

MEG Identification of Reduced Functional Connectivity Following Concussion

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Introduction

Concussion remains a clinical diagnosis with the lack of objective changes on standard brain imaging. Failure to document concussion delays appropriate intervention in this at-risk population. Magnetoencephalography (MEG) is a powerful, non-invasive imaging modality which may offer unique insight into functional brain networks affected in concussed patients.

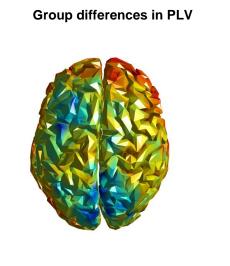
Methods

Ten symptomatic concussion patients with normal MR imaging and seven healthy controls underwent a five minute MEG recording during quiet rest using a whole-head 306 channel Neuromag® Vectorview System. Scans were done within a few weeks to months of injury while still symptomatic. Analysis was performed using MNE python suite and Matlab software. The strength of functional connections between cortical regions was measured using the phase locking value (PLV)1 between all individual sensors. PLV was computed within the delta (1-4 Hz), theta (4-8 Hz), low alpha (8-10 Hz), and high alpha (10-13 Hz) frequency bands. The small world index (SWI) was calculated from the adjacency matrix of pairwise PLV. An SWI value of 1 represents an ideal network that is balanced in terms of local connectivity and global integration. Deviations below 1 signifies a change to a more random network2.

References

1.Lachaux, J. P., Rodriguez, E., Martinerie, J. & Varela, F. J. Measuring phase synchrony in brain signals. Hum. Brain Mapp. 8, 194–208 (1999).

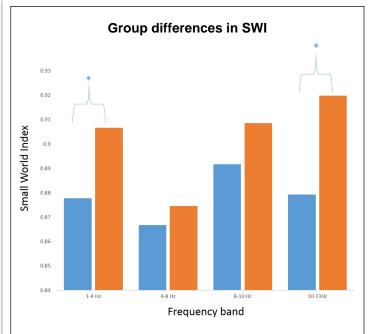
2.Douw, L. et al. Epilepsy is related to theta band brain connectivity and network topology in brain tumor patients. BMC



Differences in PLV in the delta frequency band between the concussion and control groups. Color values represent the t-statistic between groups at each cortical source. Negative values represent a decrease in PLV in the concussion group compared to controls.

Results

The SWI in concussion subjects was significantly lower than healthy controls in the delta (concussion mean=0.8777, controls mean=0.9067, p=0.0458) and high alpha frequency bands (concussion mean=0.8793, controls mean=0.9199, p=0.0232). This lower SWI score indicates an increase in network randomness, suggesting less efficient communication selectively in the delta and high alpha bands.



SWI values for concussion patients and controls in four frequency bands. The SWI was significantly lower in Concussion patients compared to controls in the delta band (p<0.05) and the higher alpha band (P>0.05).

Conclusions

These results suggest that short duration MEG recording may be employed to diagnose concussion. MEG can be used to calculate an objective measure quantifying the degree of global dysfunction that potentially can be used to predict functional outcomes or symptom severity. This is the first study to apply graph theory on MEG acquired data in concussion.

Learning Objectives

Concussion causes electrophysiological changes in brain function

MEG recordings can capture electrophysiological changes caused by concussion