Effects of Mirror Therapy combined with ‘Tong Du Xing Shen’ Acupuncture Therapy on Function Recovery of Upper Limbs after Stroke

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Abstract

Objective To investigate the effects of mirror therapy (MT) combined with ‘Tong Du Xing Shen’ acupuncture method on functional recovery of upper limbs for stroke patients. Methods Sixty patients with upper extremity motor dysfunction after stroke were selected and divided by random into mirror (n=20), acupuncture (n=20) and combination group (n=20). Patients in mirror group received MT treatment, patients in acupuncture group received ‘Tong Du Xing Shen’ acupuncture therapy treatment and those in combination group received MT treatment and at the same time were supplemented by ‘Tong Du Xing Shen’ acupuncture treatments. Treatments lasted for four weeks. The three groups of patients were assessed before the treatment and after that for 2 weeks, 4 weeks. Assessment content included Fugl-Meyer motor function (FMA) of upper limbs, Brunnstrom upper limb and hand staging, Barthel index (BI), and hemiplegia dorsal wrist active range of joint activities (AROM). Functional magnetic resonance imaging (fMRI) examinations were conducted for 6 cases in combination group before rehabilitation treatment and after 4 weeks of the treatment. Results After 2 weeks and 4 weeks of the treatments, the upper limb motor function FMA score, Brunnstrom upper limb and hand staging, and hemiparalysis of the dorsal wrist AROM as well as BI of the patients in three groups were all improved comparing with their scores before the treatments. Conclusions Mirror therapy combined with the ‘Tong Du Xing Shen’ acupuncture can better improve patients’ motor function of upper limbs, which could effectively improve the patients’ daily living abilities.

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About 55% - 75% of patients after the onset of stroke will have limb dysfunction that caused by the trait. And hand dysfunctions will account for more than 80% of them [1, 2], which seriously affect patients’ daily life, working and studying [3-6]. Mirror therapy (MT) was first applied by Ramachandran in 1995 for the treatment of phantom limb pain after amputation. Since then, one after another study used MT for rehabilitation of patients with stroke, hand trauma, and chronic regional pain syndrome [7, 8]. Acupuncture is now widely employed for the rehabilitation of stroke patients, and its efficacy has also been generally affirmed. To improve the curative effects and explore new ways of integrative Chinese and western medicine, this study utilized mirror therapy combined with ‘Tong Du Xing Shen’ acupuncture for the treatments of patients who suffered upper limb dysfunctions after stroke. The method obtained satisfactory clinical efficacy, which are reported as follows.

Materials and methods

Patients

Sixty patients with stroke admitted to Department of Rehabilitation Medicine of the Second Affiliated Hospital of Nanchang University from June 2015 to June 2016 were enrolled. Patients should satisfy following criteria: (1) In line with the diagnostic criteria of stroke that developed by the Fourth National Conference on Cerebrovascular [9], patients should be confirmed by brain CT or MRI to have cerebral hemorrhage or cerebral infarction. (2) It should be the initial onset, and patients have paralysis of one limb. The duration ≤ 6 months. (3) Patients’ age ≤ 75. And patients’ vital signs are stable. Score of Mini-Mental State Examination (MMSE) > 22 [10]. (4) Patients do not have visual impairments, can understand visual information. They are able to execute general instructions. (5) Patients are willing and able to cope with the treatment as well as sign an informed consent form. Exclusion criteria: (1) Patients have stable conditions but they have severe depression or anxiety. (2) Patients who concurrent severe heart, liver, kidney disease and infections. (3) Patients who concurrent with other diseases that affect motor function. (4) Patients that have poor compliance. All patients were divided by random number tables into mirror group (20 cases), acupuncture group (20 cases) and combination group (20 cases). There were no significant differences regarding the general clinical data such as age, sex, course of disease and pathological changes among all groups (P>0.05) so that they are comparable (Table 1).

Treatment methods

All patients received routine rehabilitation therapy such as joint mobility training, physical therapy, neurotransmission technology, operation treatment, etc. On basis of the regular treatments, special treatments are conducted for each group. Patients in MT group were treated with MT. Acupuncture group patients
were treated with ‘Tong Du Xing Shen’ acupuncture therapy and patients in combination group were treated with MT therapy as well as supplemented by ‘Tong Du Xing Shen’ acupuncture therapy.

