, causing the brain to herniate and cause ocular symptoms such as eyelid swelling or exophthalmos. Computed tomography scans are commonly used to diagnose this type of fracture, and computer-aided design and computer-aided manufacturing (CAD/CAM) can be used to render the three-dimensional model for treatment planning. Growing orbital roof fractures must be investigated as a differential diagnosis in patients with chronic ocular complaints. The case study that follows sheds light on the relevance of the use of CAD/CAM technology for such patients in treatment planning.


**Keywords:** *Computer-aided design and computer-aided manufacturing, exopthalmos, growing fractures, growing orbital fractures, latent period*

**Abhishek Kumar Gupta[1], Rekha Gupta[2], Aishwarya Saini[2], Vashi Narula[3], Rohit Kumar Singh[1]**

*[1]Department of Prosthodontics, ESIC Dental College, Rohini, New Delhi, India, [2]Department of Prosthodontics, Maulana Azad Institute of Dental Sciences, Delhi, India, [3]Department of Pedodontics, Maulana Azad Institute of Dental Sciences, Delhi, India*

**Submitted :** 18-Jun-2024
**Revised :** 26-Jul-2024
**Accepted :** 05-Aug-2024
**Published :** 25-Mar-2025

***Address for correspondence:***
*Dr. Abhishek Kumar Gupta, Department of Prosthodontics, ESIC Dental College, Rohini, New Delhi - 110 089, India.*
*E-mail: drabhishek.gupta1994@gmail.com*

**Access this article online**
**Website:** https://journals.lww.com/cocd
**DOI:** 10.4103/ccd.ccd_262_24
**Quick Response Code:**

## Introduction

Growing skull fractures are uncommon after the age of 8 years, mainly occurring within the first 3 years of life. Only 0.05%–0.1% of juvenile skull fractures have been observed.[1,2] Children with orbital fractures face a variety of traumas and treatment difficulties.[3,4] Before a linear fracture widens, there might be a varied latent period ranging from 4 months to 12 years in developing fractures. According to Taveras,[5] the arachnoidal membrane initially projects through the dural rip and into the fracture site, and subsequently, the pulsations of CSF fluid contribute to the process of craniocerebral erosion.[5] Orbit fractures have been linked to neurologic, ocular, and craniofacial problems that can need medical attention. Because of this, a wide range of experts are often involved in treating pediatric facial injuries, and each professional may have personal prejudices regarding the most effective course of treatment. Closing the bone defect and repairing the dural tear are the objectives of treating a developing fracture. Complete visualization of the dural margins requires significant bone resection surrounding the lesion because the dural edges are sometimes retracted for a considerable distance beneath the bone. Consequently, elevating a sizable bone flap over the cranial defect is more practical. By simply flipping a dural flap, this will provide a full view of related cerebral lesions in addition to extensive exposure of the dural borders. CAD/CAM is used as an aid to render the three dimensional (3D) models to locate and delineate the orbital defect more precisely. With this 3D model, a more accurate and precise bone graft can be prepared.

## Case Report

The Department of Prosthodontics sent a 4-year-old patient for the construction of a prosthetic graft to cover an orbital deformity. After taking a detailed history, it was revealed that the patient had a minor road traffic accident almost a year back. Although the patient did not suffer from any apparent injuries and was conscious and coherent afterward, so patient's parents



**How to cite this article:** Gupta AK, Gupta R, Saini A, Narula V, Singh RK. Innovative solutions in orbital fracture management: The role of computer-aided design and computer-aided manufacturing technology. Contemp Clin Dent 2025;16:49-52.

did not seek medical help. The patient gave a history of falls from stairs a few months back, and since then, she has been experiencing pain and progressive bulging of the right eye.

On clinical examination, proptosis of the right eyeball and periorbital region tenderness on palpation were observed [Figure 1a]. On evaluating the CT scan, two defects one on the superomedial roof of the right orbit and one in the anterior cranial fossa lateral to the cribriform plate were noted on the CT scan [Figure 2a and b]. Duramater being osteogenic, bony margins grow along the fracture line, resulting in elevated margins of the orbital defect. Magnetic resonance imaging (MRI) scan reveals a dural tear along the fracture line through which the brain has herniated [Figure 2c]. Therefore, surgical dural repair and polymethyl methacrylate (PMMA) graft placement were planned as the treatment approach for the repair of the orbital defect.

