Comparing results of median nerve stimulation between healthy and C7 donor rats utilizing BOLD fMRI at 9.4T

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Introduction

Traumatic brachial plexus (BP) avulsion injuries are functionally devastating. Various procedures have been developed to improve outcome including contralateral C7 root transfer[1]. It is disputed whether or not the use of the entire healthy C7 nerve root or its anterior or posterior divisions lead to permanent functional deficits of the uninjured limb, including its contributions to the median nerve.[2, 3] Moreover, it is unclear what effects occur centrally at the level of the cortex after C7 root coaptation in nerve transfer procedures. Previously, we have reported observations of cortical plasticity in response to individual peripheral nerve injury and repair using fMRI and direct nerve stimulation.[4, 5] These studies have shown direct correlations between individual peripheral nerve injury and suppression of cortical activation in corresponding regions of the sensorimotor cortex seen on BOLD fMRI. In this study, the contralateral C7 nerve transfer procedure was performed after complete brachial plexus avulsion injury in order to observe the resultant cortical changes. This particular arm of the study sought to investigate the possible cortical deficits as a result of using the C7 nerve root as a donor nerve for neurotizing the denervated forelimb.

Methods

Animal Preparation: 24 Sprague-Dawley rats were divided into three groups for this survival study: control, injury, and injury & repair. The control group underwent sham surgery with placement of electrodes on bilateral median nerves. The injury group underwent complete brachial plexus root avulsion on the right forelimb and electrode placement on bilateral median nerves. The injury & repair group underwent complete brachial plexus root avulsion on the right forelimb followed by left C7 root neurotization of the right median nerve via an ulnar nerve interposition graft across the chest and electrode placement on bilateral median nerves. Only one of the two divisions of the C7 nerve root was used as a donor nerve; in no case was the entire C7 nerve root sacrificed. The rats were then transferred to a 9.4 Tesla MRI scanner and underwent BOLD fMRI imaging. Additional follow up imaging will be performed at 3, 5, 7, and 10 months post-procedure. **Anesthesia:** Isoflurane 1.4% was administered for anesthesia during the surgery. Upon completion of the surgery and transfer to the scanner, medetomidine (0.1 mg/kg/hr) was administered via subcutaneous infusion and the isoflurane was ceased. Physiologic parameters were monitored during both the surgical and scanning portions of the procedure. **Stimulation Protocol:** Functional scans were performed with stimulation of individual median nerves at 10 Hz, 0.5 mA, and 1 msec duration. This was done in three repetitions of 20 seconds on, 40 seconds off with a four minute resting time between stimulations. **fMRI parameters:** Gradient echo scans (single shot EPI, TE = 18.4 ms, TR = 2 s, matrix 128 x 128, FOV = 3.5 cm, number of repetitions = 110, 10 contiguous 1 mm scans) were acquired on a 9.4T/30 cm Bruker MRI scanner. **Data analysis:** Two sets of gradient echo images were acquired for each stimulation protocol. The EPI scans were registered to an ideal anatomy. The images for each nerve and stimulation protocol were averaged. The averaged data for each nerve and stimulation level was then masked (3dAutomask) using AFNI. Activation was determined by an F test (3dDeconvolve) with a P-value threshold of 0.005 using AFNI. For this arm of the study, results from the control group and the injury & repair groups were compared.

Results

Figure 1 shows BOLD fMRI images after healthy left median nerve stimulation. In the control group, left median nerve stimulation produced activation in the primary sensory forelimb region (S1FL) through 3 slices. The number of activated voxels in this region was 472. In the injury & repair group in which the C7 donor nerve root was used, left median nerve stimulation produced similar activation in S1FL, however, only through 2 slices. The number of activated voxels in this region was 354. In sum, left median nerve stimulation showed diminished activation after use of the C7 anterior or posterior division as a donor nerve.

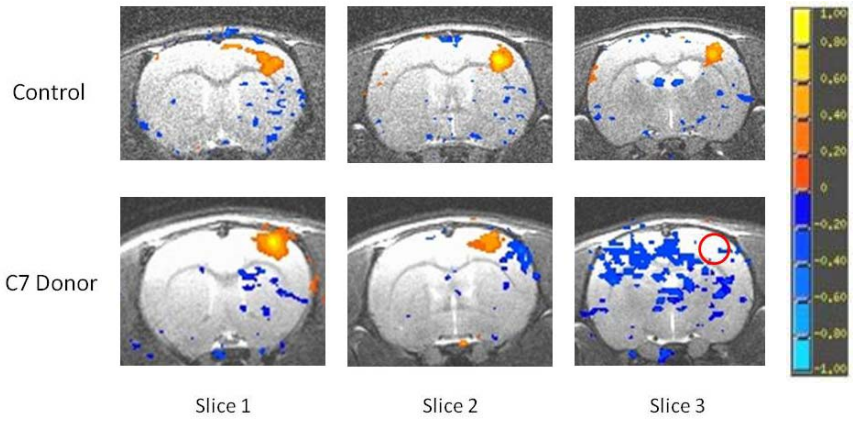

Figure 1. BOLD fMRI images during left median nerve stimulation at time 0 weeks. Note absent activation in C7 donor slice 3.

Discussion

In this study, BOLD fMRI was used to detect early cortical changes following coaptation of the C7 nerve root as a donor nerve for contralateral median nerve repair. Preliminary images and voxel counts show early decreased activation in the median nerve distribution, suggesting a peripheral nerve deficit to be expected after use of a single C7 nerve root division as a donor nerve graft. However, it is hypothesized that over time these cortical deficits will improve and will be seen on future imaging.

References

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