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Effects of Subthalamic Nucleus Deep Brain Stimulation on Parkinsonian Resting Tremor : An MEG Study

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Abstract

Objective: The pathophysiological mechanisms of Parkinsonian movement disorders are still not fully understood. We have studied the MEG signals and EMG signals of the upper limbs during isometric motor task from a Parkinsonian patient who has undergone bilateral STN DBS implantation. We compared the EMG and MEG oscillatory patterns when the DBS was both 'On' from both isometric find the differences in the coherent frequencies between M1 and resting tremor EMG and associative powers.

Method: Whole head MEG recordings and EMG were obtained from a 62 year old male patient in both DBS 'On' and 'Off'. Coherence and power were calculated in the frequency bands of 1-30Hz. Raw data were studied also.

Results: M1 – EMG coherence in the rolandic area is prominent around 8Hz when DBS is 'Off'. Coherence diminishes when the DBS is 'On'. Raw data shows that regular tremor still exists when DBS is 'On'. Power spectrum is bigger in M1 than EMG when DBS is 'On', and vice versa when DBS is 'Off'.

Conclusions: Although tremor still exists when DBS is 'On', seeing that the coherence has almost vanished between the M1-EMG, it is speculated that DBS effects the low-frequency M1-EMG synchronization which is thought to be responsible for the Parkinsonian resting tremor.

1. Introduction

There has been studies concerning the effects of STN DBS in PD patients [1], but no studies rarely attempted to measure the magnetoencephalography of a DBS device implanted patient has been performed that we know of. The difficulty lies in the fact that the DBS device itself may cause artifacts during recording. We applied the spatiotemporal signal space separation (SSS) method [2] in order to reduce the artifacts that may result from this concern.

2. Methods

The patient was a male, 62 years of age, with mild Parkinsonian symptoms including 5-7Hz right hand resting tremor and rigidity. He had a bilateral STN DBS surgery 3days after the pre DBS MEG measurement. We have used the 306 channel Elekta Neuromag system (Elekta Neuromag Oy, Helsinki, Finland) to record the cortical activities. The system has sensors arranged in triplets of two planar gradiometers and one magnetometer. The EMG signals were recorded from the abductor pollicis brevis of the right forearm simultaneously with the MEG signal employing the data acquisition unit of the MEG-system. Both signals were digitized at 3 kHz, filtered with a pass band of 1~200Hz.

We applied the SSS algorithm in order to reject artifact and noise from the implanted device around the chest and neck [2]. The SSS algorithm can distinguish between the signals coming from within the sphere helmet and from those originating from elsewhere. We expected the SSS algorithm method eliminated at least the device effect from the pacer, though from the lead in the STN, couldn't be excluded.

Analysis and calculation was performed by MATLAB and Elekta Neuromag software. We down-

sampled the raw MEG data from 3kHz to 1kHz, and applied a hanning window with 1,024 samples in order to calculate the coherences. Then EMG signals were investigated through naked eyes, and prominent features were identified.

Finally, full-view coherence topography and power spectrum were produced to compare with the actual tremor signals' activities.

3. Results

The spontaneous signal of the pre DBS state had overall coherence in the low frequency band, peaking at around 8Hz measured in the rolandic area. On the other hand, when DBS was 'ON', coherence was suppressed in the overall frequency band, especially in the rolandic area (Fig.1).

Interestingly, the EMG pattern of the 'ON' mode still maintained the tremor oscillation which was around 5-7Hz though the amplitude was notably diminished (Fig.2).

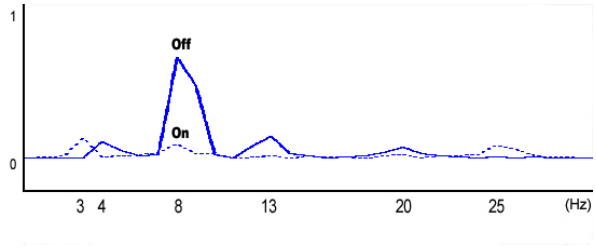

Fig.1 Coherence EMG-MEG from the sensor with the most prominent peak in the rolandic area. The graph with the bigger amplitude of the two gradiometer pairs was plotted.

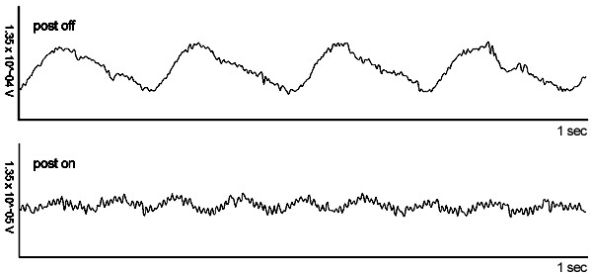

Fig.2 EMG raw data (SSS applied) of post DBS implantation.

Also, we have found that the power of tremor EMG is noticeably decreased when DBS is 'On', whereas the MEG power in the rolandic area is bigger when DBS is 'On' than when DBS is 'Off'.

Even though power still remains in the 'On' tremor EMG power spectrum, the coherence has almost disappeared in the rolandic area (Fig.1). This may be due to the fact that coherence is dependent on the phase of the two signals, so that the DBS treatment may have altered the regularity of the cortical oscillation causing the tremor.

4. Discussions

EMG signals during 'On' and 'Off' states revealed that tremor exists with a considerably reduced amplitude even in the 'On' state. However, the coherence between the tremor EMG and MEG of the rolandic area decreased when the DBS was 'On', compared to when it was 'Off'.

This may indicate that the resting state oscillations which represent the still posture of the body may have to be deliberately maintained by active brain activity. The decreased amplitude of the tremor EMG when the DBS is 'On', combined with the observation that the corresponding coherence is diminished throughout the scalp may suggest that the non-coherent oscillatory state of the resting brain activity may be a result of an effort to keep the oscillations desynchronized.

Studying DBS treated PD with MEG is still a challenging act due to the metallic equipments implanted into the patient's body. We have embodied several methods to compensate for these difficulties, mainly during the analysis process. Also, studies at the source level have been helpful.

Meanwhile, validation study may be needed on the application of SSS algorithm as a solution to cope with the DBS artifacts. More patients may have to be recruited to strengthen the outcomes of our current study, which remains as future work.

The value of the current study is that MEG has been used to analyze the deep brain stimulated PD tremor, which has the benefit of being able to obtain motor task or motor abnormalities data with millisecond precision. Also, the attempt to link the tremor pattern to the M1 – tremor EMG coherence may be a new way to look at the resting state tremor, which leads to viewing it as another active state of the brain.

5. References

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