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Current clinical magnetoencephalography practice across Europe: Are we closer to use MEG as an established clinical tool?

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ABSTRACT

Purpose: This comprehensive survey aims at characterizing the current clinical use of magnetoencephalography (MEG) across European MEG centres.
Methods: Forty-four MEG centres across Europe were contacted in May 2015 via personalized e-mail to contribute to survey. The web-based survey was available on-line for 1 month and the MEG centres that did not respond were further contacted to maximize participation.
Results: Among the 57% of responders, 12 centres from 10 different countries reported to use MEG for clinical applications. A total of 524 MEG investigations were performed in 2014 for the pre-surgical evaluation of epilepsy, while in the same period 244 MEG investigations were performed for pre-surgical functional brain mapping. Seven MEG centres located in different European countries performed ≥50 MEG investigations for epilepsy mapping in 2014, both in children and adults. In those centres, time from patient preparation to MEG data reporting tends to be lower than those investigating a lower annual number of patients.
Conclusion: This survey demonstrates that there is in Europe an increasing and widespread expertise in the field of clinical MEG. These findings should serve as a basis to harmonize clinical MEG procedures and promote the clinical added value of MEG across Europe. MEG should now be considered in Europe as a mature clinical neurophysiological technique that should be used routinely in two specific clinical indications, i.e, the pre-surgical evaluation of refractory focal epilepsy and functional brain mapping.

1. Introduction

Magnetoencephalography (MEG) is a non-invasive neurophysiological technique that provides a direct measure of neuronal activity with a millisecond time scale (for reviews, see, e.g., [1–3]). MEG records the magnetic fields mainly generated by the postsynaptic potentials of cortical pyramidal neurons (for reviews, see, e.g., [1,2,4]). This technique is highly sensitive to cortical sources that are tangential to the skull [1,2,4]. In comparison with electroencephalography (EEG), it is almost blind to pure radial sources, which corresponds to less than 5% of the whole cortical surface [1,2,4–6]. The heightened sensitivity of MEG to fissural/tangential cortical sources explains why MEG can detect brain activity not captured by EEG (and vice versa) supporting their being complementary techniques [1,2,4,6]. When combined with structural cerebral magnetic resonance imaging (MRI), MEG allows estimating the location of electrical sources at the origin of the recorded magnetic signals with sub-lobar spatial resolution (i.e., magnetic source imaging or MSI) [1,2,4]. MEG high spatial resolution comes from dense sensor arrays (275–306 sensors in modern whole-head MEG systems) and from the fact that magnetic fields, as opposed to electrical currents, suffer minimum attenuation and distortion by the different tissues they have to cross to reach the scalp surface [1,2,4].

Since the first description of magnetic fields recorded outside the human scalp by David Cohen in 1968 [7], MEG has

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progressively emerged as a useful clinical neurophysiological technique. Indeed, in parallel with the increasing interest for the methodology in neuroscience research, MEG has been gaining wider acceptance for two main clinical indications officially recognized by several scientific societies such as, e.g., the American Academy of Neurology (see AAN MEG Model Policy 2009). These indications are the non-invasive localisation of irritative/epileptogenic zone of refractory focal epilepsy and non-invasive mapping of eloquent cortex as part of pre-surgical evaluation. The increased enthusiasm generated by MEG in these clinical indications came from its manifest advantages over other functional imaging techniques such as positron emission tomography (PET) and functional MRI (fMRI) (i.e., direct measure of neuronal activity, high temporal resolution, good spatial resolution, high sensitivity to neural activity from fissural cortex). The use of MEG in epilepsy is now supported by several prospective studies that have demonstrated its clinical added-value compared with non-invasive pre-surgical evaluation procedures relying on scalp (video-) EEG as the only neurophysiological technique (see, e.g., [8–12]). Also, several studies have validated the use of MEG for pre-surgical functional brain mapping against reference procedures such as fMRI, intracranial stimulations or the WADA test for language assessment (see, e.g., [13–19]). Therefore, after more than 50 years of existence, MEG cannot be longer considered as a "new" or "investigational" clinical technology but rather as a mature clinical neurophysiological technique with specific clinical indications [20].

