

Outcomes of Orbit Reconstructive Surgery Utilizing 3D-Printed Surgical Guides

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Introduction

Orbital fractures make up a substantial portion of facial trauma managed by otolaryngologists and oral & maxillofacial surgeons. The risk of enophthalmos, decreased visual acuity, diplopia, sensory deficits, and cosmetic defects often necessitates repair of these fractures. Surgical repair is technically difficult due to the complex anatomy of the orbit and the limited view afforded by the small transconjunctival incisions typically used in surgery, so the use of 3D-printed surgical guides (3DSG) has gained favor as a tool to aid in this difficult surgery.

Due to the reported benefits and affordability of 3DSGs, the authors incorporated their use into the management of facial trauma at Denver Health Medical Center, a high-volume Level I trauma center. In this study, we aimed to assess how 3DSGs impacted surgical outcomes in patients with unilateral orbit reconstruction. We hypothesized that the use of a 3DSG improves restoration of orbital symmetry and reduces the risk of post-operative complications.

Methods and Materials

Retrospective analysis was conducted of 118 patients who underwent orbital fracture repair at a single institution between January 1, 2018, and July 31, 2024. Inclusion criteria were patients with a unilateral orbital fracture repaired, age over 15, and a postoperative CT scan available. Patients were divided into two groups: those repaired conventionally and those repaired with the use of a 3DSG. Computer-aided design modeling software was utilized to perform volumetric analysis of postoperative CT scans and characterize the volume of repaired and uninjured orbits. Post-reconstructive orbital symmetry was calculated and compared between the groups. The frequency of poor orbital volume restoration, defined as volume difference between sides of ≥ 2 mL, $>8\%$, or both, was also compared.

