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EVOKED BRAIN MAGNETIC FIELD AS AN OPTIMIZATION TOOL OF SACRAL SURFACE THERAPEUTIC STIMULATION

Hypothesis / aims of study

Sacral surface therapeutic electrical stimulation (SSTES) is effective for the treatment of refractory urinary incontinence and frequent micturition. Magnetoencephalography (MEG), the magnetic counterpart of electroencephalography (EEG), has similar high time resolution and higher spatial resolution than EEG because of the negligible effect of the inhomogeneous head conductivity. Somatosensory evoked fields (SEF) are the MEG responses to various types of stimulation of the peripheral nerves and skin. There are some SEF reports for urological organs[1) 2)]. SSTES parameters were investigated by measuring the brain response using MEG in six healthy males.

Study design, materials and methods

Electrical stimuli were applied to small (20 x 45 mm) or large (40 x 90 mm) surface electrodes placed over the bilateral second to fourth posterior sacral foramens with weak (3 times the sensory threshold) or strong (just below the pain threshold) intensity for each electrode size. SEF for the stimuli were measured with a helmet-shaped MEG system. The first peak around 30 ms (M30) originated from primary somatosensory cortex, and source strength was estimated by an equivalent current dipole (ECD) model (Figure).

Results

Both the sensory and pain thresholds for the large electrodes (6.2 +/- 1.9 and 43.2 +/- 14.6 mA) were significantly ($p<0.05$) higher than those of the small electrodes (3.0 +/- 0.9 and 24.0 +/- 10.3 mA). The maximum stimulus intensity (pain threshold for the large electrodes) evoked significantly ($p<0.05$) shorter latency (30.2 +/- 1.0 ms) response than weaker intensities. Significantly ($p<0.05$) larger ECD strength was obtained with higher stimulus intensity under all stimulus conditions (Table).

Table Latency and equivalent current dipole (ECD) strength for the first peak (M30) at different combinations of stimulus intensity and electrode size.

Electrode size	small	small	large	large	large
Stimulus intensity	weak	strong	weak	strong (small electrode)	strong
Latency [ms]	-	1) 30.4 +/-0.5	2) 32.7 +/-1.8	3) 32.8 +/-2.7	4) 30.2 +/-1.0
ECD Strength [nAm]	-	5) 10.3 +/-3.7	6) 8.6 +/-2.0	7) 13.2 +/-2.8	8) 19.7 +/-3.6

Means and standard deviations are indicated.
2) vs 4) $p<0.05$, 3) vs 4) $p<0.05$, 5) vs 8) $p<0.05$, 6) vs 7) $p<0.05$, 6) vs 8) $p<0.05$,
7) vs 8) $p<0.05$,

Interpretation of results

Larger electrodes enable toleration of stronger stimulus due to higher pain threshold. The shorter peak latency and larger dipole moments of the primary somatosensory response suggest more effective stimulus at the sacral level.

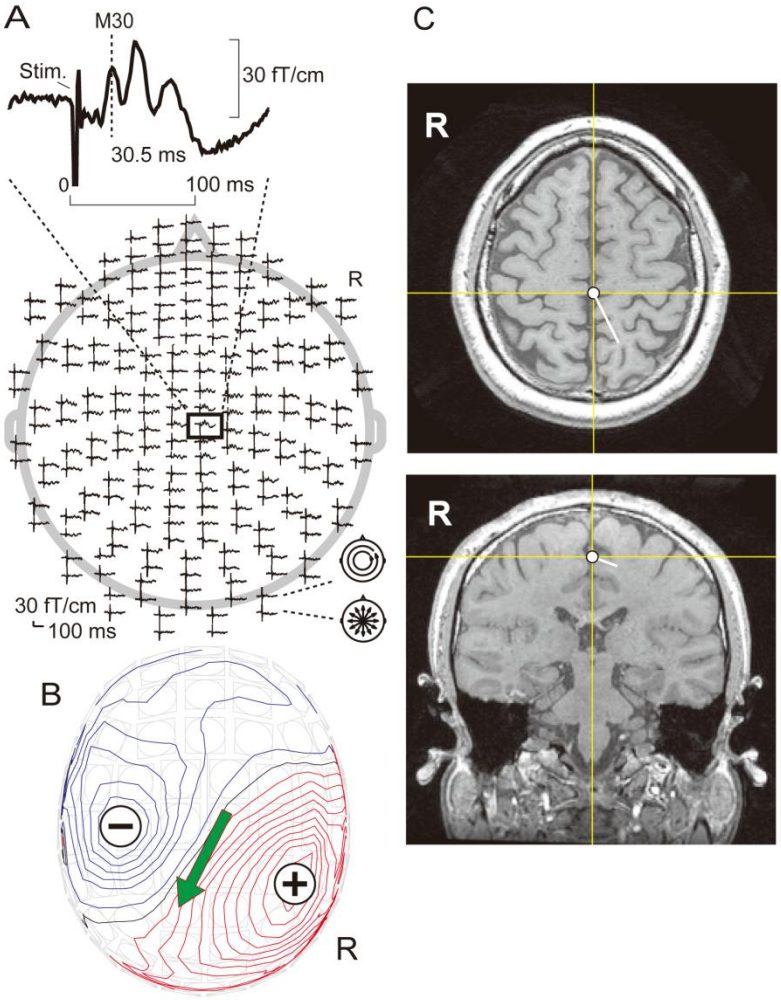
Concluding message

MEG can be used to evaluate brain cortical responses to sacral surface stimulation under different conditions. Larger electrodes and stronger stimulus resulted in shorter peak latency and larger signal intensity of M30, the first component originating from the primary somatosensory cortex, suggesting more effective stimulus at the sacral level. MEG provides an objective and non-invasive method to optimize the stimulation parameters of SSTES.

References

1) Neurosci Lett (2008) 431; 77-80.
2) Electroencephalogr Clin Neurophysiol (1998) 108; 57-61.

Figure



Somatosensory evoked magnetic fields for SSTES in a normal male subject (Subject 1). (A) The M30 is defined from a typical waveform (upper) obtained from 204 gradiometer sensors recording between 50 ms before and 150 ms after the stimulus onset (bottom). The latitudinal and longitudinal derivatives of the magnetic field (upper and lower curves in each pair, respectively) are shown at each measurement site. (B) Isofield map at the peak latency of M30 indicates a single dipole pattern over the vertex with posterior orientation. (C) ECD of M30 is superimposed on magnetic resonance images of the subject. Circles and bars indicate ECD location and orientation, respectively.

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Was this study approved by an ethics committee?	**Yes**
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Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**