The increased clinical use of MEG in the last decades has been based on an important increase in the number of clinical MEG Centres worldwide. This stimulated the Japanese Society of Clinical Neurophysiology to publish in 2004 a draft of general recommendations for the clinical use of MEG [21]. Two years later (2006), clinical magnetoencephalographers from the United States created the American Clinical MEG Society (ACMEGS) and, subsequently, the International Society for the Advancement of Clinical MEG (ISACM) in 2007. The ACMEGS aims at promoting and developing the clinical applications of MEG by supporting education, standardization of procedures though the publication of guidelines, sharing of data and protocols, and the development of strategies for improving reimbursement for clinical examinations. The ISCAM also aims at promoting and developing the clinical applications of MEG, and this is done mainly by organising international clinical MEG meetings. In this context, the ACMEGS published in 2011 the first clinical practice guidelines (CPG) aiming at providing a set of practical recommendations that should help MEG centres and clinicians to practice clinical MEG more uniformly and consistently [22]. The process of establishing those CPGs started with a comprehensive survey establishing the state of clinical MEG practice in the United States [20]. This ACMEGS survey actually revealed a large variability in organizational structures and daily practice that triggered the development of the ACMEGS CPGs [20].

In 2014, the European MEG society (EMEGS) was created after seminal meetings in 2011 and 2013 to promote and develop MEG across Europe. This clinically oriented society shares similar aims as the ACMEGS, i.e., to promote clinical, educational and research objectives relevant to the field of MEG.

In order to characterize the current clinical MEG practice across Europe, members of the EMEGS Executive Committee launched in May 2015, on behalf of the EMEGS, a comprehensive survey addressed to the head of each European MEG Centre. This survey aimed at (i) capturing the picture of current clinical practice across European MEG centres, and (ii) identifying the commonalities and the discrepancies in the clinical MEG protocols used across European MEG centres reporting some clinical use of MEG. The results of the survey reported here should serve as the basis for the establishment of clinical MEG practice guidelines at the European level.

2. Methods

The location of the MEG centres contacted for the survey across Europe is summarised in Fig. 1.

The questions addressed in this survey are detailed in the Supplementary material. They were developed after consensual discussions and agreement between the authors, and after approval by the EMEGS Executive Committee

The heads of 43 MEG centres in Europe have been contacted on the 19th May 2015 via personalized e-mail to contribute to survey. For the purpose of this survey, one non-European MEG centre (Israel) was also invited to participate, considering its geographical proximity to Europe. We used of a web-based survey hosted by Novi Survey (Novi Systems, Boston, Massachusetts, USA). The survey was available on-line for 1 month and the heads of the MEG centres who did not respond during that time were further contacted to maximize participation. Representatives of some centres were subsequently contacted personally by e-mail to get further details on their answers.

Data from the survey was exported from Novi Survey for analysis in the form of a tab-delimited text file, and were thereafter processed using Microsoft® Excel® for Mac 2011 (version 14.4.8) and MATLAB 7.6 R2008a (Mathworks Inc., Sherborn, MA). Pearson's correlation was used to search for dependencies between variables.

3. Results

3.1. European MEG centres

Fig. 1 illustrates the location of the European MEG centres that contributed to the study.

Among the 44 contacted MEG centres, 25 (57%) centres responded to the survey. Data from two contacted centres were excluded from the analysis since they did not provide sufficient answers to specific questions on their clinical use of MEG. As a result, answers from 23 (52%) centres were finally considered for the study. Among the responders, 12 centres (52% of the responders) from 10 different countries reported to use MEG for clinical applications in addition to neuroscience research, while 11 centres (48%) only used MEG for neuroscience research. No centre reported to use MEG exclusively for clinical purpose. In those 12 clinical European MEG centres, the percentage of clinical MEG activities (versus research activities) ranged from 1 to 80% (median: 25%). Three centres reported to have started to use MEG for clinical activities between 1990 and 1999, 4 centres between 2000 and 2009 and 5 centres between 2010 and 2015. Of notice, 8 centres were located in or close to a hospital. The number of employees dedicated to the clinical MEG work in each centre ranged from 0 to 6 (median: 3) persons and corresponded to 0 up to 86% (median: 44%) of the total number of people employed by the centres.

