Use of systematic stimulation mapping and functional/structural imaging to improve localization of seizure onset in patients with drug-resistant epilepsy

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Background

➢ Epilepsy is a condition characterized by spontaneous, abnormal, excessive neuronal activity that affects 1% of individuals in North America. 30% of this population is resistant to anticonvulsant medication.

➢Due to challenges in detecting epileptic foci in patients with drug-resistant epilepsy, Scalp Electroencephalography (scalp EEG) and Stereoencephalography (SEEG) record brain activity to determine epileptic onset zones.

➢Location of SEEG electrode implantation is determined by prior clinical tests and patient semiology. Patients are monitored for several days in the Epilepsy Monitoring Unit (EMU).

➢One limitation of SEEG is the lack of specificity between electrophysiological data recorded by intracranial monitoring and the neuroanatomical context that would illustrate a patient's epileptic foci.

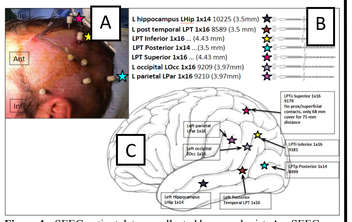

Figure 1 - SEEG patient data as collected by neurologist. **A** – SEEG electrodes on patient's scalp. **B** – description of electrode name, location, recorded stimulation **C** – 2D neuroanatomical representation of electrode location on brain surface.

Hypotheses

- SEEG stimulation induced clinical symptoms will correlate with specific cortical areas across patients.
- There is a common set of SEEG electrodes implanted in cortical areas across patients that are neurologist-identified as necessary for SEEG intracranial monitoring.

Methods

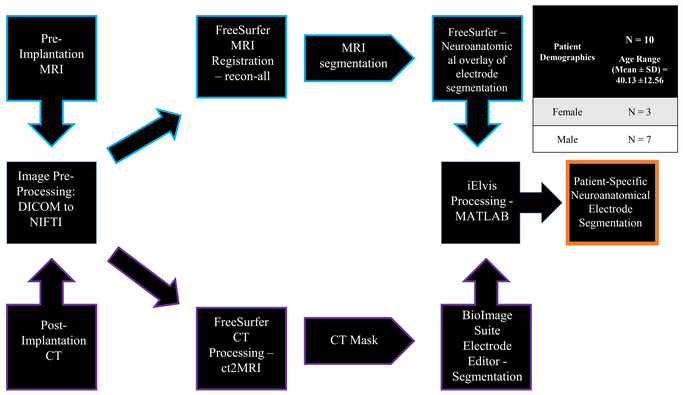

Figure 2 – overview of methods

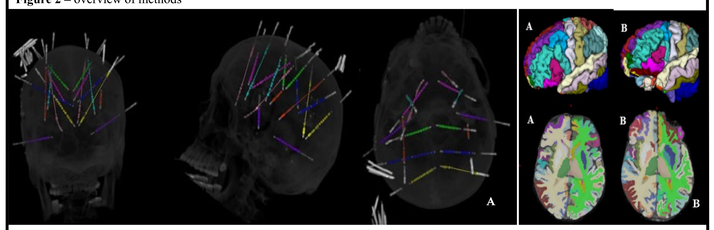

Figure 3 – Methods A) Case 2 electrodes mapped in 3D space in BioImage Suite Electrode Editor. B) Patient-specific cortical segmentations generated by FreeSurfer. Cortical areas in Patient A are different from Patient B.

