MEG/EEG in clinical practice

- State of the art – specific challenges of clinical studies
- Technical challenge and caveats
- Perspectives on MEG/EEG brain mapping in clinical practice

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Maximal resection of brain tumors

The objective is to achieve the greatest reduction of tumor volume with the least risk of neurological sequelae.

[Image of brain scan with annotations]

The goal is to remove as much of the tumor as possible while preserving vital brain functions.
Non-invasive Brain Mapping

- Vessels
- fMRI
- Neurons
- MEG, EEG
- Axons
- Tractography

Brain section
Somatosensory Evoked Magnetic Fields (SEFs)
Median N. Stim (4 mA, 5 Hz)

Brain tumors

Right

Left

↑: Central sulcus

M20 M30

M30 M70
spike analysis by MEG
Investigations of language functions

Neuropsycho. Exam.: to evaluate symptoms
Amytal test: to identify the dominant hemisphere

(angiography)

Electrical stimulation, awake surgery; Invasive, to examine one side

1. Preoperative non-invasive functional mapping for language functions

Combination of MEG & fMRI

2. Validation of the results by amytal test & electrical stimulation with subdural electrodes
4VCKFDUT

OPSNBMDPOUSPMT

1BUJFOUTɿ DBTFTXJUIDFSFCSBMJTDIFNJB

DBTFTXJUICSBJOMFTJPOT

-BOHVBHFEPNJOBODFXBTWBMJEBUFE

JODBTFTCZ"NZUBMUFTU

JODBTFTCZFMFDUSJDDPSUJDBMTUJNVMBUJPO

5PUBMTVCKFDUT
MEG
(Abstract/Concrete discrimination (reading) task)

“つくえ”
“かぼちゃ”

Left Key
1.2s
Time Limit
3.0～4.0s

Right Key
1.2s
Time Limit
3.0～4.0s
verb-generation fMRI

Inferior & middle frontal gyrus

left hemisphere

right-handed control subject
Left mesial temporal tumor in a left-handed patient

verb-generation fMRI
reading-task MEG

No. of dipoles

<table>
<thead>
<tr>
<th>right</th>
<th>left</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>15</td>
</tr>
</tbody>
</table>

(amyntal test : right)

radical removal
a mesial temporal grade-2 astrocytoma

pre op.  post op.  2 years after irradiation
Left mesial temporal tumor

verb-generation fMRI

right-handed 35-y.o. man

Brain tumor
reading-task MEG

No. of dipoles
right 30  left 136

dipole accumulation in the fusiform gyrus

J.K.
LORETA
(Low resolution tomography)

250-450ms

[nAm]

0.20
0.15
0.10
0.05
0.00
dyslexia

pre op.  post op.  J.K.

N.T.; not tested
serial changes of MEG

Left fronto-temporal

Left temporo-occipital

Right fronto-temporal

Right temporo-occipital

Case J.K

Pre OP.

10 days after OP.

3 months after OP.

8 months after OP.
reading-task MEG

8 months after resection

<table>
<thead>
<tr>
<th>No. of dipoles</th>
<th>right</th>
<th>left</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23</td>
<td>102</td>
</tr>
</tbody>
</table>
Right insular glioma, 34y.o. male

Right-handed

fMRI

Verb generation

Reading

glioma
MEG (Reading-task)

Right insular glioma, 34y.o. Male

<table>
<thead>
<tr>
<th>No. of dipoles</th>
<th>left</th>
<th>right</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>136</td>
</tr>
</tbody>
</table>

dipole accumulation in the STG and PITG
<table>
<thead>
<tr>
<th>Task</th>
<th>Left injection</th>
<th>Right injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>paresis</td>
<td>Right hemiparesis</td>
<td>Left hemiparesis</td>
</tr>
<tr>
<td>pictures &amp; objects-naming</td>
<td>60% (3/5)</td>
<td>100% (5/5)</td>
</tr>
<tr>
<td>letter-reading</td>
<td>71% (5/7)</td>
<td>14% (1/7)</td>
</tr>
<tr>
<td>auditory comprehension</td>
<td>75% (3/4)</td>
<td>25% (1/4)</td>
</tr>
<tr>
<td>repeating 7 numbers</td>
<td>possible</td>
<td>possible</td>
</tr>
<tr>
<td>retrieving 5 items (short memory)</td>
<td>100% (5/5)</td>
<td>100% (5/5)</td>
</tr>
<tr>
<td>General impression</td>
<td>impaired overt naming with severe dysarthria, but little dyslexia</td>
<td>severe dyslexia with mild dysarthria</td>
</tr>
</tbody>
</table>

**Amytal test**

Right insular glioma  
34 y.o. male
Translocation of Broca's area to the contralateral hemisphere as the result of the growth of a left inferior frontal frontal glioma.

Holodny AI, et al.
Results of Amytal test, language-MEG and –fMRI in 91 cases with brain tumors or epilepsy (controls)

<table>
<thead>
<tr>
<th>Amytal Test</th>
<th>Language-MEG</th>
<th>Language-fMRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result 1</td>
<td>Result 2</td>
<td>Result 3</td>
</tr>
</tbody>
</table>

*Note: Further details and analysis can be found in the original document.*
Conclusion 1

MEG & fMRI localized the receptive- & motor-language functions in STG and FuG, & IFG and MFG, respectively.

The combination of fMRI and MEG confidentially enabled us to identify the dominant hemisphere of the language functions.

Serial MEG and fMRI investigations might possibly reflect the neurological recovery.
Pitfalls of functional mapping for clinical utility
Cerebral Ischemia
due to Right IC occlusion

49 y.o. male

Right finger tapping
Right medial N. stim.

fMRI

Left finger tapping
Left medial N. stim.

MEG

Left SEF
Right SEF
Cerebral Ischemia
due to Right IC occlusion

49 y.o. male

SPECT with Diamox

Verb-generation fMRI

fMRI raw images
fMRI on rest SPECT

Cerebral Ischemia due to left IC occlusion

43 y.o. male

Verb generation

Right-side dominance?

Right finger tapping

Right-side activation?

Right

Left

Right

Left
Conclusion 2

BOLD-based fMRI is vulnerable to pathological brain conditions (ischemia, brain edema).

MEG can well reflect brain functions, but there still remain inverse problems.

It is, therefore, important to combine multi image modalities with different basics to make functional brain mapping more reliable for clinical purposes.
Validation of functional imaging
<table>
<thead>
<tr>
<th>age/sex</th>
<th>handedness</th>
<th>diagnosis</th>
<th>spike location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1.: 37y/F</td>
<td>Left</td>
<td>Bil. TLE (L&gt;R)</td>
<td>Bil. fronto-temporal</td>
</tr>
</tbody>
</table>

Verb generation fMRI

Reading-task MEG

Amytal test: Right

Lt; 81 dipoles << Rt; 246 dipoles
Combined 3D-image
Conclusion

The validation of functional imaging is indispensable for further development in human brain mapping.

Clinical institutes should understand benefits and pitfalls of imaging modalities and carefully use results of the brain mapping for making treatment strategy.
for future studies

White matter mapping

• Fiber Tracking based on Diffusion Tensor Imaging

\[ D(x_{i+1}) \]
\[ x_{i+1} = x_i + \Delta e_1(x_i) \]

\[ e_1, e_2, e_3: \text{eigenvectors of tensor} \quad |e_1| = |e_2| = |e_3| = 1 \]