3.2. Use of MEG for the pre-surgical evaluation of refractory focal epilepsy

3.2.1. General information

All the 12 European clinical MEG centres included in this study reported to use MEG for pre-surgical evaluation of refractory focal epilepsy with a number of investigations performed in 2014 ranging from 3 to 100 investigations (mean: 45, total: 542) with 7 centres performing $\geq$50 investigations/year. No correlation between the number of investigations performed in 2014 and the

number of years of MEG usage for clinical purpose or the number of employees was found ($p > 0.05$, uncorrected).

In 2014, 9 MEG centres investigated predominantly extra-temporal lobe epilepsies, 2 centres reported to study a majority of patients with temporal lobe epilepsy, and 1 centre did not specify the type of epilepsy. Eight centres investigated children (from <1 year) and adults with epilepsy, while 4 centres only investigated adults (from 15 years). Most of the epilepsy patients came from local or national referrals but 7 centres received few patients referred from other countries.

3.2.2. Data acquisition

All centres record interictal epileptic activity; sampling rate is ≥1000 Hz (1000 Hz–3000 Hz) in 8 centres and 600 Hz in 4 centres. Only 1 centre reported to systematically attempt to capture ictal events and 4 when it was clinically indicated or possible (in patients with frequent daily seizures). Four centres always performed simultaneous scalp EEG recording and 5 when it was possible and clinically indicated (e.g., not performed in children requiring sedation for the MEG, in rather uncooperative patients, or in patients with too big head size). The number of scalp EEG electrodes used ranged between 60 and 128. Most centres reported to acquire MEG data with the patient in the supine position and to change to the sitting position when clinically relevant. Only 2 centres always record data in the sitting position. Half of the centres reported to encourage patients to try to fall asleep during the recording and sleep deprivation was planned in 3 centres. Seven centres used sedation for MEG recordings when clinically indicated, and three of these centres had facilities and staffing to perform general anaesthesia when clinically required. In one centre only, pharmacological agents such as clonidine or etomidate are used when clinically indicated and after having failed to record epileptic discharges in an earlier MEG study.

3.2.3. Data analysis

All centres identify interictal epileptiform discharges (IEDs) manually by visual data inspection, while 4 centres also use other approaches such as template matching or data driven excess kurtosis. Half of the centres also investigate the presence of high-frequency oscillations in source-space data. MEG manufacturer software is most often used for MEG data analysis but half of the centres also use commercial software such as BESA, CURRY or ASA. All centres rely on equivalent current dipole modelling to estimate the source(s) of individual (11 centres) or averaged (5 centres) IEDs. Three centres also rely on beamforming (3 centres) or distributed source modelling (Minimum Norm Estimate or LORETA, 4 centres) for IEDs source reconstruction. Source modelling is performed on co-registered patients' structural MRI in all centres. Sources are typically estimated at the spike peak in all centres and also before the spike peak (onset or rising phase) in 9 centres. Of notice, MEG data are analysed blindly to clinical data in 3 centres.

3.2.4. Time spent

Nine centres provided information about the time typically spent for each step of MEG investigations performed in patients with epilepsy. Patient preparation typically requires between 15 and 120 min (median: 45 min), data recording lasts 60 to 420 min (median: 90 min), data analysis requires 180 up to 4.800 min (median: 480 min, about 8 h), and reporting the results takes between 20 and 360 min (median: 40 min). Of notice, in all but one centre, the reports of the MEG investigations contain figures with epileptic sources overlaid on the patient's structural MRI. No