Stimulation Mapping: Semiology Analysis

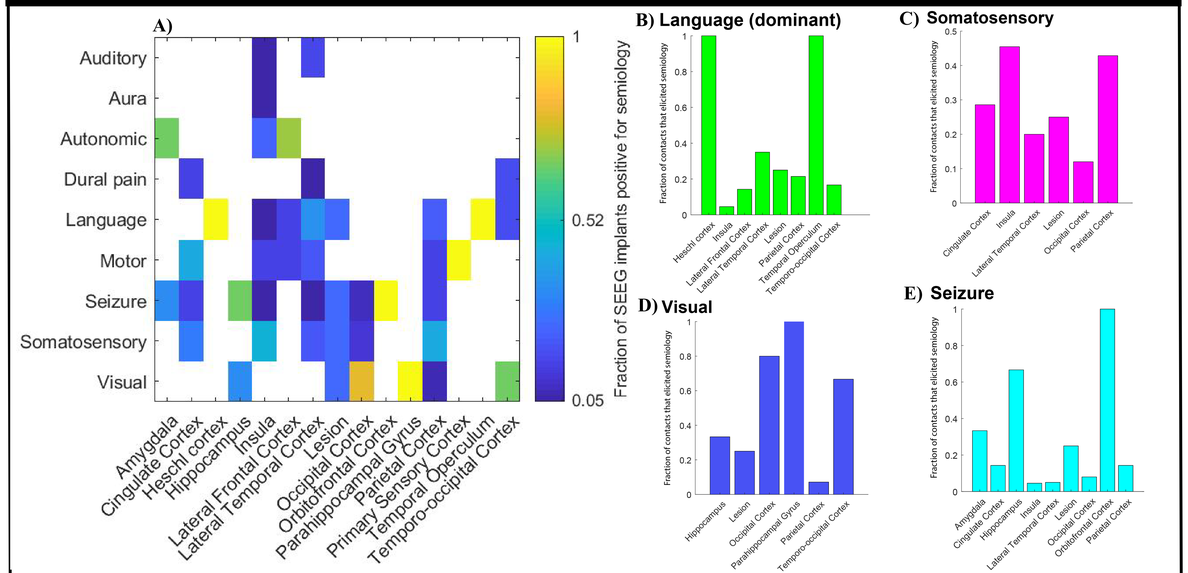

Figure 4 – Stimulation Mapping data analysis. A) Fraction of SEEG cortical implants positive for semiology across subjects. Fraction of SEEG electrodes across patients per cortical area that elicited B) Language (dominant) C) Somatosensory D) Visual and E) Seizure symptoms when stimulated

Stimulation Mapping: Intensity

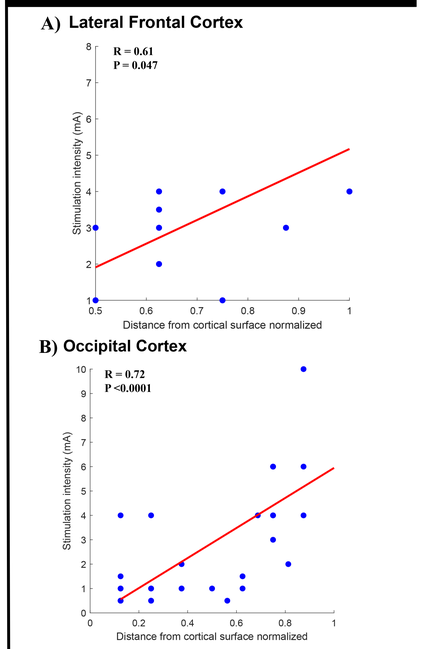

Figure 5 – Minimum SEEG stimulation mapping intensity (mA) required to elicit a symptom response across patients in A) Frontal Gyrus and B) Occipital Cortex. Correlations are statistically significant.

BioImage Electrode Mapping Results

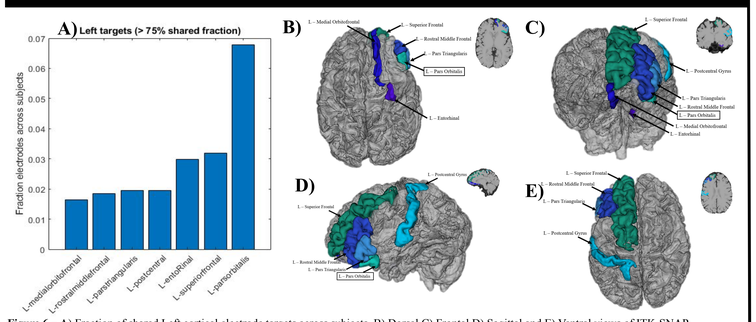

Figure 6 – A) Fraction of shared Left cortical electrode targets across subjects. B) Dorsal C) Frontal D) Sagittal and E) Ventral views of ITK-SNAP segmentation of common cortical targets across subjects.

