

Case report

Neurorehabilitation of congenital mirror movements enhanced by stroke: A case report with fMRI study



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1. Case present

Congenital mirror movements (CMMs) occur in childhood and disappear after neurological maturation. Persistent MMs may occur in complex neurological syndrome. Acquired mirror movements can be resulted from brain injury, stroke or other disease [1–3]. Though the mechanism of mirror movements is not elucidated, the insight into the motor cortex in mirror movements has been done with the neuroimages recently [2–4]. Here, we present a CMMs case who presents more severe MMs after stroke. A series of rehabilitation program and function Magnetic Resonance Image (fMRI) study

are performed to resume the motor function and to investigate the motor training effect of this MMs case.

A 47-year-old woman with right dominant hand is admitted for left hemiparesis due to right corona radiata infarct. Her bimanual activities were slightly affected before the stroke due to MMs. Her MMs become more severe after stroke: for instance, the unaffected hand performed the same movement when she tries to tighten a screw with her affected hand. In addition, involuntary movements of the affected hand presents during the normal hand move. MMs occurred less often when performing simple and repetitive activities; while the condition worsened during complex activities. Initially we applied constraint-induced movement therapy (CIMT) to restrain the unaffected upper extremity and provide training for the affected upper extremity in first four months according to previous re-organization of motor-related regions theory [5]. However, myofascial pains occur due to overuse of the substituted muscles. For example when the patient raises her arm, parts of the body, such as the shoulders, neck, face, eye muscles, and even toes, are substituted for the restrained normal arm. Thus, activity of daily life (ADL) is limited and quality of life is decreased. Consequently, it is difficult to continue CIMT in this CMM recover from stroke. Then we try to apply the bilateral training and task-oriented interventions for the

Abbreviations: CMM, congenital mirror movement; fMRI, function Magnetic Resonance Image; SPM, statistical parametric mapping; MRC, Medical Research Council scale; FMA, Fugl-Meyer Motor Assessment; ADL, activity of daily life; CIMT, constraint-induced movement therapy; TCI, transcallosal inhibition; IPC, ipsilateral corticospinal; SMC, sensorimotor cortex; SMA, supplementary motor area.

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Table 1

The various assessments record after different neurorehabilitaion.

Time	Sites	1st month	5st month	10st month
Training plan				
Fugl–Meyer Motor Assessment (FMA)	Forearm Wrist/hand	4 (36) 2 (36)	18 (36) 27 (36)	34 (36) 30 (36)
Criteria of Woods and Teuber for MM	Forearm Wrist/hand	1 0	4 4	3 3
Medical Research Council scale (MRC)	Forearm Wrist/hand	3 2	4 3	4 4

CIMT, constrained induced movement therapy; Fugl–Meyer Motor Assessment (FMA) values in parentheses illustrate the maximal value of the FMA.

Criteria of Woods and Teuber for mirror movement (MM): Grade 0: no clearly imitative movement; Grade 1: barely discernible repetitive movement or increased tone; Grade 2: either a slight but unsustained repetitive movement, or a stronger but briefer repetitive movement; Grade 3: a strong and sustained repetitive movement; Grade 4: a movement equal to that expected of the intended hand. Medical Research Council scale (MRC): 0, no contraction; 1, palpable contraction, but no visible movement; 2, movement without gravity; 3, movement against gravity; 4, Movements against a resistance lower than the resistance overcome by the healthy side; 5, movement against a resistance equal to the maximum resistance overcome by the healthy side.

training due to the evidences of motor recovery on post stroke and MMs cases [6,7]. We design ADL training, such as pouring water, holding a spoon and picking beans. We encourage the patient to utilize the intact limb to promote functional recovery of the impaired limb from easy to difficult tasks through repetitive practice. During rehabilitation, she experiences little involuntary movements of her affected upper limbs. This phenomenon gradually improves during recovery. All the procedures are under the permissions of the institutional review board at Chang Gung Hospital.

