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Skull Defects in MEG and EEG: Experimental Results and Modelling

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Introduction

While the influence of skull defects on the electroencephalogram (EEG) has been reported, the magnetoencephalogram (MEG) is thought to have a negligible sensitivity to skull defects. However, quantitative experimental evidence under realistic conditions is rare. Our objective is to experimentally investigate the influence of conducting skull defects on the EEG and MEG using a controlled current source under and next to the defect and to develop a finite element head model and equivalent source model to explain it.

Methods

We measured a 64-channel EEG simultaneously to a 16-channel MEG produced by a miniaturized artificial coaxial dipole implanted in a rabbit brain tangentially to the inner skull surface in vivo. Following a recording with intact skull, a skull defect was introduced above the dipole and filled with agar (1.0 S/m at 30˚C). A CT (0.4 mm3) provided the defect geometry and the dipole position. The dipole was shifted in 0.35 mm steps from a position next to the skull defect to a position under the defect and further to the opposite side and a recording was taken at each step under otherwise identical conditions.

Results

Our results demonstrate that both EEG and MEG were significantly and reproducibly influenced by the introduction of a conductive skull defect with a maximal relative magnitude deviation of above 300% for EEG and above 20% for MEG. Both, the EEG and to a smaller degree also the MEG topography, are altered in a fashion that is spatially corresponding to the skull defect location and geometry. These observations are reflected in our finite element models of the skull defects.

Conclusion

We conclude that skull defects need to be accounted for in volume conductor models used in the reconstruction of brain activity sources from EEG and also MEG, particularly in infants with open fontanels and patients with post-surgical skull conditions.