Plasticity of the primary motor cortex in bilateral upper-extremities amputees with different foot movement skill

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Introduction

There are many dramatic examples that have revealed the human brain as a remarkably adaptable organ. In the last scientific meeting and exhibition of ISMRM, it has been reported that toe tapping activated cortical hand area in a both upper-extremities amputee with excellent foot movement skill (YU XJ et al. 2005). To further elucidate whether such phoneme is common and whether this is associated with the obtaining of foot movement skill, we studied five upper-extremities amputees with different foot movement ability.

Methods

Five both upper-extremities amputees were involved in the studies (Table 1). Six right -handed sex- and age-matched healthy subjects were studied as control group at same time. Every volunteer was told to trace a circle with a radius of 50 mm with his right foot using a pen between the big toe and the second toe. The individual sum of deviation was calculated as a performance test result. fMRI Data were acquired by EPI sequence using the 1.5 T GE SIGNA CV/I. SE T1 image was scanned as anatomy reference. Scan scheme included up-down movement of right toes and right hand fingers tapping (the 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. At last, 3D T1 image (3D-FSPGR, thickness =1mm) were scanned. fMRI data were analyzed by AFNI with consistent parameters.

Results

From the resulting deviation measurements of the performance test, the sum of deviation of case 1 was 1.30mm, case 2 was 0.40mm, case 3 was 9.90mm, case 4 was 16.30mm, case 5 was 58.70mm, while the control subjects had a mean Sum of 60.85mm (Min=42.50 mm, Max=81.25 mm, SD=6.32 mm). It can be concluded that case 1 and case 2 possessed more excellent foot movement skill than case 3 and case 4. From the fMRI data, in addition to activation of the foot area, toe movement of case1 and case 2 activated the contralateral precentral and postcentral gyrus, the finger tapping area of the control group, and toe tapping of case 3 and case 4 activated the bilateral precentral and postcentral gyrus (Fig 1). Toe tapping of case5 only activated the paracentral lobe, the classic foot area.

Discussion

Toe tapping of case 1-4 activated the contralateral or bilateral hand area, while that of case 5 did not activate it. According to the previous study (Cramer SC et al. 1999) simple motor tasks activate contralateral precentral gyrus, while complex motor tasks activate the bilateral precentral gyrus. We think because of possessing different foot movement skill, case 1 and case 2 would 'feel' the task of toe tapping more easier than case 3 and case 4, as resulted in different activation site We consider that plasticity of the primary motor cortex is responsible for obtaining foot movement skill and reorganization of the primary motor cortex in the amputee is related with higher and more complex brain functions.

Reference

Yu XJ, et al. The Thirteenth Scientific Meeting and Exhibition of ISMRM. 2005

Cramer SC, et al. J Neurophysiol 1999,81:383-387

Figure 1

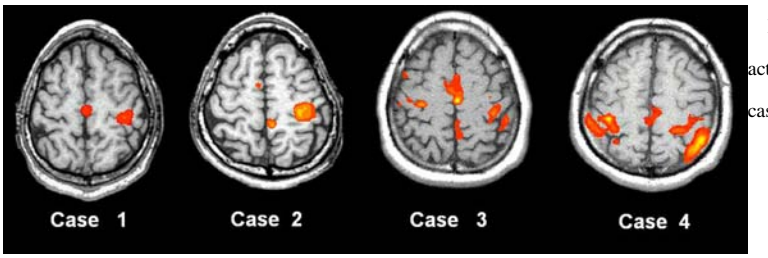

Figure 1: In addition to activation of the foot area, toe tapping of case1 and case 2 activated the contralateral precentral and postcentral gyrus, and toe tapping of case 3 and case 4 activated the bilateral precentral and postcentral gyrus ($P<10^{-8}$).

Table 1: Patient data

Case	Age at time of investigation	Site of amputation L	Site of amputation R	Age at time of Amputation	Activities with foot every day
1	30	On Shoulder	On Shoulder	4	Painting, writing and daily living activity
2	33	Above elbow	Below shoulder	8	Sculpturing, writing and daily living activity
3	32	Below shoulder	Above shoulder	10	Daily living activity
4	37	Below shoulder	Below shoulder	6	Daily living activity
5	35	Below elbow	Below elbow	6	Only responsible for locomotion and gesture