Comparison of electrophysiologic connectivity with imaging connectivity from DWI and resting state fMRI

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BACKGROUND

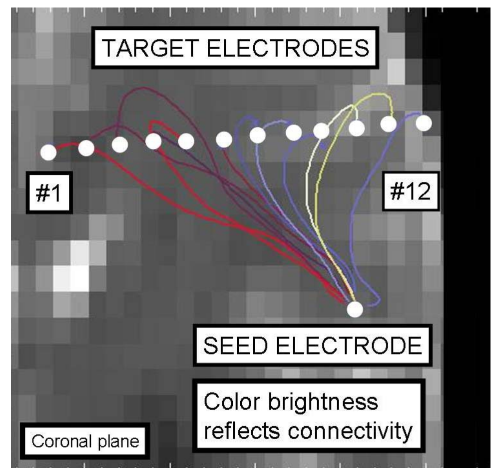
There is tremendous clinical utility for a robust scalar connectivity score between any two arbitrary points in the human brain. For example, one immediate application is patients with pharmacoresistant focal epilepsy, where accurate identification and resection of the true ictal onset zone provides a cure. In practice, however, multiple candidate ictal zones are often identified, likely reflecting underlying connectivity. Thus, any method to rank-order these foci would greatly aid these patents, which necessitates a validated connectivity score.

We present a comparison of invasive electrophysiologic (EP) connectivity with noninvasive imaging measures of connectivity in epilepsy patients undergoing evaluation for presurgical planning. The imaging measures include both resting-state functional connectivity and probabilistic tractography-based connectivity. This study examines both the utility of imaging measures for presurgical planning and the potential of EP connectivity as a test bed for validation of imaging-based connectivity measures.

METHODS

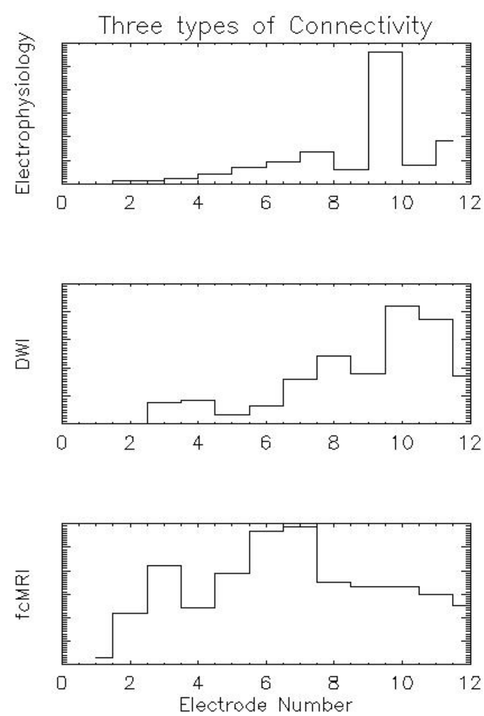
EP connectivity data was obtained in epilepsy patients from both surgically implanted deep stereotactic electroencephalography (SEEG) electrodes, and subdural grid electrodes [Nair DR, et al, Clin Neurophys 119 (2008) 11-18]. While there is no gold standard for EP connectivity, various measures could be obtained from pairs of electrodes using (1) functional arrests after stimulation, (2) seizure propagation patterns, (3) inter-ictal correlations, and (4) direct stimulation of one cortical electrode while recording all other cortical electrodes (CCEP).

Prior to implantation, the patient underwent pre-procedural imaging at 3T, which included high angular resolution diffusion imaging (HARDI) [Tuch DS et al, MRM 48:577-582 (2002)] and resting state fMRI (rsMRI) [Lowe et al. 1998 Neuroimage, 7, 119]. All electrode positions were coregistered to anatomic imaging using in-house software. Post-processing analysis for the HARDI data included probabilistic tracking between all pairs of electrodes containing a stimulus, with a similar parallel analysis for the rsMRI. Scalar connectivity between electrodes were developed and computed, and compared to EP connectivity.



RESULTS

Preliminary results focused on several SEEG probes in one patient, each with up to 12 contacts. On one probe a trigger contact was identified as coinciding with a seizure focus, which was then electrically stimulated while recording all other 92 electrode-contacts. The top figure shows connectivity tracks from the trigger to all 12 contacts on a different probe about 3-4 cm away. Electrode #1 is against the midline, and #12 is around the pial surface. Each pathway is color coded representing the magnitude of a DWI connectivity score derived from probabilistic tracking. The bottom graphs show three connectivity scores to the same electrodes: EP connectivity for CCEP is greatest on cortex adjacent to electrodes #9-10, while DWI connectivity is greatest at #10 and #11 (5 mm apart). fcMRI showed greatest correlation at electrodes #6 and #7.



CONCLUSION

We present a comparison of EP connectivity to imaging connectivity, within a living human brain. Preliminary results show strong concordance of structural connectivity (from DWI) to with EP connectivity (from CCEP). Further data will be presented from all remaining SEEG electrodes, and other patients with subdural grids and SEEG electrodes. Testing of both imaging and EP scoring methods will complement each other, provide validation for connectivity and may satisfy an urgent clinical need for identifying and ranking ictal foci.