Cortical Plasticity of the Ipsilateral Motor Areas in Cervical Myelopathy following Decompression Surgery

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Purpose

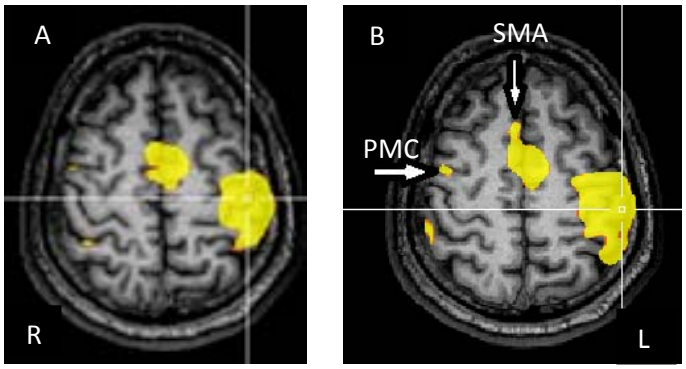
Cervical spondylotic myelopathy (CSM) is a common neurodegenerative disease caused by compression of the spinal cord, which leads to motor and sensory impairment. The purpose of the current study was to contrast the patterns of cortical activation between healthy individuals and patients with CSM before and after decompression surgery. Ipsilateral motor activation has been shown to be prominent in motor learning, especially when additional cortical output is necessary[1]. We hypothesized that prior to surgery, patients with CSM would have a unique cortical representation in response to a motor activity in comparison to healthy controls. Secondly, patients with CSM would show a preferential recruitment of ipsilateral supplementary motor area (SMA) and premotor cortex (PMC) after decompression surgery, compared to pre surgery. Lastly, patients with evidence of increased activation of the ipsilateral SMA and PMC would demonstrate greater functionality as measured by clinical scores.

Methods

A 3 Tesla Siemens MRI was used to acquire functional images in 24 patients and 11 healthy individuals. During the functional task, blood oxygenation level dependent (BOLD) images were acquired continuously using an interleaved echo planar imaging pulse sequence (ipat = 2, 80 x 80) acquisition matrix, 45 slices/volume, 3 mm isotropic resolution, repetition time/echo time = 2500/ 30 ms, flip angle = 90º). Participants were instructed to perform finger to thumb opposition ('duck-quack') using a button box with the right hand. To control the frequency at which participants performed the button tapping, visual cues instructed the participant to tap every 3 seconds during a 30 second interval, followed by a 30 second rest period. Healthy individuals performed the task on two different occasions, 6 months apart from each other, while patients participated before surgery and 6 months post decompression surgery. Functional images were analyzed using BrainVoyager QX software to quantify the volume and the strength of activation (beta value). Clinical functional outcomes were assessed before surgery, as well as 6 months after surgery with the modified Japanese Orthopaedic Association scale (mJOA). Correlations between cortical activation and clinical measures were assessed using the Pearson Product Moment Correlation Coefficient.

Results

Healthy controls demonstrated an increase in ipsilateral activation at baseline compared to CSM patients at baseline. In healthy individuals we found a decrease in both the strength and volume of activation in ipsilateral PMC and SMA at 6 months compared to baseline. Additionally, patients with CSM had an increase in the strength and volume of activation of the ipsilateral SMA 6 months after decompression surgery (B) compared to baseline (A) (Figure 1). Cortical activation of ipsilateral SMA and PMC were moderately correlated ($r = 0.60$, $p < 0.01$ and $r = 0.41$, $p < 0.05$ respectively) at baseline with the mJOA.



Discussion

Ipsilateral motor areas are recruited during the learning of a motor task to assist in the proper execution of the task[1]. The lack of cortical activation in CSM patients at baseline may indicate that compression of the spinal cord limits information from travelling up and down the spinal cord. However six months after decompression surgery, the spinal cord is no longer compressed and sensory feedback signals allow for appropriate recruitment of cortical areas, such as PMC and SMA[2].

Conclusion

The ipsilateral non primary motor areas play an important role in motor learning and may be integral to the rehabilitation of patients with CSM. By learning more about the activation of these areas and the role they play in the recovery process of patients with spinal cord injury, rehabilitation efforts can be tailored and perhaps focused on modifying cortical plasticity to enhance functional recovery.

References

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