## Fabrication of polymethyl methacrylate implant

For the defect on the right orbit, the Department of Prosthodontics determined to manually build a heat-polymerized PMMA-based orbital implant (using a rapid prototyping 3-D skull analog). Prosthodontists assisted the pediatric neurosurgery department doctors in planning the orbital implant's placement.


**Figure 1: Rehabilitation view (a) Pretreatment view. (b) Posttreatment view**

Computational tomography data were used to generate a virtual model of the skull. With the use of computer-aided design (CAD) software (Autodesk Mesh mixer), the STL images from CT scans (0.5 mm) were imported into CAD software to create a virtual model of the skull segment that contained the orbital cavity and the defect. This software allowed for the T3D display of the fault. These STL file images were then forwarded to the 3D printer. The RPT fused deposition modeling approach was applied. In this method, a 3D printer was equipped with polylactic acid resin. Using 3D printing, the prototype 3D skull was created [Figure 3a]. PMMA acrylic plate of 5 mm thickness was fabricated over this model with extended 5 mm margins to compensate for the growing orbital floor [Figure 3b].

The prosthesis was then soaked in distilled water at 37°C for 24 h to remove any remaining monomer, followed by sterilization with 2% glutaraldehyde for 48 h.

## Surgical insertion of polymethyl methacrylate implant

The PMMA implant was inserted under general anesthesia during the surgical process.

The coronal scalp incision was made on the right side to raise the bi-coronal flap and expose the defect in the floor of the anterior cranial fossa, communicating with a defect on the superomedial aspect of the roof of the orbit [Figure 4a]. Subsequently, the herniated gliotic brain was excised, dural repair was performed, and the fit of the PMMA implant was checked, which accurately fitted into the defect and was found to be stable [Figure 4b]. The prosthesis was placed in the defect of the anterior cranial fossa and the defect of the roof of orbit was left as such. This was done so that there is provision for revision surgery later after growth is completed. The prosthesis was placed in the defect without screws or plating so as to allow for uninterrupted growth of the bones. The underlying tissues were closed in layers with vicryl suture, and then, the skin was sutured. A drain was placed to reduce postoperative hematoma and removed after 4 days. The patient was provided postoperative care of the surgical site, and weekly follow-up sessions were planned for 4 weeks to check for postoperative problems. Two weeks postoperatively significant reduction in proptosis and pain was observed [Figure 1b]. Patient was

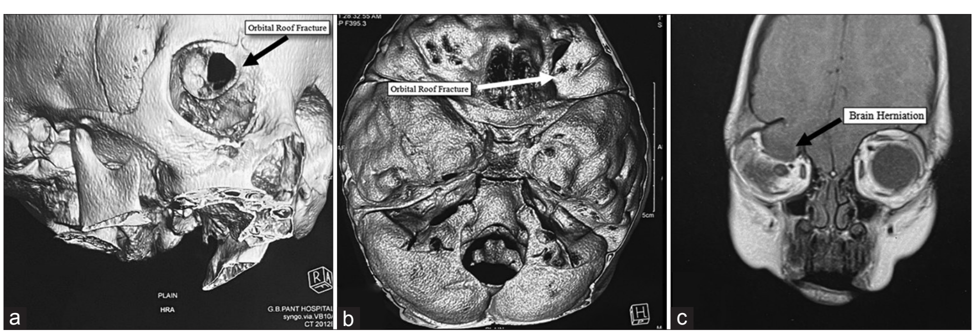


**Figure 2: (a) Fracture in the roof of the orbital cavity. (b) Fracture in the floor of cranial fossa. (c) Magnetic resonance imaging revealing brain herniation and dural tear**