2. fMRI task

Magnetic resonance imaging (MRI) scans were obtained with a 3.0T human MRI scanner (MAGNETOM, Verio, Siemens; Munich, Germany). Functional images were obtained using a blood oxygenation level dependant single-shot multislice T2*-weighted gradient-echo EPI sequence. The brain patterns of cortical activations following the task consist of repetitive sequential gripping of a small ball with right hand. They are investigated under fMRI and a block design, in three periods of activation alternated with four periods of rest. During the task, MM of the left paretic hand was observed. Analysis of fMRI data is performed by statistical parametric mapping (SPM5). We report activations below a threshold of $P \leq 0.05$, corrected for multiple comparisons [2,3,8].

3. Result

In one month after the stroke, the Brunnstrom's stage of her affected upper extremity movements was from II to III; and till nine months was from III to IV. The improvement of Fugl–Meyer Motor Assessment (FMA), criteria of Woods and Teuber and Medical Research Council scale (MRC) assessment of her affected upper limb's are recorded in Table 1 [3–5]. The fMRI is applied to investigate the effect of different neurorehabilitation applications with the brain activation areas. These activation areas of her movement during the fMRI study are listed in Fig. 1.

4. Discussion

The theories of MMs include (1) deficient transcallosal inhibition (TCI) (2) ipsilateral corticospinal (IPC) tract influence [1]. According to the intermanual crosstalk models, two independent motor plans exist. One is deficient TCI; the other crosstalk is through IPC. Most corticospinal fibers cross the contralateral side at the pyramidal decussation and form the lateral corticospinal tract; approximately 10% of the fibers remain uncrossed, descending in the ventral corticospinal tract. It results in that each hand is mainly controlled by the contralateral hemisphere, while an ipsilateral side is also integrated with transcallosal inhibition in motor control [1,4,8,9].

Though the muscle power recovery well in the upper extremities of this case, she could not complete the complex bimanual task due to more severe MMs than before. CIMT is conducted based on the previous evidence of contralateral SM1 and ipsilateral cerebellum achieves satisfactory recovery after stroke [10]. After initial CIMT, she gets little improvement and the activated brain areas are primary sensorimotor cortex (SMC), supplementary motor area (SMA) and spinocerebellum areas under the fMRI task (Fig. 1a). Our study of next bilateral training show better results on the recovery of functions. It tends to induce more activation areas on the similar area (SMC, SMA and spinocerebellum). We acknowledge that there was a bias of successive scans over time, which makes it theoretically impossible to exclude that the differences in activations were due to a non-specific time effect, unrelated to the rehabilitation strategy. Nevertheless, we propose bilateral movement training able to facilitate cortical neural plasticity in this case through the mechanisms: (a) motor cortex disinhibition that allows increased use of the spared pathways of the damaged hemisphere, (b) increased recruitment of the ipsilateral pathways from the contralateral hemisphere to supplement the damaged crossed corticospinal pathways, and (c) upregulation of descending premotor neuron commands onto propriospinal neurons [6–10]. Besides, we also demonstrate better neural plasticity effect of the bilateral movement training than CIMT from the more brain activation areas at this fMRI study (Fig. 1b) [8,9].

Although there are multiple case reports of congenital mirror movements and fMRI in the literatures, our case provides new inspirations of motor control mechanism of congenital MM after stroke. First, to our knowledge, the present study is the first study upon the neural plasticity effect on congenital mirror movement after stroke through different neurorehabilitation process. Second, the progression of MMs on this CMM case after stroke should result from deficient transcallosal inhibition after the stroke with lesion at corona radiata since it is indicated the contralateral hemisphere inhibits the IPC tract through the transcallosal fiber as the corpus callosum matures in previous post stroke MM study [2–4]. Thirdly, review from the previous studies, CIMT did not provide satisfactory effect may result from less involvement of the contralateral SMC, SMA and the ipsilateral cerebellum with deficient interhemisphere coordination. It suggests the horizontal plasticity is non-specific in CIMT; while the widening of the paretic hand representation beyond the primary somatomotor areas is observed in bimanual training [6–10]. Moreover the effect of bimanual movement training with task goal can be explained by neural plasticity and neural repair around the lesion area by interhemisphere communication, which can be through transcollosum fiber [6,10]. Furthermore, this fMRI study on CMM after stroke can show us the different brain activation areas and activities of crosstalk between two hemispheres on different neurorehabilitation process. Finally our result

