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Abstract

Development of Transparent and Flexible 3D-Printed Patient-Specific Intracranial Aneurysm Models for Device Testing

H. Prakasam Prabhakaran[1*], F. H. Ghauri[1], R. Bedi[2], J.-B. Hövener[1], O. Jansen[3], N. Larsen, and M. S. Pravdivtseva

[1] *Section Biomedical Imaging, Department of Radiology and Neuroradiology, University Hospital Schleswig-Holstein (UKSH), Kiel University, Germany*
[2] *Institute for Materials Science, Faculty of Engineering, Kiel University, Germany*
[3] *Department of Radiology and Neuroradiology, UKSH, Kiel, Germany*
[*] *Corresponding author, email: Harsha.PrakasamPrabhakaran@uksh.de*

In vitro models of intracranial aneurysms are essential tools for preclinical evaluation of endovascular devices. This study explores a variable-thickness, multi-material stereolithography (*SLA*) approach to fabricate anatomically accurate, transparent phantoms. Patient-specific vascular geometries were segmented from radiological images using *MeVisLab*, employing region-growing and marching cubes algorithms. *Region-growing* algorithms were applied to isolate the aneurysm and connected vasculature by adjusting threshold parameters that differentiate vessel lumen from surrounding tissue. Meshes were refined and processed in *MeshLab*, *Autodesk Meshmixer*, and *Fusion 360* for wall adjustments and connector design. Final models were printed using *Clear Resin V4* (Formlabs) on a *Form 3* SLA printer.

Three resins were assessed: *Clear Resin V4* (rigid), *Elastic Resin 50A*, and *Flexible Resin 80A* (elastomeric). Rigid models featured 3 mm uniform walls and localized thinning at the aneurysm dome (2 mm and 1 mm). Transparency was assessed using a semi-quantitative scale from 0 (opaque) to 3 (high clarity) Transparency improved with reduced thickness, with the 1 mm variant rated 2–3, enabling catheter visibility. The 2 mm and 3 mm models were rated 1–2 and 0–1, respectively. To assess deformability, *Elastic 50A* and *Flexible 80A* were printed at 1.0 mm and 0.8 mm. The 0.4 mm variant of *Elastic 50A* lacked structural stability, though reduced-scale versions performed better, suggesting a scale-dependent effect. *Flexible 80A* showed better tear resistance and form retention, with slightly reduced optical clarity. More quantitative mechanical tests such as tack test and tensile tests are ongoing.

These preliminary findings show that variable wall thickness improves transparency in key regions, supporting better optical tracking and device deployment. Rigid models aid visualization, while flexible variants enable vessel deformation analysis, advancing *in vitro* aneurysm testing.

AUTHOR'S STATEMENT

Conflict of interest: Authors state no conflict of interest. Ethical approval: The research related to human radiological data complies with all the relevant national regulations, institutional policies and, was performed in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board. Acknowledgments: This work was supported by the Institute of Digital Implant Research (IDIR).

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