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Simulation of Implantation of EEG Electrodes, Strips and Grids Utilizing 3D Printing of Mesh-Like Cerebral Cortex and Deep Brain Structures

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Introduction

The aim of this project was to develop a 3D printed simulation system for mimicking the placement of EEG electrodes, strips and grids, which could also potentially be used for patient-specific preprocedural planning.

Methods

The “Split” function along with the basic segmentation tools of Materialise InPrint 2.0 was used to remove the calvarium and osseous skull base from the brain parenchyma in a DICOM dataset of a T1-weighted 3D FSPGR MRI brain. The result was exported as a Stereolithography (STL) file into Autodesk 3D Studio Max, where using the “Pro Optimizer” modifier, the number of polygons were decreased by 60% and the “Lattice” modifier was applied in order to create a mesh-like brain surface. Deeper brain structures, i.e. the deep gray nuclei were graphically designed and added, also with a mesh-like surface. The final model was then 3D printed as a cerebral hemisphere with polyamide material using selective laser sintering technology through an online commercial service.

Results

The purpose of the mesh-like nature of the surface of the brain and deep structures is three-fold. Not only the surface anatomy can be fully appreciated and taught, but also the deep structures can be visualized through the surface. Additionally, electrodes can be passed through the model to reach the deep structures numerous times without damaging the model. The final model is light and durable and can be placed in a hemi-calvarium 3D printed from CT head data, with gypsum-based material, which would also allow for drilling of burr holes.

Conclusions

Knowledge of the brain surface anatomy and the approach to reach deep brain structures with electrodes is important for both neurosurgeons and epileptologists. This relatively low-cost technique can also be implemented for interdisciplinary preprocedural planning for patients requiring intracranial EEG monitoring.

Learning Objectives

Reduce risks and improve safety by simulating placement of depth electrodes prior to the surgical procedure with the help of this model.

References

1. Nagahama Y, Schmitt AJ, Nakagawa D, Vesole AS, Kamm J, Kovach CK, Hasan D, Granner M, Dlouhy BJ, Howard MA 3rd, Kawasaki H.:Intracranial EEG for seizure focus localization: evolving techniques, outcomes, complications, and utility of combining surface and depth electrodes. J Neurosurg. 2018 May 25:1-13. doi: 10.3171/2018.1.JNS171808

Final 3D model

Final 3D model.

3D printed model.

3D printed model.