

Low-frequency Oscillations Characterize Motor Network Plasticity Abnormalities in Patients with Brain Gliomas

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Introduction:

Brain plasticity is a continuous process during slow-growing tumor formation, which remodels neural organization and optimizes brain network function [1-3]. In this study, we aimed to investigate whether motor function plasticity exists in patients with slow-growing brain tumors located in or near to motor areas, and who exhibited no motor deficits. We use resting-state functional magnetic resonance (rs-fMRI) data in the frequency domain, and investigate the relationship between the low frequency band shift and motor functional plasticity changes in patients with brain tumor, and achieve a better understanding of underlying mechanisms.

Materials and Methods:

13 patients with histopathologically confirmed brain gliomas located in or close to the motor cortex and 13 age-matched healthy volunteers were enrolled in this study. Both structural images (3D FSPGR 1x1x1 mm³, 140 slices) and BOLD EPI data (TR/TE = 2500/40 ms, flip angle=90°, 3.75x3.75x3mm³) were acquired. All subjects performed a motor task to identify individual motor activity in bilateral primary motor cortex (PMC) and supplementary motor area (SMA). Frequency-based analysis was then used to investigate possible alterations in the power spectral density (PSD) of low-frequency

oscillations; We divided our frequency range into three domains based on previous findings. For each subject, the predominant power-spectral distribution of resting state time-course in each motor cortex region was estimated corresponding to the 'low frequency' (0.01–0.02 Hz), 'Middle frequency' (>0.02–0.06Hz) and 'higher frequency' (>0.06–0.1 Hz) frequency band. For each group, the average PSD was determined for each brain region and a 2-sample t-test was performed to determine the difference in power between the 2 groups.

Result:

The power spectral density (PSD) of BOLD oscillations in the low frequency band within three key motor regions (LPMC, RPMC and SMA) of controls and patients are shown in Fig. 1. Our result indicated remarkable PSD decrease in patients compared with controls in the range of 0-0.1Hz. A difference between mean PSD of controls and patients in the low frequency band within each key motor region are shown by red and blue traces, respectively ($p < 0.05$). We

Fig. 1 The power spectral density (PSD). a and b show group mean PSD of the left and right PMC between healthy subjects (red traces) and patients with brain gliomas (blue traces). c. Group mean PSD of SMA. d. The localization of 3 key motor regions.

found significantly decreased PSD in patients compared with controls in 3 different frequency bands (low: 0.01–0.02 Hz; middle: 0.02–0.06 Hz; and high: 0.06–0.1 Hz) at 3 key regions. (Fig .2).

Discussion:

For patients with brain tumors, brain plasticity plays an important role in motor and language areas[4]. In current study, our results showed a significant difference in the inter-regional functional connectivity of the LPMC-RPMC between patients and controls. In addition, brain tumor patients exhibited an abnormal amplitude of low-frequency fluctuation activity during the resting state, and showed a significant decrease in PSDs within 3 key motor cortical regions.

our results suggest that the low-frequency brain oscillation is abnormal in patients with brain tumors even in the absence of motor deficits. This finding indicates that power spectral analysis is more sensitive in detecting the underlying neural mechanism abnormality during slow-growing tumor-induced brain motor plasticity, and provides a novel insight for explaining how abnormal oscillations might impact brain plasticity. Furthermore, this finding explores the underlying relationship linking brain plasticity to the low-frequency oscillation.

Conclusion:

The analysis of oscillations in the low-frequency spectrum of patients with brain gliomas appears to be a useful method for investigating motor functional plasticity induced by brain tumors.

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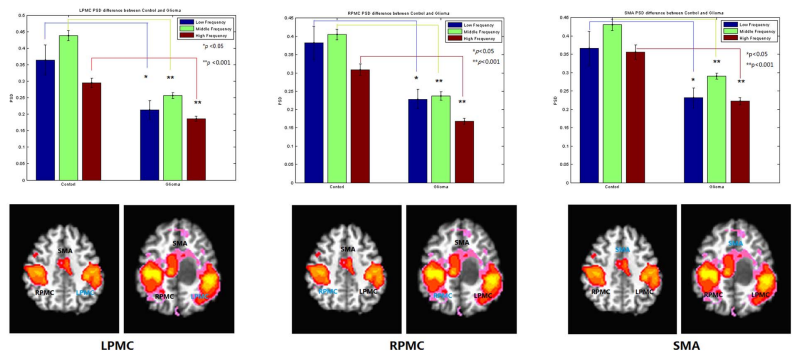
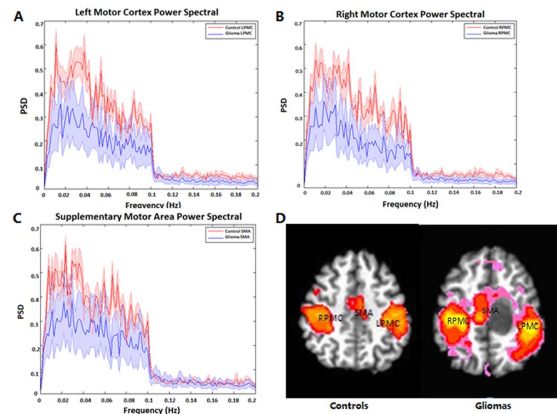


Fig. 2 Bar graphs show the PSD in the 3 non-overlapping frequency bands for the 3 key regions of motor network within healthy subjects and patients with brain gliomas.