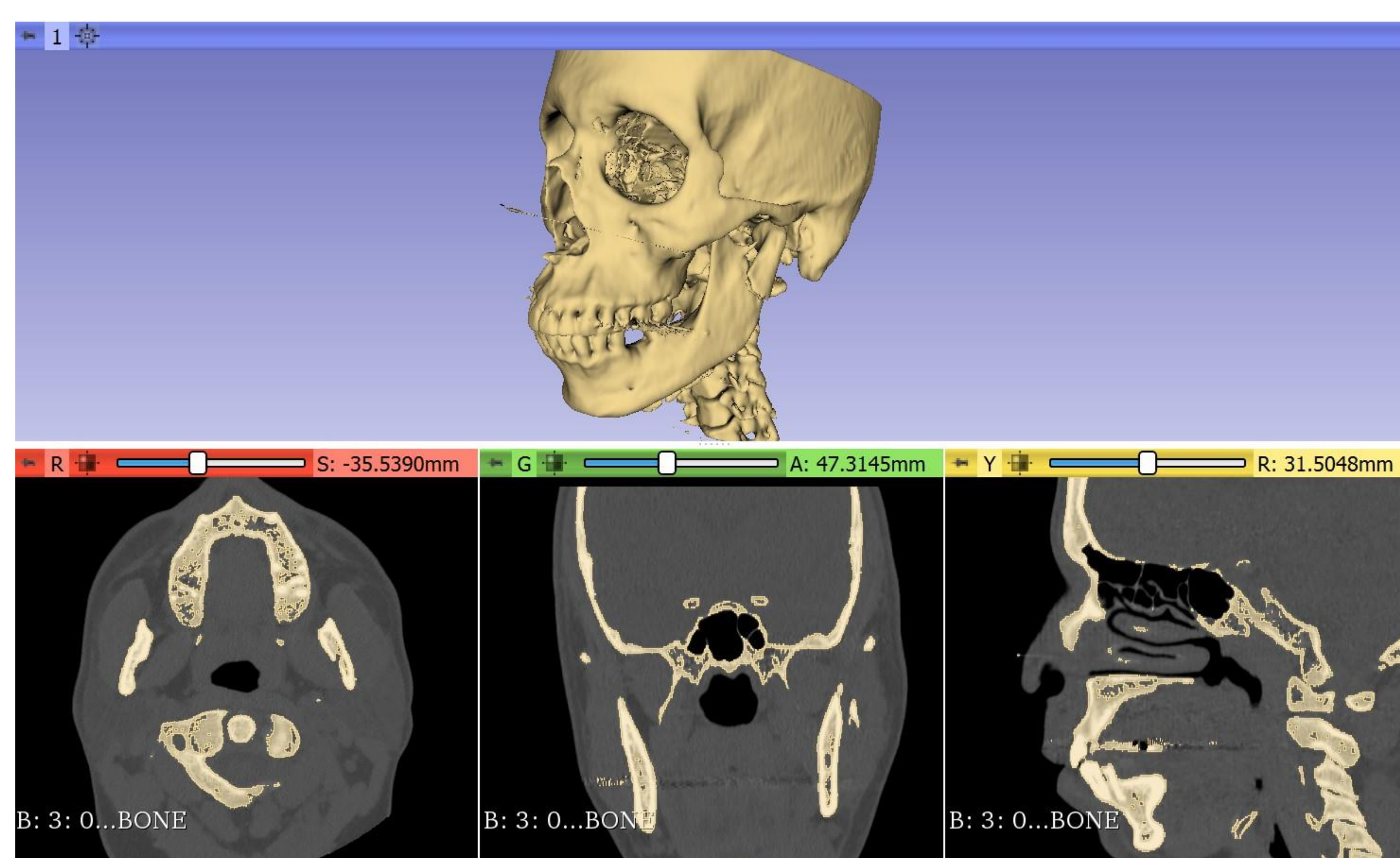


Figure 1. Bone segmentation. 3D Slicer is used to segment the patient's bony structures from their CT scan.

Results

Records from 446 patients who underwent an orbital fracture repair were examined. Of these patients, 118 had a postoperative CT available, met all other inclusion criteria, and were included in the analysis. Of the patients included, 87 had orbit reconstruction with the conventional surgical method and 31 underwent surgery with a 3DSG. The average time to repair and average operative time between the two methods were similar. Asymmetry between the repaired and unaffected orbital volume was greater in the conventional group (1.35 mL, SD \pm 0.95 mL) than the 3DSG group (0.72 mL, SD \pm 0.48 mL), $p < 0.0001$. Incidence of poor postoperative volume restoration was less common when using a 3DSG (3.23% vs 19.54%, $p = 0.039$) and NNT of 7. The frequency of postoperative infection, implant failure, or revision surgery were similar between groups.

Outcome	Surgical Guide Used (n=31)	Surgical Guide Not Used (n=87)	Odds Ratio	p-value
Average orbit volume difference (mL)	0.72	1.35	--	0.000008*
Orbit volume difference $> 8\%$	1 (3.2%)	15 (17.2%)	0.16	0.07
Orbit volume difference ≥ 2 mL	0 (0%)	14 (16.1%)	0.0	0.02*
Orbit volume difference of either $> 8\%$, ≥ 2 mL, or both	1 (3.2%)	17 (19.5%)	0.14	0.04*
Average time to repair (days)	5.9	7.8	--	0.16
Average operative time (hours)	1.61	1.59	--	0.96
Any postoperative complication	2 (6.5%)	7 (8.0%)	0.79	1.0
Postoperative infection	0 (0%)	1 (1.1%)	0	1.0
Revision Surgery	2 (6.5%)	7 (8.0%)	0.79	1.0
Implant Failure/Malposition	2 (6.5%)	6 (6.9%)	0.93	1.0