1. **Mirror therapy.** Patients in MT group are treated by MT. At the initial stage of the treatment, the MT mechanism and training methods were explained and instructed to the patients. Treatments were conducted in a relatively quiet room with single color of the surrounding environment, and decorations on patients’ upper limbs and hands were removed before the treatment. Patients were asked to sit by the table, on top of which a 40cm × 40cm mirror was placed. The injured limbs were put on the side of the mirror’s non-reflective surface while the healthy limbs were put on the side of mirror’s reflection surface, and the two upper arms were equidistant from the mirror surface. The therapist first explained and showed the action to be taken and then the patient imitated [11, 12]. Five actions were instructed for the patients to complete using the contralateral upper limbs, which included flexion of the shoulder, flexion and extension of the elbow, pronation and rotation of the forearm, flexion and extension of the wrist, extension and grabbing actions of the finger [13]. It was required to do 4 min for each action and to reach the maximum range of joint activity. We required patients to avoid watching the actions of healthy hands. Patients were asked to watch the motion of the contralateral upper limb and image that the limbs on the affected side were in motion. To the greatest extent, the injured limbs should do the same movements as the contralateral limbs do [11, 14]. The training was conducted once per day and 20 min once. The process would be carried out 6 days a week, and last for 4 weeks.

2. **‘Tong Du Xing Shen’ acupuncture method.** Patients in acupuncture group were treated by ‘Tong Du Xing Shen’ acupuncture therapy. Patients should sit down and exposure their acupuncture points. Select Baihui, QianShenCong and other acupuncture points. Make acupuncture on Baihui and top frontal oblique of ipsilateral side. Quickly twist tactics after the gas gain. The twisting needle speed is maintained at about 200 times / min. Twist the needle once every 10 min, and twist for 1-2 min every time. For the remaining acupoints, acupuncture is applied to supplement and relieve diarrhea. Once a day and 20 min / time. 6 day per week for 4 weeks.

3. **Combined therapy.** Patients in combination group received MT treatment and at the same time were supplemented by ‘Tong Du Xing Shen’ acupuncture treatments (Figure 1). Treatments lasted for four weeks. 6 days per week and once a day. 20 min for each time.

**Assessment method**

Efficacy was assessed before the treatment and after 2 and 4 weeks of the treatment respectively. The same physician who neither attended nor knew the patient grouping would conduct all assessments in the quiet and bright environment. The upper extremity was scored by Fugl-Meyer assessment (FMA) with a total of 66 points. The higher the score, the better the up-
per extremity motor function [8]. The FMA scores of upper limbs’ motor function, Brunnstrom motor function assessment was used to assess the staging of upper extremity and hand function [15]. Protractor is utilized to determine the active range of motion (AROM) of patients with hemiplegic lateral wrist stretch. The Brunnstrom index (BI) was used to assess the daily life activities and abilities of patients with a total score of 100 points. The higher the score, the better the activity ability of patients in daily life [9].

Six patients in combination group were treated with functional magnetic resonance imaging (fMRI) before and after 4 weeks of the treatment, and the mechanism of combination therapy was explored. For fMRI examination, block design is used. Injured hands of the patients took fist exercise for 1 min, and then they rested for 1 min. The process was repeated for 5 times with total of 10 min. In this manner, the activated image of the brain function area was observed and captured.

**Statistical analysis**

SPSS17.0 statistical software package is utilized to analyze the data in the current study. Measurement data with normal distribution or approximately normal distribution is denoted by \( \bar{x} \pm s \). Comparisons of the measurement data are conducted by ANOVA. Kruskal-wallis analysis is employed to compare quantity data. \( R < 0.05 \) is considered as statistically significant.

**Results**

Before the treatment, there was no significant difference among the three groups concerning FMA scores of upper limbs’ motor function, AROM scores of hemiparesis, and BI score (\( R > 0.05 \)). After 2 weeks and 4 weeks of treatment, all the scores of the 3 groups are superior to those before the treatment and the differences were statistically significant (\( R < 0.05 \)). After 2 weeks and 4 weeks of treatment, the FMA scores of upper extremity motor function and AROM of hemiplegic dorsal wrist in the combination group were superior to those of patients in MT group and acupuncture group. There were significant differences (\( P < 0.05 \)). After 2 weeks of treatment, BI score in the combination group was improved compared with that of the MT group, but the difference was not statistically significant (\( R > 0.05 \)). While after 4 weeks of treatment, all scores of the combination group were better than those of the MT group and the acupuncture group, and the difference was statistically significant (\( R < 0.05 \)). After 2 weeks and 4 weeks of treatment, the AROM score on the dorsal wrist with hemiplegia in MT group was better than that of acupuncture group. There were significant differences (\( R < 0.05 \)). After 4 weeks of treatment, the BI score of MT group was better than that of acupuncture group and there were significant differences (\( P < 0.05 \)). The remaining scores in MT group got improved comparing with the acupuncture group over the same period, but the difference was not statistically significant (\( R > 0.05 \)). Detailed data is listed in Table 2.