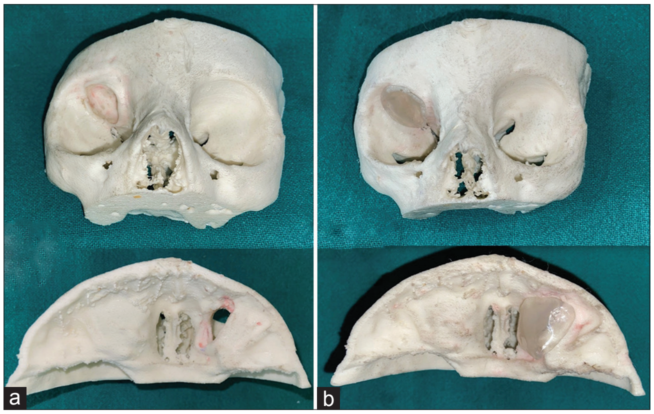

Figure 3: (a) 3D printed skull. (b) Polymethyl methacrylate prosthesis

advised for regular follow-up every 6 months for the first 3 years, then once in every year. It was observed that there was no complication during any postoperative follow-up.

## Discussion

Most cases of a developing skull fracture occur in newborns and young children. Although the precise etiology is uncertain, a dural laceration along the fracture line is present in every case.[6,7] Taveras and Ransohoff[5] and Prasad *et al*.[8] state that cerebral pulsations typically erode the fracture edge, resulting in encephalocele. Local atrophy and encephalomalacia indicate gradual injury to the herniating and underlying brain. The literature states that there is always contused brain tissue beneath the defect site's dura. There are soft, nonresisting tissues in the orbit. Therefore, via the injured brain region, elevated intracranial pressure and brain pulsation may aid in relieving the growing orbital roof skull fracture. A developing skull fracture can be easily diagnosed by collecting consecutive X-rays that show the fracture line spreading over time. The MRI and computed tomography scans show the type and size of the fracture line. In addition, a 3D CT scan can reveal any bone abnormalities throughout the length of a fracture. Therefore, this diagnostic imaging is helpful in treatment planning and surgical approaches for treating growing orbital fracture. Children who have had an orbital fracture should be checked again in 2–3 months to see if there is any indication of the fracture. Because ocular fractures may not be seen on ordinary X-ray graphs, a follow-up radiological evaluation with CT or 3D CT is recommended.

Improved preoperative planning, patient education, surgical process simulation, implant and equipment customization, decreased surgical time and problems, and useful research and training are just a few advantages that come with using 3D models. More accurate surgical techniques can result from surgeons' ability to see intricate neuroanatomy in three dimensions. By gaining a greater understanding of their disease and the suggested procedure, patients may make well-informed decisions. In addition, patient-specific implants and tools may be made thanks to 3D printing technology, which improves fit and lowers the risk of problems.

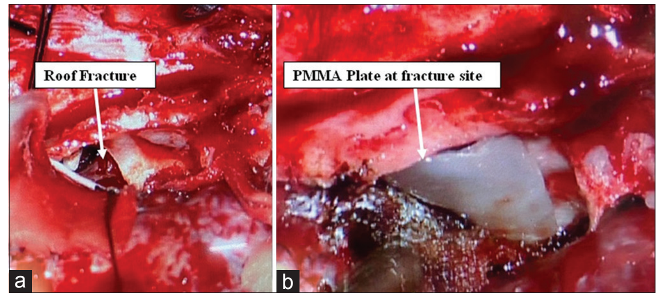


Figure 4: (a) Fracture site *in situ*. (b) Polymethyl methacrylate plate placed *in situ*

Comprehending the evolving patterns of pediatric orbit fractures requires a comprehension of the changing facial skeletal architecture and physiology, including the growth of the cranium, face, and paranasal sinuses. Infants and newborns have enormous craniums on their faces. Several implant materials, including silicon sheets, bioresorbable polycaprolactone, titanium mesh, high-density porous polyethylene, and sterilized X-ray plate, are employed to rebuild the defect.[9,10] Many publications have been written about orbital fracture repair using a wide range of materials that can be autogenic, allogenic, or alloplastic. Given the rarity of direct comparisons between the materials used, it would be challenging to obtain a formal determination of which material is most appropriate to repair these damages. Materials are selected by surgeons based on what they think will produce the greatest outcomes with the fewest complications.[11-14] Autologous bone material excision is a highly invasive treatment that causes severe morbidity to the donor site. Consequently, at this point, the invasive processes of obtaining distant autologous bone material have essentially been replaced with alloplastic materials. PMMA is favored due to its inexpensive cost, simple handling and processing requirements, and easy availability. The disadvantage of PMMA is that its residual monomer release, which may cause postoperative infection.[12,15,16]

## Conclusion

A pediatric child's silent latent period following a forehead injury should raise the possibility of an orbital roof-growing fracture. The MRI and CT scan are essential for determining the nature of the orbital bone defect that causes encephalocele and brain herniation. For the treatment of such cases, a multidisciplinary approach and appropriate treatment planning are necessary.