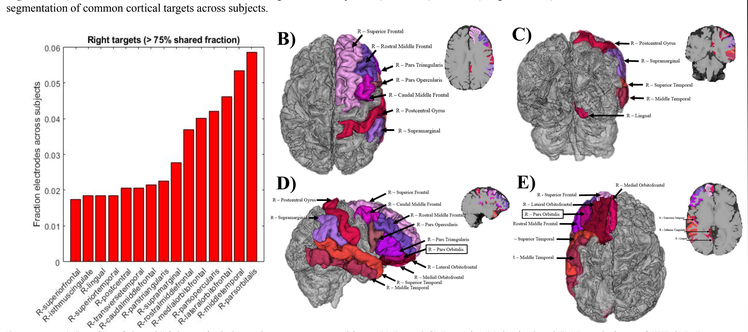

Figure 7 – A) Fraction of shared Right cortical electrode targets across subjects. B) Dorsal C) Posterior D) Sagittal and E) Ventral views of ITK-SNAP segmentation of common cortical targets across subjects.

BioImage Electrode Mapping Results (cont.)

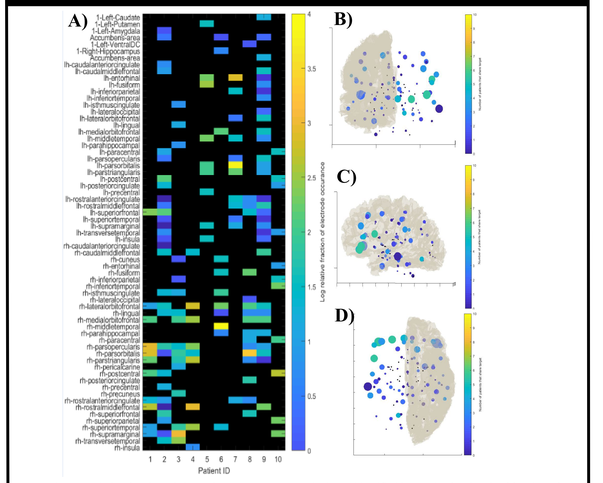

Figure 8 – A) Relative fraction of electrode occurrence per cortical area identified in FreeSurfer. Graph of fraction of electrode occurrence per cortical areas B) Coronal C) Sagittal D) Dorsal views.

Refinement of Electrode Localization

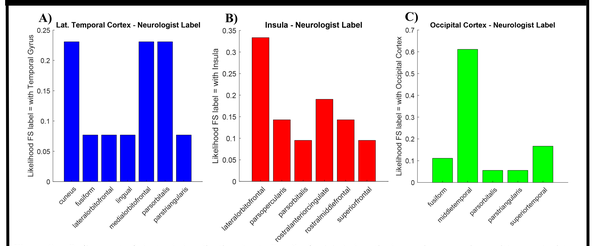

Figure 9 – Refinement of electrode localization due to FreeSurfer-labeled cortical areas in comparison with neurologist-identified electrode locations in A) Lateral Temporal Cortex, B) Insula, C) Occipital Cortex.

Conclusion

- Neurologist-identified SEEG electrodes were mostly mapped in the temporal and frontal regions, specifically the pars orbitalis.
- The closer the SEEG electrodes are to the intended target, the smaller the stimulation required to elicit a clinical symptom.
- Further investigation is required to assess the clinical relationship of the BioImage Suite electrode mapping in context with current clinical practices to better guide resection and treatment of drug-resistant epilepsy.

References

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