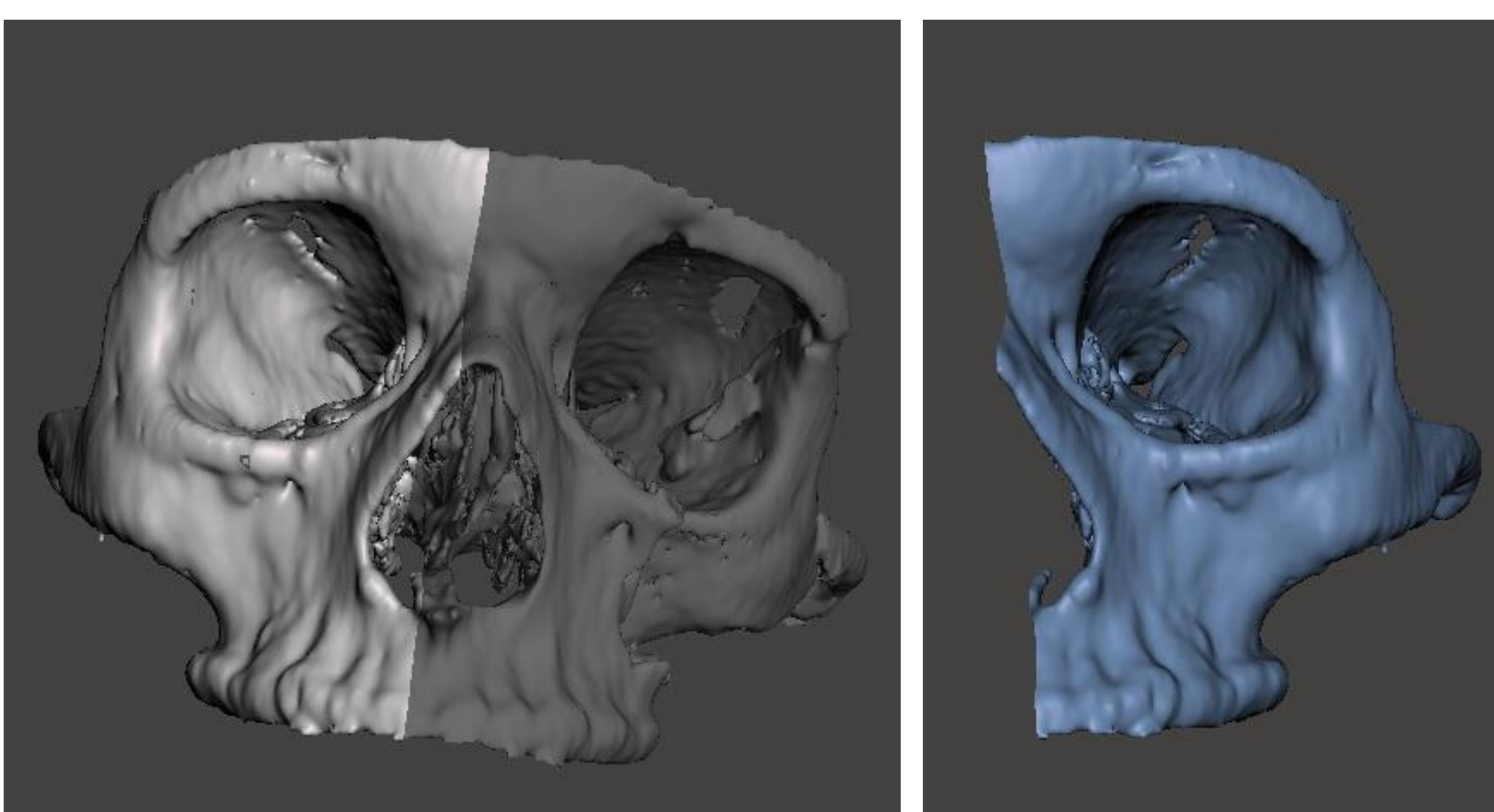


Figure 2. Segmented orbits and surrounding structures. The left (dark grey) orbit is fractured, whereas the right (light grey) orbit is unaffected.