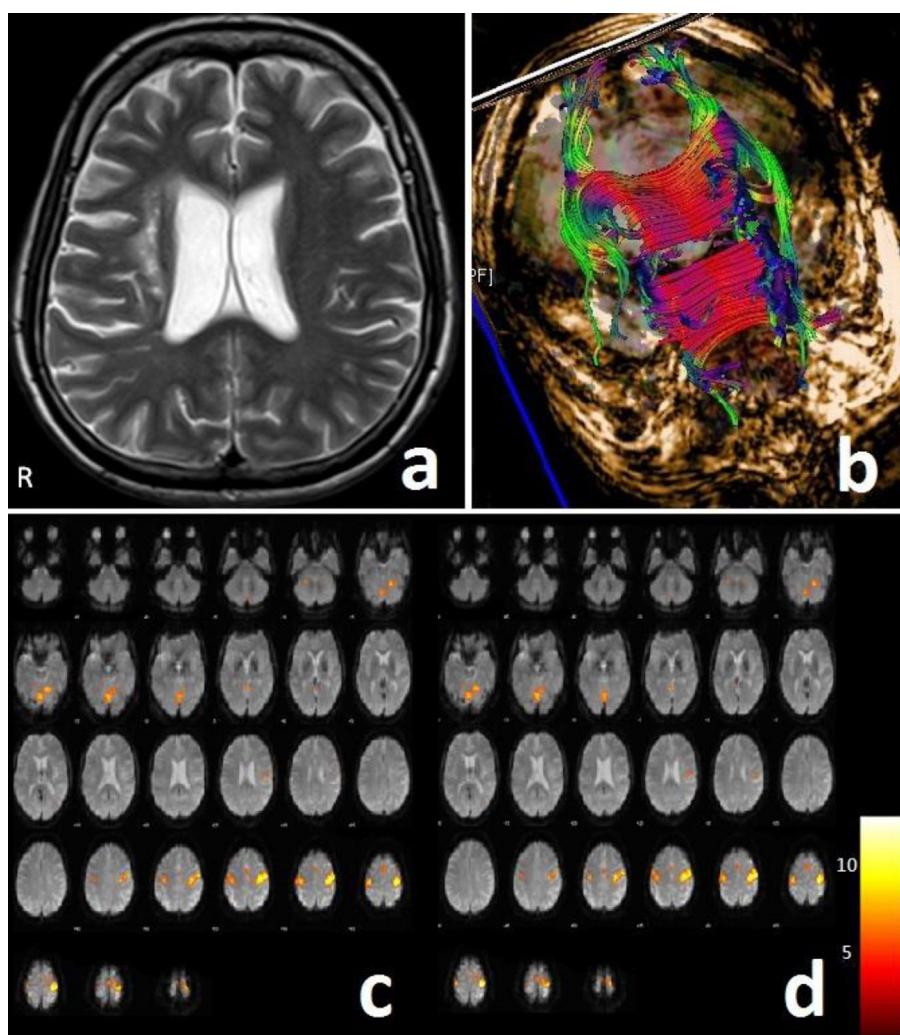


Fig. 1. (a) Axial T2-weighted imaging shows infarction in right corona radiate. (b) Diffusion tensor tractography shows reduction of inter-hemispheric connecting white matters in the body of corpus callosum. (c) Functional MRI following constrained induced movement therapy (CIMT) and (d) functional MRI following bimanual training. The primary sensorimotor cortices (SMC), supplementary motor area (SMA) and spinocerebellum are activated during unilateral hand gripping. Increased signal intensity is more active in both hemispheres at (d) than (c) (CIMT).

can give some guidance on the neurorehabilitation approach on the acquired MMs such as post stroke MM. However, more evidence and more preliminary studies are warranted.

Conflict of interest

All authors have no conflict of interest.

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