There was no significant difference (\( R > 0.05 \)) regarding Brunnstrom upper limb and hand staging scores among the three groups before
the treatment. After 2 and 4 weeks of treatment, both MT group and the acupuncture group with the three groups obtained better scores than theirs before the treatment with significant differences (P < 0.05). While the score of MT group was better than that of the acupuncture group without significant difference (R < 0.05). After treatment for 2 and 4 weeks, the Brunnstrom ipsilateral upper limb staging results of the patients in the combination group were better than those in both MT group and the acupuncture group with significant differences (P < 0.05). While the score of MT group was better than that of the acupuncture group without significant difference (R > 0.05). The specific results are listed in Table 3.

### Table 1. Comparison of general clinical data between 3 groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Sample</th>
<th>Gender</th>
<th>Age</th>
<th>Course</th>
<th>Pathological change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>F</td>
<td>(x±s)</td>
<td>(x±s) week</td>
</tr>
<tr>
<td>Combination</td>
<td>20</td>
<td>16</td>
<td>4</td>
<td>55.15±10.97</td>
<td>2.82±2.88</td>
</tr>
<tr>
<td>Mirror</td>
<td>20</td>
<td>18</td>
<td>2</td>
<td>54.90±11.29</td>
<td>4.43±4.10</td>
</tr>
<tr>
<td>Acupuncture</td>
<td>20</td>
<td>16</td>
<td>4</td>
<td>54.80±10.14</td>
<td>3.12±2.47</td>
</tr>
</tbody>
</table>

### Table 2. Comparisons regarding FMA upper limb score, wrist back stretch AROM and BI score of patients before treatments, after 2 weeks, 4 weeks of treatments (x±s).

<table>
<thead>
<tr>
<th>Group</th>
<th>Sample</th>
<th>FMA score of upper limb</th>
<th>Wrist back stretch AROM (°)</th>
<th>BI score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combination</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before treatment</td>
<td>20</td>
<td>14.80±7.80</td>
<td>2.45±2.16</td>
<td>37.25±13.71</td>
</tr>
<tr>
<td>2 weeks after</td>
<td>20</td>
<td>29.75±9.06</td>
<td>13.20±4.46</td>
<td>50.50±14.59</td>
</tr>
<tr>
<td>4 weeks after</td>
<td>20</td>
<td>47.70±9.71</td>
<td>20.55±3.18</td>
<td>70.25±13.61</td>
</tr>
<tr>
<td><strong>Mirror</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before treatments</td>
<td>20</td>
<td>12.35±5.34</td>
<td>2.00±2.80</td>
<td>37.25±17.65</td>
</tr>
<tr>
<td>2 weeks after</td>
<td>20</td>
<td>18.60±6.50</td>
<td>8.70±3.81</td>
<td>46.75±17.11</td>
</tr>
<tr>
<td>4 weeks after</td>
<td>20</td>
<td>32.70±8.73</td>
<td>16.9±2.66</td>
<td>59.00±17.66</td>
</tr>
<tr>
<td><strong>Acupuncture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before treatments</td>
<td>20</td>
<td>14.50±9.84</td>
<td>1.80±2.85</td>
<td>32.50±15.93</td>
</tr>
<tr>
<td>2 weeks after</td>
<td>20</td>
<td>18.95±10.37</td>
<td>5.40±3.56</td>
<td>39.50±15.71</td>
</tr>
<tr>
<td>4 weeks after</td>
<td>20</td>
<td>26.90±9.92</td>
<td>8.55±4.23</td>
<td>47.50±15.85</td>
</tr>
</tbody>
</table>

**Note:** comparison within the group, before treatments, *P < 0.01, †P < 0.05; comparison with mirror group, after the same period of the treatments, *P < 0.05; comparison with acupuncture group, after the same period of the treatments, †P < 0.05.
function defects that caused by cerebral hemorrhage may have been re-activated on the original injury side (Figure 2).

**Discussions**

In the recent decades, the rate of cerebrovascular disease has gradually increased. The recovery of upper extremity motor function for stroke patients is relatively difficult, which has added heavy psychological and financial burdens to both patients’ families and the society [16].

