Desktop Stereolithography: An Affordable And Time-Efficient Alternative

Zachary J. Collier, BA, Laura S. Humphries, MD, Chad M. Teven, MD, Daniel Ginat, MD, Patrick Reavey, MD, Russell R. Reid, MD PhD

Disclosure/Financial Support: The authors have no relevant disclosures or external funding.

INTRODUCTION: Three-dimensional printing technology has been used in medicine for anatomical modeling, pre-operative planning, prosthetic construction, and most recently bioprinting.[1,2] The high purchase cost of 3D printers has previously limited their widespread use, causing surgeons to outsource 3D anatomic model manufacturing at an average cost of $4,000/print.[3] The development of “desktop” 3D printers has decreased printer purchasing costs from $45,000 (2001) to under $2,000 (2016),[4] providing an opportunity to bypass high-cost third-party manufacturing to create patient-customized 3D models. We provide a proof-of-concept demonstration using a desktop 3D printer and open-access software to create patient-specific computerized tomography (CT)-based 3D models to guide skeletal deformity reconstructions.

METHODS: Four patients (2 syndromic craniosynostosis, 1 cranial defect, 1 distal radius deformity secondary to arthrogryposis) were included. CT scans (≤1 mm slices) were obtained (DICOM file) for volumetric conversion to 3D models (STL file) using free open-source software (3D Slicer, http://www.slicer.org). The resulting STL files were uploaded to the MakerBot desktop application for printing with the MakerBot Replicator 2 ($2,750, MakerBot Industries, Brooklyn, NY). Material cost and printing time were recorded for comparison to alternative manufacturing methods. The 3D models were used to guide pre-operative planning and intra-operative reconstruction.

RESULTS: CT-to-3D models were successfully printed for all patients. Two distinct 3D models were created for the cranioplasty case (volumetric skeletal reconstruction and topographic representation of the defect). The printing material (polylactic acid) averaged $15/model and its unique properties allowed for inexpensive gas sterilization for intraoperative use. CT-to-3D model conversion time averaged 24-hours/case. All patients underwent successful reconstruction without complications.

CASE EXAMPLE: A 23-month old female with a history of ruptured middle cerebral artery aneurysm requiring craniotomy, hematoma evacuation, and ventriculoperitoneal shunt placement with resulting 40 cm^2 parietal cranial defect successfully underwent parietal exchange hybrid cranioplasty[5] with particulate bone graft and demineralized bone matrix. 3D models of her neurocranium with the cranial defect and a topographic representation of the defect were created to guide reconstruction.

CONCLUSION: An affordable, user-friendly 3D printer provides a practical, cost-effective, and time-efficient alternative to traditional outsourcing of 3D anatomic model manufacturing. This technology affords reconstructive surgeons the ability to construct realistic, economical 3D models for enhanced pre-operative planning and intra-operative guidance for complex defect reconstruction.

REFERENCES:

1. Watson RA. A low-cost surgical application of additive fabrication. J Surg Educ 2014;71(1):14–7.

2. Rankin TM, Giovinco NA, Cucher DJ, Watts G, Hurwitz B, Armstrong DG. Three-dimensional printing surgical instruments: are we there yet? J Surg Res 2014;189(2):193–7.

3. Ventola CL. Medical Applications for 3D Printing: Current and Projected Uses. Pharm Ther 2014;39(10):704–11.

4. Mota C. The Rise of Personal Fabrication [Internet]. In: Proceedings of the 8th ACM Conference on Creativity and Cognition. New York, NY, USA: ACM; 2011 [cited 2015 Nov 4]. p. 279–288.Available from: http://doi.acm.org/10.1145/2069618.2069665

5. Beederman M, Alkureishi LWT, Lam S, Warnke P, Reid RR. Exchange Hybrid Cranioplasty Using Particulate Bone Graft and Demineralized Bone Matrix: The Best of Both Worlds. J Craniofac Surg 2014;25(2):451–4.