### Acknowledgement

I would like to thank my senior guides, Dr. Rekha Gupta and Dr. Shubhra Gill, for constantly guiding me in completing this challenging clinical case. I would like to thank my colleagues Dr. Divyajoti, Dr. Kriti, and Dr. Nikita for helping in each step of the clinical and laboratory procedure till the completion of the case. I would like to thank my parent and friends for their constant support.

### 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. DesChamps GT Jr., Blumenthal BI. Radiologic seminar CCXLIX: Growing skull fractures of childhood. J Miss State Med Assoc 1988;29:16-7.
2. Ramamurthi B, Kalyanaraman S. Rationale for surgery in growing fractures of the skull. J Neurosurg 1970;32:427-30.
3. Alcalá-Galiano A, Arribas-García IJ, Martín-Pérez MA, Romance A, Montalvo-Moreno JJ, Juncos JM. Pediatric facial fractures: Children are not just small adults. Radiographics 2008;28:441-61.
4. Koltai PJ, Rabkin D. Management of facial trauma in children. Pediatr Clin North Am 1996;43:1253-75.
5. Taveras JM, Ransohoff J. Leptomeningeal cysts of the brain following trauma with erosion of the skull; a study of seven cases treated by surgery. J Neurosurg 1953;10:233-41.
6. Gupta SK, Reddy NM, Khosla VK, Mathuriya SN, Shama BS, Pathak A, *et al*. Growing skull fractures: A clinical study of 41 patients. Acta Neurochir (Wien) 1997;139:928-32.
7. Muhonen MG, Piper JG, Menezes AH. Pathogenesis and treatment of growing skull fractures. Surg Neurol 1995;43:367-72.
8. Prasad GL, Gupta DK, Mahapatra AK, Borkar SA, Sharma BS. Surgical results of growing skull fractures in children: A single centre study of 43 cases. Childs Nerv Syst 2015;31:269-77.
9. Barh A, Swaminathan M, Mukherjee B. Orbital fractures in children: Clinical features and management outcomes. J AAPOS 2018;22:415.e1-7.
10. O'Connor RC, Abazi S, Soleman J, Thieringer FM. Reconstruction of a combined frontal bone and orbital roof defect with associated meningoencephalocele using 3D modeling and 3D navigation. Craniomaxillofac Trauma Reconstr Open 2021;6:24727512211023340.
11. Mok D, Lessard L, Cordoba C, Harris PG, Nikolis A. A review of materials currently used in orbital floor reconstruction. Can J Plast Surg 2004;12:134-40.
12. Bridle C, Macdonald T, Ellamushi H, Holmes S. Orbital roof fractures: Raising the bar. Br J Oral Maxillofac Surg 2008;46:e29-30.
13. Murray-Douglass A, Snoswell C, Winter C, Harris R. Three-dimensional (3D) printing for post-traumatic orbital reconstruction, a systematic review and meta-analysis. Br J Oral Maxillofac Surg 2022;60:1176-83.
14. Shihadeh H, Willson TD. Multidisciplinary treatment of a pediatric orbital roof fracture: Case report and literature review. Plast Reconstr Surg Glob Open 2021;9:e3347.
15. Sandhu PS, Bucur S, Good C, Cutler M, Rajak S. The management of orbital roof fractures and defects: A review. Ophthalmic Plast Reconstr Surg 2022;38:8-16.
16. Lucas JP, Allen M, Nguyen BK, Svider PF, Folbe AJ, Carron M. Orbital roof fractures: An evidence-based approach. Facial Plast Surg Aesthet Med 2020;22:471-80.