Dynamics of Initial Seizure Onset Determined from MEG Data Utilizing MR-FOCUSS

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Background:
Interictal activity recorded by MEG is commonly used to identify irritative zones which encompass the epileptogenic zone (area of cortical tissue when removed will result in a seizure free outcome). Visual inspection of the EEG electrode waveforms has been used for decades to determine the location of the ictal onset. MEG evaluation of interictal spikes usually uses the single equivalent current dipole (ECD) [1] to localize the cortical area on the subject’s MRI scan. The ECD technique is less useful for low amplitude spikes. We report an evaluation of a current source density imaging technique [2,3] to improve localization of the ictal source. The dynamics of time and location of seizure onset can be seen in the MEG data using MR-FOCUSS, a current density imaging algorithm. MR-FOCUSS is capable of imaging multiple sources that are simultaneously active especially if an ictal event is captured with MEG.

Results
• Thirteen patients experienced their typical seizures during data collection.
• Visual inspection showed initial seizure onset at a few specific MEG channels or a few EEG electrodes in all thirteen patients (Figure 1).
• ECD solutions only met our acceptance criteria [1] if the amplitude of spike activity was significantly above background activity during the beginning of the seizure (Figure 2).
• The MR-FOCUSS solutions were able to suggest the localization of ictal patterns earlier than ECD (Figure 3).
• Locations of seizures coincided with the approximate locations from visual inspection of the EEG data for all thirteen patients. MR-FOCUSS provided details of cortical activity at times earlier than the first visual indications of the seizure (Figure 4).

Methods
Thirteen patients (6 male and 7 female; age range: 7 - 39 years old) with localization related epilepsy had typical seizures while being monitored with 148 MEG channels (4D Neuroimaging Magnes WH2500), and 32 channels of EEG. The EEG utilized the modified combinatorial nomenclature to the 10-20 international system of electrode placement with electrodes at F9/10, P9/10, T9/10, FC5/6, CP1/2, and a reference electrode at POz. Data were digitized at 508 samples per second from 0.01 Hz to 100 Hz. Data were forward and backward filtered using a 3-100 Hz bandpass with a 60 Hz notch filter.

All of these patients had partial seizures. Data were visually inspected for epileptic seizure activity. Data during small intervals of time before the onset of seizure (400ms) and during the seizure onset (300ms), were selected for imaging (Figure 1). ECD [1] and MR-FOCUSS [2,3] solutions were performed on the 700 ms of data. The MEG localization results were co-registered to the patient’s MRI scan.

Conclusion:
This study demonstrates how MR-FOCUSS can be used to study initial cortical dynamics of seizure onset. The MR-FOCUSS technique allows the dynamics of ictal onset to be observed and localized the ictal activity to a specific region of the brain. This may be useful in determining the initial location of seizure onset in patients with partial epilepsy not localized by typical non-invasive studies.

References

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WEB site:
http://www.megimaging.com