![Figure 1](image1) | After stroke (a-b), a hemiplegia patient is undergoing combination training.

![Figure 2](image2) | The brain MRI results of the patient in combination group before and after the treatments. 2a Cross section of MRIT1 weighted image prior to rehabilitation. There is left basal ganglia hemorrhage. 2b fMRI prior to rehabilitation. Right auxiliary exercise activation area is displayed (denoted by black arrows). 2c After 4 weeks of combination treatment, the first exercise area on left (denoted by the black arrow) and auxiliary exercise activation area (indicated by white arrow) are displayed by fMRI.

Studies have shown that self-care ability of stroke patients mainly depends on the recovery of upper extremity motor function [17]. As a result, the main mechanism of MT for the treatment of upper extremity dysfunction is as follows: (1) To activate the mirror neurons. This requires that the ipsilateral upper limbs accomplish the mirror motions provided by the contralateral limb as much as possible so as to stimulate the motor nerve to transmit pathways and activate the mirror neurons that dominate the ipsilateral motion. In this manner, the method can promote brain remodeling and improve ipsilateral limb motor function [13]. (2) To slow down acquired disuse. MT improves the sense of presence on affected limbs by providing visual inputs. It re-enables the disabled areas and moves the balance back.
### Table 3. Comparisons regarding ipsilateral upper limb and hand Brunnstrom stage of patients in 3 groups before, 2 weeks after and 4 weeks after the treatments.

<table>
<thead>
<tr>
<th>Group</th>
<th>Sample</th>
<th>Upper limb Brunnstrom stage</th>
<th>Hand Brunnstrom stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td><strong>Combination</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>20</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>2 weeks after</td>
<td>20</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>4 weeks after</td>
<td>20</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Mirror</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>20</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>2 weeks after</td>
<td>20</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>4 weeks after</td>
<td>20</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td><strong>Acupuncture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>20</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>2 weeks after</td>
<td>20</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>4 weeks after</td>
<td>20</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

4 weeks of treatment for 6 patients in the combination group showed that after 4 weeks of treatment, high signal activation area was found in the first exercise area and auxiliary exercise area on the affected side of all these 6 patients in combination group.

There is a typical case, in which the patient is male, with 48 years old. He was urgently delivered to the local hospital in April 2016. There were no obvious incentives and he suddenly suffered the right limb weakness with dizziness, headache, unconsciousness, but no nausea or vomiting. He was urgently sent to the local hospital and the head CT examination results showed that there were left basal ganglia hemorrhage, left parietal lobe cerebral hemorrhage. Dehydration and intracranial pressure as well as other symptomatic treatment were conducted. Before patient's rehabilitation, fMRI showed that only the right accessory exercise area was activated. However, after 4 weeks of rehabilitation training, fMRI showed that there were high signals on both of the first motor area and the auxiliary motor area on the left side, indicating that patient's motor function improved.
wards, which results in the use-dependent functional reorganization of the brain structure. Thus the acquired disuse is slowed down [19, 20]. (3) Bilateral training can relieve the inhibition between the two cerebral hemispheres and achieve their reorganizations in the neuron level [20]. Some scholars confirmed by the observation of brain magnetic resonance that brain activation is greater, and the activation area are more during the MT training [21]. In the initial exploration of combined treatment mechanism, fMRI examination was performed in 6 patients from the combination group before and after the treatment for 4 weeks. The results showed that the combination of MT and ‘Tong Du Xing Shen’ acupuncture could obviously activate the first exercise area and the auxiliary exercise area on the affected side of the patients. The injured nerve function can reversibly recover, which shows that the combined treatment can also make remodeling of the central nervous system.

In traditional Chinese medicine (TCM), stroke is called ‘Zhong Feng’ and people think that stroke patients have insufficient oxygen and blood in the body; also patients may have poor liver and kidney functions. Combined with drinking and overeating, as well as worries and exogenous evils, the body is imbalanced and many dysfunctions occur, which causes stroke finally [22, 23]. Some studies have pointed out that acupuncture can improve cerebral blood circulation in patients with stroke. It could help to reconcile the blood flow, as well as stimulate the human cerebral cortex to produce electrical activity, which increases the peripheral sensory that input to brain cells. Using different needles and skills, acupuncture can also induce or inhibit muscle tone, activate the body's motor and sensory functions, as well as promote functional recovery of hemiparetic limbs [24]. With the development of TCM, many TCM scholars focus on the use of "brain marrow machine" theory to treat stroke dysfunctions. Academician Xuemin Shi initially popularized "Xing Shen Kai Qiao" acupuncture therapy to treat stroke dysfunctions, which was agreed and adapted by majority of TCM experts. "Tong Du Xing Shen" acupuncture was one application of "brain marrow machine" theory for the treatment of stroke dysfunction, which also obtained many good clinical effects [25, 26].

