Outcomes of 3-Dimensional Printed Custom Porous Polyethylene Orbital Implant for Reconstruction in a Tertiary Referral Center

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ABSTRACT

Purpose: To assess surgical outcomes of custom orbital implants in diverse orbital reconstruction settings.

Methods: A retrospective chart review of 8 consecutive patients receiving custom orbital implant placement between 2020-2023. Patient data included demographics, preoperative CT findings, pre- and post-operative clinical features, and surgical complications.

Results: The mean age of patients was 47.3 years (range 23-73), with 50% female. Indications for surgery were diplopia, enophthalmos, hypoglobus, orbital or facial deformities after significant trauma or tumor removal. The mean follow-up time was 13.7 months (range 1-20). Trauma accounted for 62.5% of cases, with silent sinus syndrome and facial deformity after tumor resection comprising the remainder. The median time from trauma to surgery was 13.2 months (range 6.1-18.3). Orbital fractures most involved the floor (62.5%), followed by medial (12.5%), and lateral wall (12.5%). Preoperative enophthalmos, hypoglobus, and diplopia occurred in 87.5%, 62.5%, and 50% of patients, respectively. The mean surgery duration was 183.4 minutes (range 61-245), with 60% of trauma cases needing prior hardware removal. Postoperative improvements were observed in enophthalmos (87.5% to 12.5%), hypoglobus (62.5% to 12.5%), and diplopia (50% to 12.5%), with average exophthalmometry asymmetry reduction from 3.1mm to 0.5mm. Outcomes were consistent among the 4 surgeons involved.

Conclusion: Custom orbital implants demonstrated effectiveness and safety in diverse orbital reconstruction cases, yielding significant improvements in enophthalmos, hypoglobus, and diplopia. This study supports custom orbital implant use for various clinical indications.

BACKGROUND

Orbital reconstruction, often performed in cases of significant orbital fractures or remaining bone abnormalities after tumor removals, can be challenging due to the complex three-dimensional (3D) nature of the bone structures. Traditional methods, such as intraoperative measurements and manual shaping of implants, may still face difficulties in accurately contouring complex 3D orbital defects, leading to persistent functional and aesthetic issues. The advent of 3D modeling and tailored cast-molded implants has introduced an innovative approach for addressing these challenges, offering the potential for improved functional and aesthetic outcomes in reconstructing intricate orbital defects with customized porous polyethylene implants.

METHODS

For each patient, high-resolution computed tomography scans were utilized to generate 3D models of their existing bone structure (Fig. 1). The contralateral orbit's 3D shape on the was digitally mirrored to the side presenting the bone deficiency (Fig. 2). Subsequently, the skull was 3D printed, and a custom porous polyethylene implant (Stryker, Kalamazoo, MI) was fabricated via cast-molding to achieve the intended normal orbital contour, with the implant designed to fill the defect in comparison to the contralateral side (Fig. 3).

