Magnetoencephalography (MEG) in focal cortical dysplasia (FCD)*

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Purpose. Focal cortical dysplasias (FCDs) are the most common single pathology found in epilepsy surgery patients (Frater et al., 2000, Sisodiya, 2004). The outcome of surgery is generally favorable and seizure-free outcomes of 50-75% have been reported (Fauser et al., 2008, 2002, Sisodiya, 2004). Incomplete resection of an FCD is the main predictor of poor post-surgical outcome (Krsek et al., 2009).

Magnetoencephalography (MEG) and EEG reflect postsynaptic currents in pyramidal cells. MEG is selectively sensitive to tangential currents, typically produced by fissure walls. Because the bottom of sulci are predilection sites for FCD lesions, we investigated whether MEG results could predict clinical outcome in epilepsy surgery patients with FCD. We specially focused on patients with no visible lesions on magnetic resonance imaging (MRI).

Methods. MEG findings of 30 epilepsy surgery patients with confirmed histological diagnosis of FCD subtypes I or II (Palmini et al. 2004) were retrospectively evaluated. MEG was recorded as a part of their pre-surgical planning. Tens of single (non-averaged) MEG spikes were modeled with equivalent current dipoles, and the dipole sets were classified into 'scattered' or 'clustered' according to lida et al (2005). We studied the MEG dipole localizations in respect to the removed area defined by postoperative MRI scans, and evaluated the value of MEG-findings in predicting the seizure outcome after surgery (according to Engel 1993). In patients with no visible 3-Tesla MRI lesion (n=12), the location of MEG dipoles were also compared with localization results of sub-dural and/or depth electrode EEG.

Results. Inter-ictal MEG spikes were observed in all but one patient. Dipole clusters were found in sixteen (53%) patients. Twelve of the 30 (40%) patients became seizure free (Engel class I). Four of the seventeen (24%) patients with FCD I and eight of the thirteen (62%) patients with FCD II became seizure free (p=0.05). In patients with dipole clusters and favorable outcome Engel class I or II (n=11), 51% of the source clusters had been removed; while in patients with unfavorable outcome (Engel class III or IV; n=5) only 5.5% of the cluster volume had been removed (p=0.02).

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Six (50%) of the twelve patients with an MRI-negative lesion achieved Engel class I; the outcomes did not differ from patients having a visible MRI lesion (p=0.55). The concordance between MEG localizations and the invasive studies was good in nine of the twelve patients without visible MRI lesions.

Patients with unfavorable outcome had their MEG dipoles partly overlapping the primary motor cortex, (n = 2), or they lacked epileptiform MEG signals discovered in the insular cortex by depth electrodes (n = 1), or they had an extended multi-lobar lesion confirmed by later operations (n = 4).

Significance. MEG is particularly useful, or even essential, in finding small FCDs not visible on MRI thus rendering them 'visible'. The clinical outcomes of these patients did not differ significantly from those with a clearly visible MRI lesion.

The vicinity or overlap of spike sources with eloquent sensori-motor cortex could be used to evaluate the risks of surgery.

However, existence of even clear MEG clusters pointing out an FCD, do not exclude the possibility of other FCDs that may not always give detectable MEG signal.

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