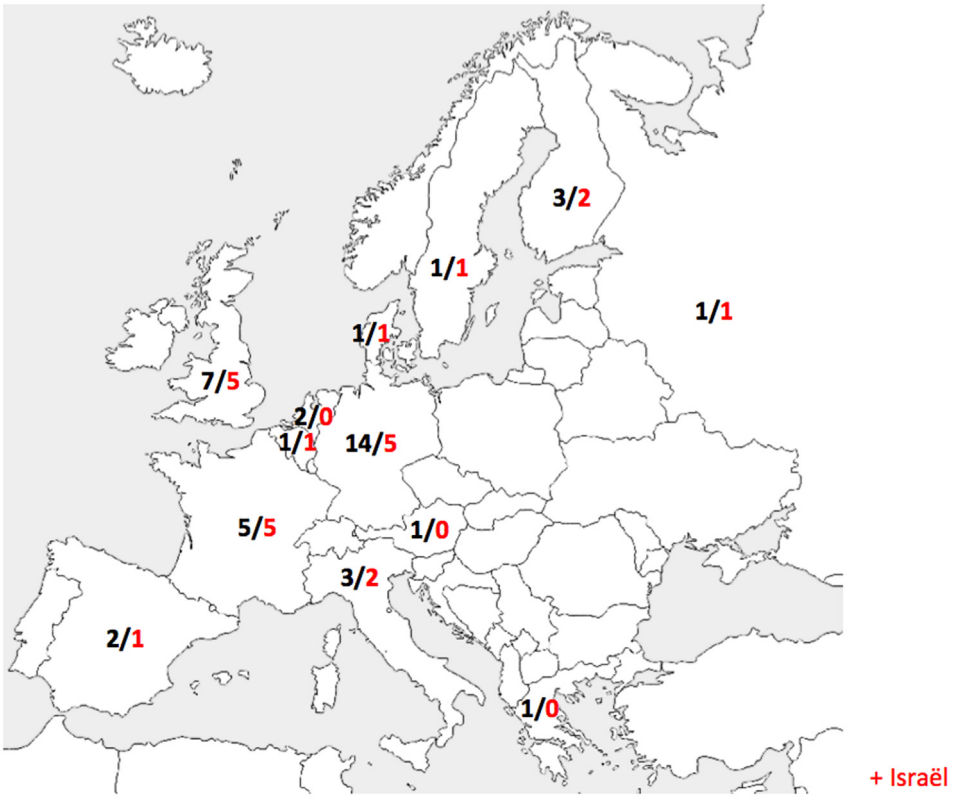

Fig. 1. Location of the MEG centres contacted for the survey across Europe. Black numbers correspond to the number of contacted MEG centres. Red numbers correspond to the MEG centres that answered to the survey. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

significant correlation was found between the number of patients investigated in 2014, the experience of the centres in clinical MEG, or the number of employees and the time required for preparation, recording, analysis, reporting or the total time required from preparation to reporting (all $p > 0.05$, uncorrected). Of notice, MEG centres that investigated more than 50 patients in 2014 spent on average about 8.8 h from preparation to reporting, while those that studied less than 50 patients spent about 32 h on average (not statistically significant, unpaired *t*-test).

3.2.5. Reimbursement

Nine centres also gave information about the reimbursement of MEG investigations for this indication, which was only available in three countries (Denmark, Finland and United Kingdom).

3.3. Use of MEG for pre-surgical functional mapping

3.3.1. General information

Among the 12 clinical European MEG centres included in this study, 10 (83%) reported to use MEG for pre-surgical functional mapping with a number of investigation in 2014 ranging from 2 to 70 (median: 25, total: 244). As for the pre-surgical evaluation of epilepsy, no correlation between the number of investigations performed in 2014 and the number of years of MEG usage for clinical purpose or the number of employees was found ($p > 0.05$, uncorrected).

In 6 of these 10 centres, the investigations are performed in patients with conditions other than epilepsy, while 4 only performed test in patients undergoing pre-surgical evaluation for drug-resistant epilepsy.

3.3.2. Type of investigations

Most of the MEG centres perform somatosensory (using electrical peripheral nerve stimulation or tactile stimulation), motor (using motor evoked fields, mu rhythm suppression, cortico-muscular coherence or cortico-kinematic coherence), visual (using checkerboard pattern reversal stimulation of the visual field), auditory (using mono- or binaural pure-tone auditory stimulation) and language (using covert picture naming, covert verb generation, discrimination of vowels versus tones, discrimination of words versus non-words, verbal memory task or word recognition paradigms) mapping when clinically indicated. A minority of the invited centres reported never to have performed pre-surgical auditory (1 centre), visual (2 centres), language (2 centres) or motor (1 centre) functional mapping.

