3D-SEEG: A Novel Technique for Surgical Identification of Eloquent and Epileptogenic Cortex

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Introduction

Successful surgical treatment of epilepsy requires accurate definition of areas of ictal onset and eloquent brain. While invasive monitoring can be helpful, subdural grids cannot sample sulci or subcortical tissue, and traditional stereo-EEG (SEEG) depth electrodes are placed too far apart to provide sufficient resolution for mapping. We report a strategy of depth electrode placement in a dense array (3D-SEEG) to allow precise anatomic localization of epileptic and eloquent cortex that can be used during surgical resection.

Methods

Five patients with medically intractable epilepsy arising adjacent to motor (n=3) or speech (n=2) areas underwent placement of arrays of depth electrodes into and around the putative area of seizure onset using framed stereotaxy. Each array consisted of a "grid" of parallel electrodes placed in a rectangular pattern with approximately 1 cm between entry sites. Trajectories were modified when necessary to avoid cortical vessels defined on contrast-enhanced MRI. Patients were monitored for 7-14 days to establish the precise location of seizure onset. Stimulation was performed to map cortical and subcortical eloquent regions. Electrode locations were co-registered for frameless stereotaxy during subsequent resection of the seizure focus.

Results

A total of 61 electrodes were implanted. Discrete regions of seizure onset and functional cortex were identified, frequently involving sulci, and this information was used during resection to completely remove epileptogenic brain while preserving eloquent areas. Insertion of electrodes into the primary motor area resulted in transient weakness in one patient that resolved completely within two days. After mean follow up of 93 days, three patients were seizure-free and two had significant reduction in seizure frequency and intensity. There were no hemorrhagic or infectious complications, and no patient suffered a neurological deficit.

Conclusions

3D-SEEG is a useful to identify epileptic and eloquent brain for epilepsy surgery.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) Discuss the importance of identifying eloquent and epileptogenic cortex, 2) Describe the technique of 3D-SEEG, 3) Identify epilepsy patients for whom 3D -SEEG would be appropriate for surgical planning.

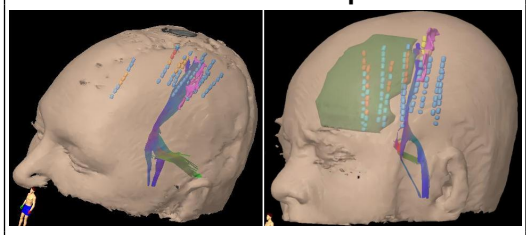
References

Cossu M, Cardinale F, Castana L, et al. Stereoelectroencephalography in the presurgical evaluation of focal epilepsy: A retrospective analysis of 215 procedures. Neurosurgy. 2005;57:706–718.

Guenot M, Isnard J, Ryvlin P, et al. Neurophysiological Monitoring for Epilepsy Surgery: The Talairach SEEG Method Indications, Results, Complications and Therapeutic Applications in a Series of 100 Consecutive Cases. Stereotact Funct Neurosurg. 2001;(77):29–32.

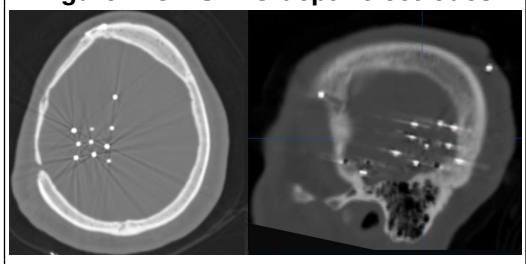
Talairach J, Bancaud J. Stereotaxic Approach to Epilepsy: Methodology of Anatomo-Functional Stereotacic Investigations. In: Progr. neurol. Surg.Vol 5. Karger; 1973:297–354.

Figure 1. Reconstruction of 3D-SEEG for motor cortex in 2 patients



Red = epileptic activity, Yellow = eloquent cortex, Green = intended resection

Figure 2. 3D-SEEG depth electrodes



Mapping of motor (left) or speech (right)