Restoration of Interhemispheric Resting-State Connectivity in S1FL Following Median Nerve Injury and Surgical Repair

C. P. Pawela[1,2], B. B. Biswal[3], R. Li[2], A. G. Hudetz[4], and J. S. Hyde[2]

[1]Department of Plastic Surgery, Medical College of Wisconsin, Milwaukee, WI, United States, [2]Department of Biophysics, Medical College of Wisconsin, Milwaukee, WI, United States, [3]Department of Radiology, University of Medicine and Dentistry of New Jersey, Newark, NJ, United States, [4]Department of Anesthesiology, Medical College of Wisconsin, Milwaukee, WI, United States

Purpose: Resting-state functional connectivity MRI (fcMRI) has been introduced as a tool to study longitudinal brain reorganization (1). In this study, interhemispheric brain reorganization was followed using independent component analysis (ICA) in a rat model of peripheral nerve injury and repair. Rats were tracked over a 12-week period.

Introduction: Several independent resting-state brain networks have been previously described in rats (2,3). The strongest of these networks is the cortical sensorimotor system. This network is characterized by strong cross-hemispheric correlation between the resting time-courses of the left and right primary sensory cortex (S1FL). The cortical sensorimotor system is the first component derived from ICA analysis. Recently, we described cross-hemispheric disruption in the sensorimotor cortex caused by complete deafferrentation of the four major nerves of the rat forepaw brachial plexus (median, ulnar, radial, musculocutaneous). This was determined by using both fMRI and fcMRI methods. The hypothesis was made that the cross-hemispheric disruption was due to a unilateral change in thalamic signals into the cortex caused by modifying input into the thalamus. Input into the thalamus was caused by blocking signals from the peripheral nervous system. In this abstract, we describe a similar phenomenon in which a brachial plexus nerve is completely transected followed by immediate surgical repair.

Materials & Methods: Sixty rats were first divided into two groups of thirty rats. One group was assigned as an experimental group and the second as a sham control group. The two groups of 30 rats were further subdivided into groups of six, which were each assigned a specific time-point (0, 2, 4, 8, 12 weeks). The experimental group received a complete transection of the forearm median nerve followed by immediate repair using standard microsurgical techniques. The sham control group received a surgical procedure that mimicked the experimental group approach without any median nerve transection or repair. The subject rats were then allowed to recover for their assigned time point. The animals were imaged in a Bruker 9.4 T animal scanner equipped with a Bruker linear transmit coil (T10325) and Bruker surface receive coil (T9208). Medetomidine was infused through a femoral vein catheter at a continuous rate of 100 µg/kg/hr during the imaging session. Gradient echo scans (single shot EPI, TE = 18.76 ms, TR = 2 s, matrix size 128 x 128, FOV = 3.5 cm, number of repetitions = 110, 10 contiguous interleaved 1 mm slices, acquisition time = 3 min 40 s) were acquired. The images were co-registered to an "idea" anatomy, and motion correction was performed. ICA analysis was performed, and the component corresponding to the cortical sensorimotor network was further analyzed.

Results & Discussion: Figure 1 displays ICA maps from the component corresponding to the cortical sensorimotor system in both the median nerve repair group and the sham control group immediately (0 weeks) following surgery. Figure 2 shows the same component 12 weeks following the initial surgical procedure. Figure 3 is a display of the left and right cortical voxel counts in the S1FL region for the median nerve rats over the 12-week period. Note the trend toward restoration of the bilateral cortical network over the 12-week period. In Fig. 3, left and right refer to the S1FL region corresponding to the left and right paw.

Conclusion: Bilateral symmetry is gradually restored as the nerve input is restored during the nerve regeneration process over the 12-week period.

References: (1) Pawela et al. Neuroimage (2010) 49:2467-78. (2) Pawela et al. Magn Reson Med (2008) 59:1021-9. (3) Hutchison et al. J Neurophysiol (2010) 103:3398-406.

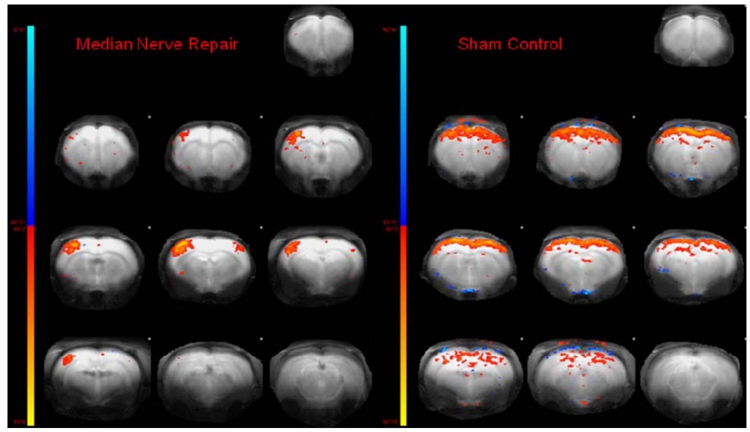

Figure 1: 0 weeks ICA results following initial surgery in the cortical sensorimotor network.

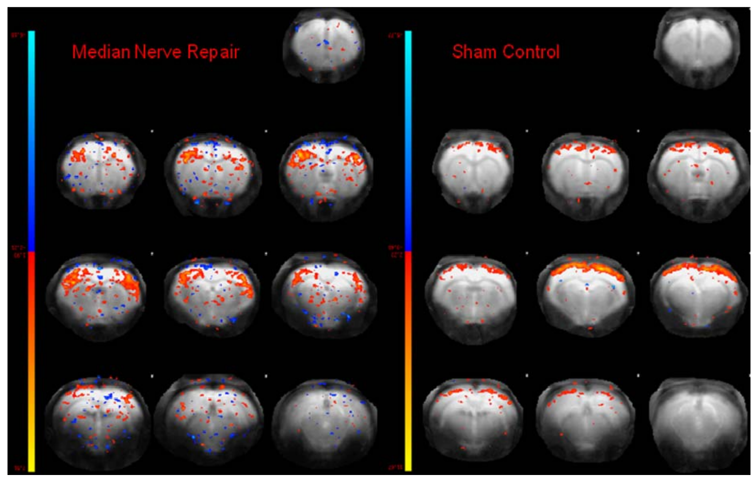

Figure 2: 12 weeks ICA results following initial surgery in the cortical sensorimotor network.

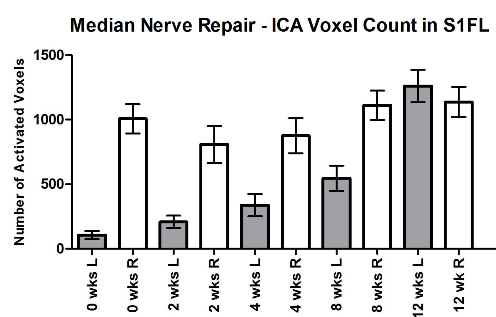

Figure 3: Voxel counts determined from analyzing the sensorimotor network derived from ICA in the median nerve repair group.