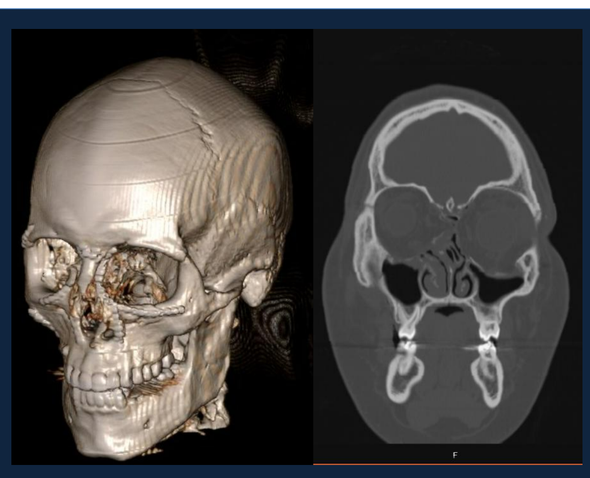


Figure 1: 3D reconstruction of orbit from high resolution CT scan

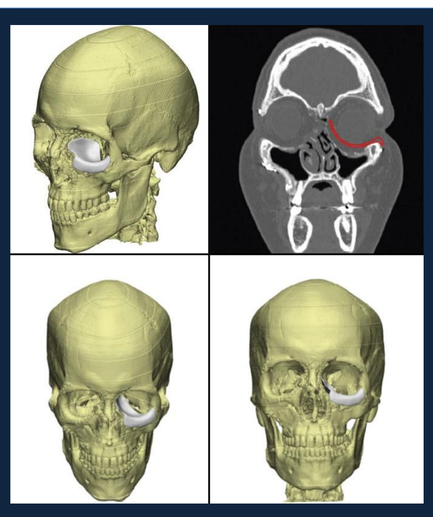


Figure 2: Creation of implant model by mirror image

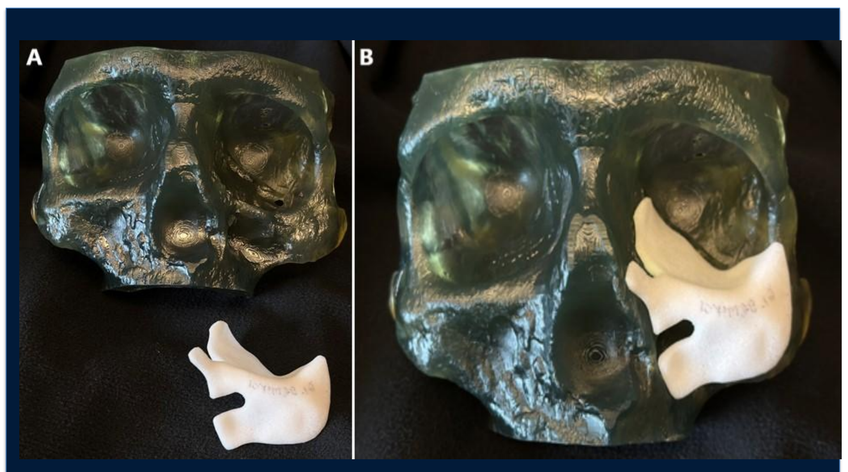


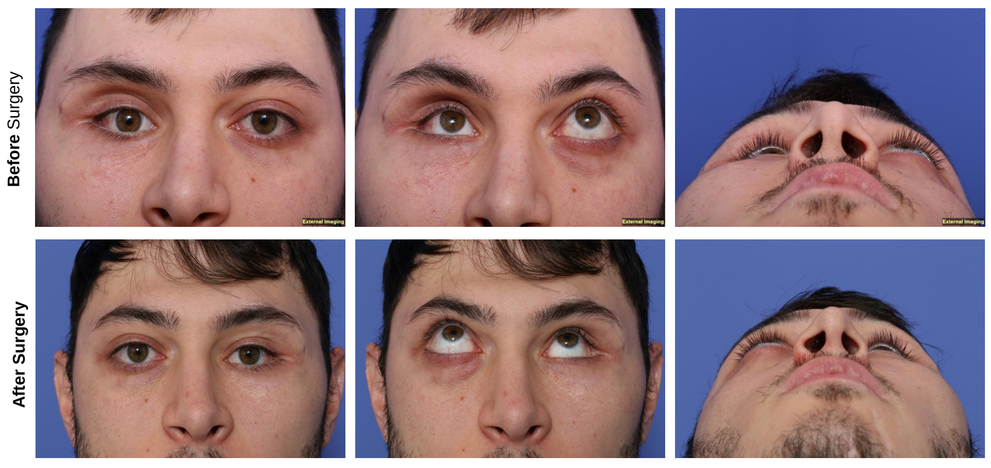
Figure 3: Custom orbital implant before and after being placed into the 3D printed skull

During surgery, previous implants were removed, and the new custom implant was accurately positioned to fully reduce the fracture and reconstruct the preexisting bone deficiency. Implants were secured using titanium screw fixation, and the surrounding operative area was assessed to confirm the complete reduction of orbital soft tissue around the implant.

RESULTS

Patient	Age	Sex	Indication for Surgery	Orbital Defect	Pre-operative Evaluation			Post-operative Evaluation		
					Enophthalmos	Hypoglobus	Diplopia	Enophthalmos	Hypoglobus	Diplopia
1	50	F	Persisent diplopia on up gaze, after fall	floor and medial orbital walls	+	+	+	-	+	+
2	62	M	Facial deformity after left lacrimal adenocarcinoma ex pleomorphic resection	Absence of lateral orbital wall	+	+	-	-	-	-
3	48	M	Silent sinus syndrome	Depressed orbital floor	+	+	+	-	-	-
4	27	M	Enophthalmos, lateral canthal dystopia, diplopia, after MVA	Floor and medial orbital walls	+	-	+	-	-	-
5	50	F	Enopthtmalos, after fall	Orbital floor	+	-	-	-	-	-
6	23	M	Hypoglobus, enophthalmos after MVA	Orbital floor	+	+	-	-	-	-
7	73	M	Enophthalmos after fall	Orbital floor	+	-	+	-	-	-
8	49	F	Facial deformity after gunshot wound	Floor and lateral orbital walls	N/A	N/A	N/A	N/A	N/A	N/A

Table 1: Summary of patient demographics, surgical indications, and pre- and post-operative evaluations. The table displays information on patient age, sex, indication for surgery, orbit defect, and pre-operative and post-operative evaluations for enophthalmos, hypoglobus, and diplopia. Patient outcomes are compared before and after receiving customized porous polyethylene implants for orbital reconstruction.



Representative clinical images of patient 4 who endured enophthalmos, lateral canthal dystopia and persistent diplopia after unsuccessful orbital fracture repair (top row). 8 months after custom orbital implant placement, he had improved motility, resolved enophthalmos and more symmetric appearance (bottom row)

CONCLUSIONS

3-Dimentional printed custom orbital implants manufactured by mirroring technique demonstrated effectiveness and safety in diverse orbital reconstruction cases, yielding significant improvements in enophthalmos, hypoglobus, and diplopia even in presence of bilateral orbital defects. Our findings support the custom orbital implant use for various clinical indications.

Limitations of our study are the small sample size and retrospective design. However, the literature on the clinical outcomes of the use of cast-molded patient-specific customized porous polyethylene implants mirrored to the contralateral normal orbit is still limited and while our study acknowledges its own limitations, the valuable insights gained contribute significantly to the growing body of knowledge in this specialized field.