3.4. Time spent

Eight centres provided information about the time typically spend for each step of pre-surgical MEG functional mapping procedures. Patient's preparation typically takes between 10 and 60 min (median: 35 min), data recording 30 to 120 min (median: 32.5 min), data analysis 30 up to 500 min (median: 240 min, 4 h), and reporting and interpretation of the results takes between 10 and 180 min (median: 30 min). No significant correlation was found between the number of patients investigated in 2014, the experience of the centres in clinical MEG, or the number of employees and the time required for preparation, recording, analysis and reporting (all $p > 0.05$, uncorrected).

4. Discussion

Apart from the evident variability in the current clinical MEG practice across European MEG centres, this study demonstrates that there are several experienced European MEG centres working in accordance with most of the recognized good practices (e.g., as established by the ACMEGS CPG) for clinical MEG. This expertise could serve as a basis for future harmonisation of clinical MEG procedures and promote the added value of clinical MEG across Europe.

4.1. Disparities

The notion that the clinical use of MEG varies across European MEG centre is not surprising since the same was found in the ACMEGS survey [20] and in surveys performed by the European E-PILEPSY consortium about the use and the standards of other methods of investigation such as long-term video-EEG monitoring, neuropsychological assessment or neuroimaging procedures in representative European epilepsy surgery centres [23–25]. More broadly, this is in line with evidence of wide variability in medical/surgical practice among doctors, specialties and geographical regions of the world, resulting in patients with similar clinical problems receiving different care depending on their clinicians, hospital or location [26]. Clinical guidelines are a powerful tool to minimise this often unjustified variability [27]. Surveys assessing the use of specific procedures in a medical community are often considered as a first step towards harmonization and the definition of clinical guidelines [23], as was the case for the ACMEGS CPGs [20]. The substantial diversity in the current practice of clinical MEG across European MEG centres was therefore not unexpected given that the technique is available in centres with different backgrounds, often as evolving from neuroscience research. Still, this survey offers important information and facts that will pave the way for the future development of clinical MEG in Europe, as this field continues to expand with, e.g., 4 further clinical MEG centres inaugurated in Europe since the completion of this survey (information provided by Elekta, Stockholm, Sweden).

Of notice, apart from disparities in clinical MEG practice, this survey also highlights the mismatch in the number of MEG centres between Western and Eastern, and between Northern and Southern Europe (see Fig. 1). Indeed, almost all European MEG centres are located in the Western Europe and most of them in Northern European countries. This geographical disparity (for which aspects like costs might have played a role) should be taken into account at the wider European political level to promote a more equitable access for European countries in which clinical MEG is currently unavailable.

4.2. Establishing the use of MEG for pre-surgical evaluation of refractory focal epilepsy

Seven MEG centres (58% of the European clinical MEG centres that responded to the survey) located in different European countries (Belgium, Denmark, France, Germany, Israel, United-Kingdom) performed $\geq$50 investigations in 2014 (both in children and adults), which is comparable with the mean annual number of clinically indicated and billed epilepsy localization studies reported by US clinical MEG centres for 2006 and 2007 (see Table 1 of [20]). Three of these centres have a long experience (>15 years) of MEG in this clinical indication, while the remaining four have been using MEG for less then 10 years (6.2 years on average). This distribution reflects the continuously increasing numbers of clinical MEG centres in Europe (and worldwide) that reflects increasing recognition of MEG as a clinical tool with dedicated clinical indications. It also nicely parallels what has been described by the ACMEGS [20]. Our findings highlight that—together with other experienced European clinical MEG centres, which unfortunately did not respond to this survey—several MEG centres located in a number of European countries have an established track record in the use of this diagnostic methodology for non-invasive pre-surgical evaluation of refractory focal

epilepsy. This therefore opens the way for a more proactive collaboration of those experienced centres with the newly opened European clinical MEG centres (i) to develop and promote good clinical MEG practice in the field of epileptic network mapping both in children and adults, (ii) to advocate the importance of including MEG in the pre-surgical work-up of certain sub-groups of patients with refractory focal epilepsy (e.g., patients with extra-temporal lobe epilepsy, patients with normal EEG, patients with normal structural MRI, etc.), and (iii) to advocate for the reimbursement of MEG in this clinical indication at the National and the European levels. This survey indeed demonstrates that, despite disparities across centres that contributed to the survey, most of them actually share some commonalities that are in agreement with ACMEGS GCP [28,29].

