DukeHealth

Comparison of 3D Printing Techniques with Patient-Specific Models for Epilepsy Surgery

Ishaan Kumar[1], Abhi Khapuria MD[2], Chip Bobbert[1], Muhammad Zafar MD[2], Bilal Berke Ayvaz[3]

[1]Duke Innovation Co-Lab, Durham NC, [2]Duke University Department of Neurology, Durham, NC, [3] Istanbul University-Cerrahpasa,Cerrahpasa School of Medicine, Turkey

ICNC 2022
17th INTERNATIONAL CHILD NEUROLOGY CONGRESS
ANTALYA, TURKEY | OCTOBER 3-7, 2022

INTRODUCTION

In recent years, there has been an emerging interest in healthcare related applications of 3D technology, specifically related to models based on patient specific MRI and CT scans.[1,2] This models may be very helpful for cerebral modeling in epilepsy surgery given the limitations of 2D projection in surgical planning, simulations and patient education.[3,4] With comparing different techniques directly in the scope of epilepsy surgery, we aim to present foresight for providers to adaptate different 3D methods to their own demands.

METHODS

IMAGE GENERATION

The imaging data was derived from 3T MRI and CT scans of patients with epilepsy at Duke University Hospital. These DICOM (digital imaging in communications in medicine) files were converted into Standard Tessellation Language (STL) models ,which contained both cerebral structures and implanted depth electrodes.

Two types of files were generated; 1) 'rosary bead' brains, which had internal beads along the lines of intracranial electrode insertion and 2) 'swiss cheese' brains, which have internal cavities in the models along the lines where the intracranial electrodes would be inserted ,and a separate insert was added as a part of a post-processing phase.

PRINTING 3D MODELS

Generated STL files uploaded to different printers to create the physical models. We tested three common printing methods in terms of reproducibility, resolution, practical limitations, and cost: Polyjet, Stereolithography (SLA), Filament Deposition Modelling (FDM). In all cases, each hemisphere of the brain was printed separately, if visualization of both hemispheres was needed. In all cases, STL files were used.

RESULTS

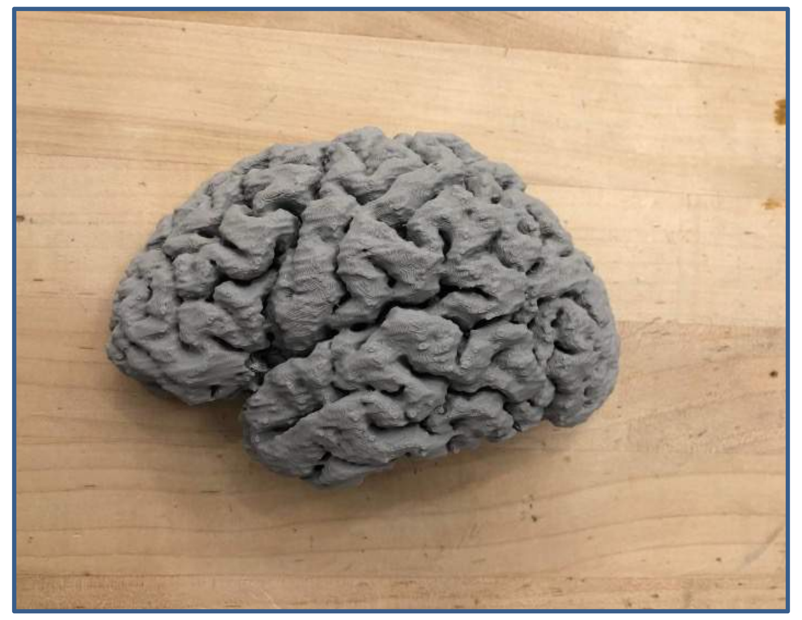
Polyjet


Figures 1 & 2. Rosary bead models generated from patient data printed on the Stratasys J750. Materials: VeroClear (brain mass) and VeroMagenta (electrode highlights).

SLA


Figures 3 & 4. Swiss-Cheese models with inserted 'electrodes' printed on the Form 3. Brains were printed at 75% size due to buildplate limitations of the Form 3. Post-print UV curing was not performed to avoid cloudiness. Materials: SLA Clear

FDM




Figures 5 & 6. Rosary Bead models printed on an Ultimaker S3. Materials: PLA Clear (brain mass) and PLA Red (electrode highlights)

	Material Capacities	Model Transparency	Cost
Polyjet	Up to 5 material printed simultaneously	Very Transparent	Most expensive (~500$ per hemisphere)
SLA	Only one material per print	Quite Transparent	Less expensive (~100$ per hemisphere)
FDM	Dual material abilities	Opaque	Least expensive (~15$ per hemisphere)

Table 1. Summary of relevant capacities of each printing technology evaluated here.

DISCUSSION

We found that generally, rosary bead models are to be preferred, as they represent a more intuitive and cogent model. However, this requires the 3D printing system to have multi-material capabilities.Polyjet provided the highest quality and most design flexibility with multi-material printing, while being the most expensive. SLA was far less expensive but was limited to one material. FDM was the least expensive and shared dual-material capacities but had the greatest number of printing errors.

CONCLUSIONS

Apperception of these different techniques may guide providers to choose the appropriate method for needed application which ultimately may improve communication in conferences, peer-to-peer surgical planning, and patient education both within and beyond the scope evaluated here for epilepsy surgery.

ACKNOWLEDGEMENTS AND REFERENCES

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