The results of current study showed that after 4 weeks of treatment, the FMA scores of upper limb motor function, hemiplegia dorsal wrist AROM, Brunnstrom upper limb and hand staging on the affected side of patients in combination group were higher than those of the same patients before the treatment, which were also better than those of the patients in MT group and acupuncture group during the same period of treatments. Combination therapy did help to improve the therapeutic effects, improve the patient's upper limb and hand motor function. After 4 weeks of treatment, the BI score of the combination group was higher than that of the same group before the treatment, and scores circulation in patients with stroke. It could help were better than those of the patients in MT group and acupuncture group in the same period. This indicated that the combination therapy also has more positive signifi-
cance in improving patients' daily living ability. Its possible mechanism is as following. (1) It strengthened the immediate effects. Acupuncture treatment of hemiplegia has immediate effects, that is, most patients’ muscle strength increased significantly after the acupuncture treatment. As time went by, this effect gradually declined until the next day when acupuncture effects decreased to the weakest. Acupuncture combined with simultaneous rehabilitation training could strengthen the immediate effects rather than let the effects rapidly decay, which result in synergy effect [27, 28]. (2) It improved the excitability of cerebral cortical neurons. Neurophysiological theory considered that [28] "For each stimulus that could cause the motor neurons to release excitement, it can make its anatomically adjacent motor neurons be in the subthreshold excited state." In this study, the acupuncture piercing the human body increased the excitability of cerebral cortex nerve cells. It also made the anatomically adjacent motor neurons in a state of subthreshold excitement so that they were sensitive to various stimuli. On this basis, MT treatment can enlarge its role in improving the function of affected limbs. (3) ‘Tong Du Xing Shen’ acupuncture can activate cerebral blood flow in various regions of the cerebral cortex. Through two-way regulations, it is possible to improve the active muscles of affected limbs, as well as to improve antagonistic muscle and coordination of the muscles [6], so that patients can better complete the actions that required in the MT treatment process. (4) At the same time of acupuncture treatment, combination of MT can fully maneuver and induce patients’ initiative of rehabilitation training, which increased the distribution of motor nerve impulses in the cerebral cortex and promoted the emergence of free and independent separation movements [27, 28].

It is worth mentioning that although all the scores from MT group were better than those from acupuncture group, only AROM of hemiplegia dorsal wrist in the MT group after 2 weeks and 4 weeks of treatment comparing with acupuncture group in the same period has statistically significant difference (R < 0.05). However, the BI score has statistically significant difference (R<0.05) only after 4 weeks of treatments compared with acupuncture group. The analysis suggests that this may possibly be caused by relatively short duration of training. Related studies have pointed out that MT treatment regarding stroke patients’ function improvement is time-dependent [29]. Previous studies considered that acupuncture combined with rehabilitation therapy can stimulate motor neurons on the right ways to regulate their excitability, and the sooner the intervention, the better the effect [30-32]. The authors found in the present study that after 2 weeks of treatment, majority of patients in combination group had scores that were superior to patients in both MT group and acupuncture group over the same period. This indicated that MT combined with ‘Tong Du Xing Shen’ acupuncture could shorten the recovery time of stroke patients and improve the curative effects.

In summary, compared with pure ‘Tong Du
Xing Shen’ acupuncture therapy or pure MT, the combination of MT and ‘Tong Du Xing Shen’ acupuncture therapy has a synergistic effect, which can significantly improve patients’ motor functions of upper limbs and hands as well as promote patients’ daily life ability. The combination also has shed new lights for the rehabilitation treatments, which are worth of being generalized to clinical applications. However, the in-depth study on its mechanism still needs to be further expanded. The number of samples that examined by various rehabilitation groups during different rehabilitation periods should be improved, and the follow-up time needs to be extended. We need to strengthen the quantitative analysis of fMRI so as to better guide the clinical rehabilitation treatment and benefit the patients.

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Conflict of interest No potential conflicts of interest relevant to this article are reported.

Ethics approval Ethical approval was given by the Medical Ethics Committee of Third Affiliated Hospital of Southwestern Medical University.

References