4.3. Mature and well-documented method

There are now sufficient published studies supporting the clinical utility and validity of MEG in the routine pre-surgical evaluation of refractory focal epilepsy [30]. Indeed, MEG has shown so far sufficient evidence of efficacy [8–12,31–33] to justify its place alongside video-EEG monitoring, structural MRI, PET or ictal SPECT for which –similarly to MEG– there is no Class 1 evidence for their clinical-added value in this indication yet [34]. The evidence from this survey of rapid growth of some MEG centres in terms of numbers of patients with epilepsy investigated, demonstrates that some of the still widespread misconceptions about clinical MEG are probably outdated. Indeed, thanks to the continuous developments in the field, the technical and the logistic constraints typically considered as intrinsic to the MEG technology (see, e.g., [23]) are probably overestimated by most of the epileptologists or neurologists. Newly created clinical MEG centres across Europe can also benefit from the experience of other European MEG centres to initiate their epilepsy program and overcome some of the common difficulties encountered at the starting of such clinical activity. For example, this survey suggests that MEG centres investigating more than 50 epileptic patients per year spend less time from patient preparation to MEG data reporting than those investigating a lower annual number of patients. This highlights the fact that there is indeed a learning curve to be able to conduct efficient pre-surgical epilepsy mapping using MEG. This learning process could certainly be shortened by an exchange in expertise between experienced MEG centres and newly created ones; this corresponds to the primary role of professional clinical MEG societies like EMEGS, ACMEGS and ISACM.

4.4. Room for improvements

Some centres might benefit from the findings of this survey and adapt their MEG protocols in the way data are acquired (e.g., simultaneous EEG should be performed in all centres, availability of sleep recordings could become standard), analysed (e.g., several time points of each IED should be modelled) or reported (e.g., reports of the MEG investigations should contain figures with epileptic sources overlaid on the patient's structural MRI) [28,29]. Interestingly, in the European E-PILEPSY consortium survey that investigated the current use of neuroimaging and electromagnetic source imaging in 25 representative European epilepsy surgery centres, only 7 (28%) centres reported to have access and use MEG (alone or in combination with EEG) for the pre-surgical evaluation of epilepsy [23]. This contrast with the fact that 21 of those centres have access to interictal PET, and that ictal SPECT is available in 19 centres. Furthermore, MEG was still considered by this European E-PILEPSY consortium as a technique that could benefit from further validation [23], which actually contrasts with the available evidence and guidelines supporting its use in this brain disorder [35]. It also contrasts with the results of this survey and those of the ACMEGS [18] showing that there are multiple clinical MEG centres in Europe and the USA that incorporate MEG in the routine work-up of patients with refractory focal epilepsy. Therefore, considering the available clinical MEG expertise in Europe for the pre-surgical workup of refractory epilepsy, there is margin for European MEG centres to join forces and promote their competence and the published data [8–12,31–33] on the clinical added value of MEG for this clinical indication across Europe. A professional clinical MEG society like EMEGS is an eminently suitable forum for such interaction.

4.5. The lack of reimbursement limits the use of MEG

This survey also demonstrates that one of the main limiting factors to the development of clinical MEG is probably the limited reimbursement for the epilepsy indication [23], as only 25% of the 12 centres that contributed to the survey actually benefit from such reimbursement. This also probably explains why all clinical MEG centres are also using MEG for neuroscience research and why there is no centre that uses MEG only for clinical investigations. Future efforts at the European level should therefore concentrate, as done with great success the last years in the USA by the ACMEGS, on the promotion and the dissemination of the recognized clinical added value of MEG in the pre-surgical evaluation of refractory focal epilepsy in order to support request for reimbursement at national level.

