Reorganization of Primary Motor Cortex in a both Upper Extremities Amputee with Skilled Foot Movement Ability

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Introduction

Several experiments (Wu CWH et al. 1999, Farsin H et al. 2001) have shown an expansion of the adjacent cortical representations into the cortical area representing the deafferentated body part. But study on amputee with skilled foot movement ability hasn't been reported. This study was aimed to investigate how functional and structural PM would change when amputee achieved dexterous foot movement skill.

Methods

Amputee, male, 30 years old, who lost both upper extremities because of high voltage shock, at age 4. The sites of amputation were both on shoulder. He hadn't used prosthesis. After long time effort, he was good at Chinese-writing, Chinese-sculpture and Chinese-painting with his foot (Fig 1). Six right -handed sex- and age-matched healthy subjects were studied as control group at same time. All subjects were involved in a performance test on rough and delicate movement of foot. MRI Data were acquired by using a 1.5 T GE SIGNA CV/I. SE T1 image was scanned as anatomy reference. FMRI data were acquired by EPI sequence. Scan scheme included up-down movement of right toes, open-closure of both eyes and right hand fingers tapping (control group). Using block design, each active state alternated with a rest state, each state lasted 24s and every task repeated 3 times. Voice instructions were edited by Goldwave 5.08. FMRI data were analysed by AFNI with consistent parameters. At last, 3D T1 image (3D-FSPGR, thickness =1mm) were scanned. We measured width and depth of the hand knob (hand representation) within the central sulcus of the amputee on T1 image, according to the protocal of Yoursy (1997). Sizes of hand knobs from other 10 healthy volunteers were measured additionally. Results from amputee were compared with those of healthy normal volunteers.

Results

During all three trials, active areas of normal volunteers displayed consistency with previous knowledge, while the eye representation of the amputee did not show significant difference with those of normal volunteers. The foot tapping of the amputee activated much more area than control groups. The area extended into the hand knob of the contralateral precentral gyrus, which was consistent with the finger tapping area of control group (Fig 2). From axial T1 image section, both central sulci of the amputee were inverted omega sign, without atrophic parietal lobule. The transverse diameter and depth of inverted omega of the amputee were among the 95% confidence interval as compared with normal volunteers.

Discussion

Our study suggests that the dramatic reorganization may involve new connections between gyrus, by collateral sprouting. We propose that due to the hand PM being involved in the foot movement after long-term practice, the central sulcus keeps its function and structure. These results are different with the brain plasticity of amputee without skilled foot movement ability. We consider that competitive plasticity is involved. Our study maybe supports the theory basis for developing potential ability of amputee extremity.

Reference

Wu CWH, et al. Neurosci. 1999,19:7679–7697.

Farsin H et al. Neuroreport.2001,12:957-962

Yousry TA et al. Brain.1997, 120, 141–157

Fig1

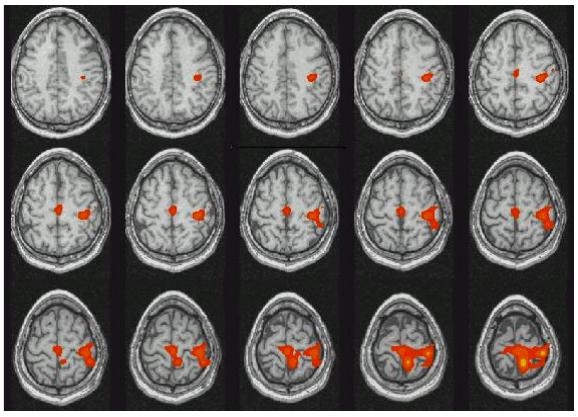

Fig 2

Fig1 The amputee was painting on a fan, using a writing brush. (permission from the amputee)

Fig 2 Foot representation of the amputee extended into the absent hand representation