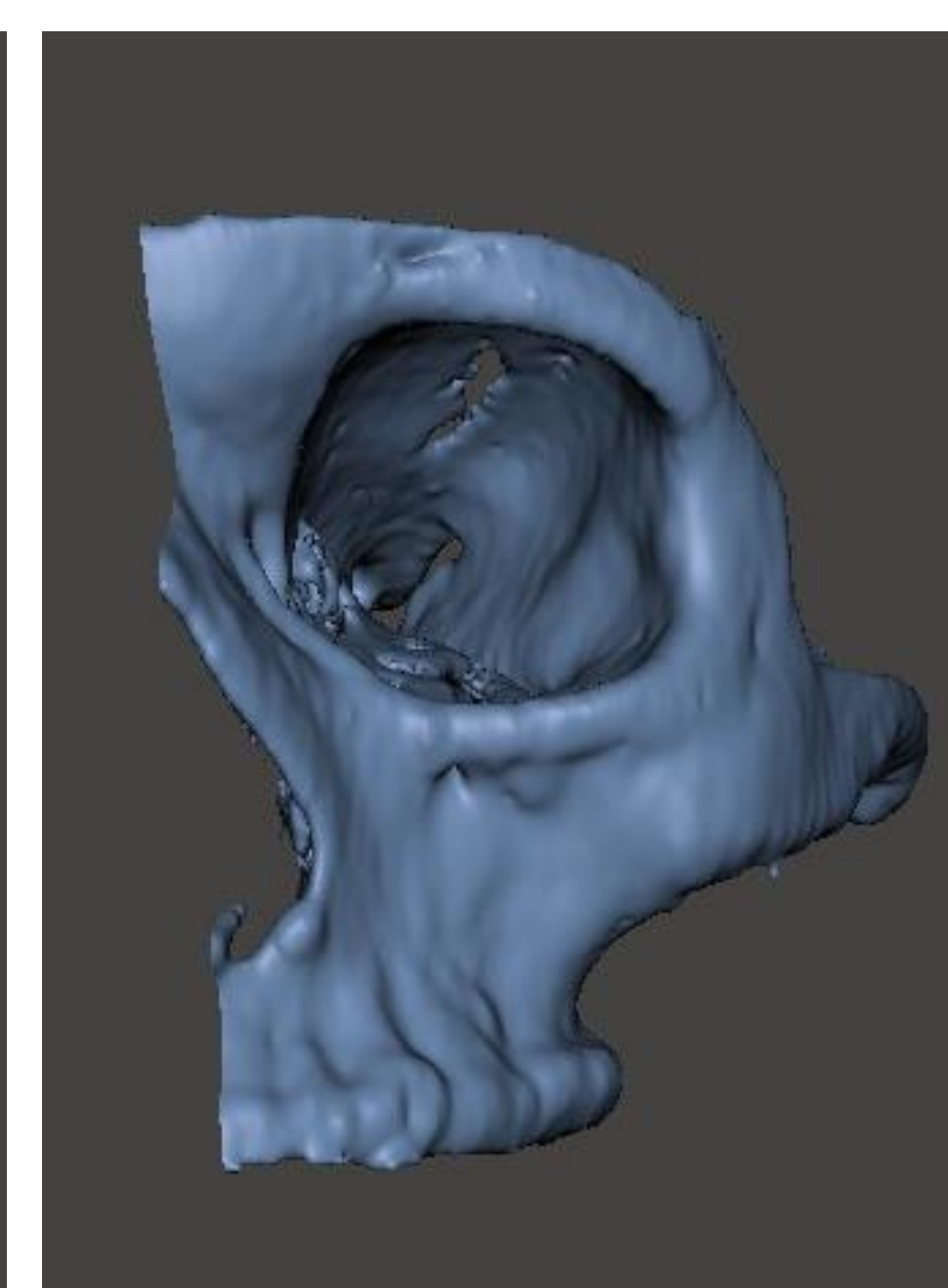


Figure 3. Mirror image of unaffected orbit.

Discussion and Conclusions

Post-traumatic orbital reconstruction is an important procedure for restoring orbital symmetry, while preventing complications such as enophthalmos, vertical dystopia, and changes in vision. Orbital reconstruction is a technically difficult surgery, often performed through small transconjunctival incisions with the use of alloplastic implants to restore the volume and contour of the orbit. To improve outcomes of facial fracture patients, our institution began a program of producing patient-specific 3DSGs for use in reconstructive surgery.

For the purposes of this study, we defined a postoperative asymmetry at risk of globe malposition as a difference in orbital volume ≥ 2 ml or as those with $>8\%$ difference between sides. In this study, the rates of any type of orbital asymmetry (≥ 2 ml, $>8\%$, or both) was significantly lower in the 3DSG group. The NNT was 7, meaning 3DSG would only need to be utilized in 7 patients to likely prevent a significant postoperative asymmetry. Though the rates of revision surgery were similar in the two groups, we suspect the 3DSG group would have fewer revisions if the study were larger.

The use of patient-specific 3D surgical guides (3DSG) during the reconstruction of unilateral orbital fractures was associated with improved postoperative orbital symmetry and likely decreased risk of postoperative complications such as globe malposition. The affordability of 3D-printed guides, along with their potential to enhance surgical technique, makes them a promising tool for future use in orbital reconstruction.



Figure 4. 3D-printed surgical guide. The mirrored orbit is printed to serve as a guide to bend the plates to in the operating room.

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