4.6. Functional mapping in MEG superior to fMRI-based mapping

Regarding the use of MEG for the pre-surgical functional brain mapping, 83% of the European clinical MEG centres that contributed to this study also use MEG for this recognized clinical indication. Importantly, the number of investigations performed in 2014 is less than half of those performed in the context of the pre-surgical evaluation of refractory focal epilepsy. These findings is similar to the data reported by the ACMEGS survey, which showed that those investigations were actually performed much less often than expected by some neurosurgical institutions that invest in MEG as a "mapping tool" [20]. This was surprising considering the many advantages of MEG compared with fMRI, which is by far the most widely used neuroimaging modality for pre-surgical mapping. Indeed, MEG represents a validated and recognized alternative to fMRI for pre-surgical functional mapping in patients with vascular and other brain disorders (for reviews, see, e.g., [36–40]) as it does not suffer from the same limitations as fMRI (i.e., neurovascular coupling, low temporal resolution). Also, MEG presents an additional key strength over fMRI for the pre-surgical mapping of eloquent cortices i.e. the ability to investigate in one single MEG session different neurophysiological processes (i.e., evoked magnetic responses, induced magnetic responses, coupling between peripheral and cortical signals or between cortico-cortical signals) that can be altered or affected differently by brain disorders or patient's clinical status. MEG therefore provides the unique opportunity to get multiple functional "indicators" or "localizers" of eloquent cortices in a reasonable time for the patients in a much less intimidating environment than fMRI. The anatomical convergence of the different MEG functional indicators/localizers can then be assessed in order to increase the level of confidence about the functional mapping results (compared with a uni- or bimodal approach) and to better determine the clinical need to undergo further intracranial mapping procedures [41]. Despite these obvious methodological advantages over fMRI, MEG still appears clearly underused in this clinical indication. As for epilepsy, much effort therefore needs to be done to promote the

major interests of MEG over fMRI for pre-surgical functional brain mapping. This survey also highlights the need to harmonize the stimulation paradigms or methods used to map eloquent cortices as they substantially vary across centres, as for fMRI. This is the case mainly for sensorimotor and language mapping, which are the two main neural systems investigated for pre-surgical functional mapping.

4.7. Limitations

Finally, this survey has some unavoidable limitations. First, the response level was of 52% and some influential or recently established European MEG centres did not respond. This response rate, which some could consider as relatively low, might be related to the web-based method used to conduct the survey as some studies have suggested lower response rate for such internet-based surveys compared with mail-based surveys [42–44]. Still, this response rate is higher than those usually encountered in web-based healthcare surveys, which typically range around 30–35% [43,45]. Nevertheless, some authors judge that to consider a survey valid, a response rate approximating 60% should be reached [45]. Of notice, the response rate of this survey is substantially lower than those of the ACMEGS (90%); though a different strategy was used to contact the MEG centres [20]. Similarly to the limitations acknowledged in the ACMEGS survey, any survey approach cannot account for any discrepancy between what was declared and what was actually practiced [20]. We cannot therefore properly exclude that part of the data reported here, actually do not reflect the true practice of the contributing centres. Despite these caveats, we believe that this survey data can be valuable and sufficiently representative of the European clinical MEG field since 12 clinical centres from 10 different countries and with different levels of clinical MEG expertise contributed to the present survey for a total of 542 MEG investigations for epilepsy and 244 for functional brain mapping in 2014.

4.8. Conclusions

This survey demonstrates that there is an increasing and widespread expertise in Europe in the field of clinical MEG. This should trigger European clinical Such promotion should aim at (i) harmonizing clinical MEG procedures (indications, data acquisition, sedation protocols, data analyses, data reporting, etc.), (ii) support less experienced professional involved in the development of clinical MEG centres (i.e., clinical magnetoencephalographers, MEG technologists) as well as referring physicians (i.e., epileptologists, neurologists and neurosurgeons), and (iii) obtaining generalized reimbursement for clinical MEG applications. Time has come for MEG to be part of routine clinical protocols for pre-surgical functional and epilepsy mapping, and for the European MEG Society to take the lead of this promotion.

Disclosures

Xavier De Tiège and Ritva Paetau benefited from some consulting fees from Elekta (Stockholm, Sweden) during the last five (XDT) or ten (RP) years. Sándor Beniczky benefited from non-monetary (travel expenses) support from Elekta (Stockholm, Sweden).

Conflicts of interest

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