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Original Article

Mirror therapy for severely affected ankle joints of stroke patients

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ABSTRACT
Wada Y, Kondo I, Sonoda S, Yamada K, Narukawa A, Kawakami K, Nonoyama S, Miyasaka H, Teranishi T, Nagai S, Takeshima N: Mirror therapy for severely affected ankle joints of stroke patients. Jpn J Compr Rehabil Sci 2011; 2: 71−76.
Objective: This study investigated the improvement in dorsiflexion of severely affected ankle joints of first-stroke patients after mirror therapy.
Methods: Nine first-stroke patients participated in this study. A mirror was placed to reflect the non-paralyzed lower limb. A set of 50 dorsiflexion movements of the ankle joint was performed 4 times a day for 7 days. Foot functions of the Stroke Impairment Assessment Set (SIAS-F) and the foot-floor angle at active dorsiflexion were measured every 7 days starting from 14 days before initiation of the mirror therapy training to 7 days after, for a total of 5 times.
Results: SIAS-F did not differ among the cases before mirror therapy training. After the mirror therapy training, 5 of the 9 patients showed SIAS-F improvement. Significant differences were found between the scores at the beginning and at the end of the mirror therapy training, and between the scores at the beginning and 7 days after training. The mean foot-floor angle changed from 0 degrees at the beginning of training to 3.0 degrees at the end of training and 1.2 degrees 7 days after the training; however, these values did not differ significantly.
Conclusion: Significant improvement in dorsiflexion of the ankle joint, as measured by SIAS-F, was achieved with mirror therapy.
Key words: ankle dorsiflexion, hemiplegic, mirror therapy, stroke

Introduction

Functional restoration of paralysis caused by central nervous system disorders is expected because of the advancements in neuroscience [1]. New therapies and training methods have been investigated and developed for the rehabilitation of stroke patients [2]; however, measures for the effectiveness of these methods have not yet been developed. Recently, mirror therapy has attracted interest due to the reasonable cost of the necessary equipment and its applicability to even severely affected patients. Therefore, it is thought to be a promising therapy from a clinical perspective. Mirror therapy has also been investigated for the reduction of phantom limb pain in amputees [3] and has been used for paralyzed upper limbs [4−10] and lower limbs [11−13]. Sutbeyaz et al. provided mirror therapy to 20 stroke patients after less than 1 year after onset; the therapy consisted of dorsiflexion of the ankle joint 30 minutes a day for 4 weeks in addition to ordinary training. They evaluated the Brunnstrom stage and Functional Independence Measure (FIM) of the treated patients and control subjects, and found significant improvement in FIM motor items [11]. However, they did not evaluate ankle joint function independent of the other FIM scores.

Improving the ankle joint function of stroke patients is often more difficult than improving their hip or knee

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joint function [14]. Since dorsiflexion of the ankle joint is important for gait and posture, dorsiflexion training is necessary. Hirano et al. reported that 12 first-ever stroke patients, whose foot function according to Stroke Impairment Assessment Set [15] (SIAS-F) scores was 2 or less, had significantly improved dorsiflexion after mirror therapy (mean 79.7 days after onset) compared with that of control patients [12]. In the paper by Hirano et al., some patients could perform very small dorsiflexion movements of the paralyzed ankle (SIAS-F score = 2). The reasons for their improvement could be the additional training in dorsiflexion, the effect of mirror therapy, or both. In the present study, the effect of mirror therapy was evaluated in more severely affected patients (SIAS-F score = 0 or 1).

Subjects

The study participants were first-stroke patients in the Kaifukuki (convalescent) ward of Nanakuri Sanatorium at Fujita Health University. They were undergoing the Full-time Integrated Treatment Program [16], had SIAS-F scores of 1 or 0 without recognition difficulties (cf. Table 1), and were enrolled in the study after they agreed to participate in mirror therapy. The patients' mean age was 58.6 ± 14.9 years, and the interval between onset and admission was 29.9 ± 9.7 days, the interval between onset and initiation of mirror therapy was 76.9 ± 9.3 days, and the interval between onset and the final evaluation was 90.9 ± 9.3 days.

Methods

1. Mirror therapy

The setup for mirror therapy is shown in Fig. 1. The patient sat on a chair that was height adjusted to maintain a 60-degree knee angle. A mirror was placed between the legs to reflect the non-paretic lower limb at the paretic lower limb. The patient performed repeated dorsiflexion movements. He/she was also

Table 1. Characteristics of patients

Case no.	Age (y)	Gender	Type of injury	Focus	Paretic side	Time between onset and Time 1 (days)	Time between admission and Time 1 (days)	Passive range of ankle dorsiflexion	Spasticity of planter flexion muscle[1]	Sense of hallux position[2]
1	63	M	hemorrhagic	thalamus	R	78	45	5°	2	1
2	45	F	hemorrhagic	putamen	R	77	43	10°	2	2
3	38	M	hemorrhagic	putamen	L	68	46	5°	3	3
4	43	F	hemorrhagic	thalamus	L	74	50	15°	2	1
5	69	M	hemorrhagic	putamen	L	87	61	5°	2	1
6	86	F	ischemic	internal capsule	R	64	46	10°	1	2
7	66	F	hemorrhagic	putamen	L	68	45	10°	3	0
8	59	F	hemorrhagic	putamen	R	86	43	15°	0	1
9	58	M	ischemic	MCA	R	90	44	10°	3	3

[1]Scored using the Modified Ashworth Scale, [2]scored using the Stroke Impairment Assessment Set (L/E position).
M, male; F, female; R, right; L, left

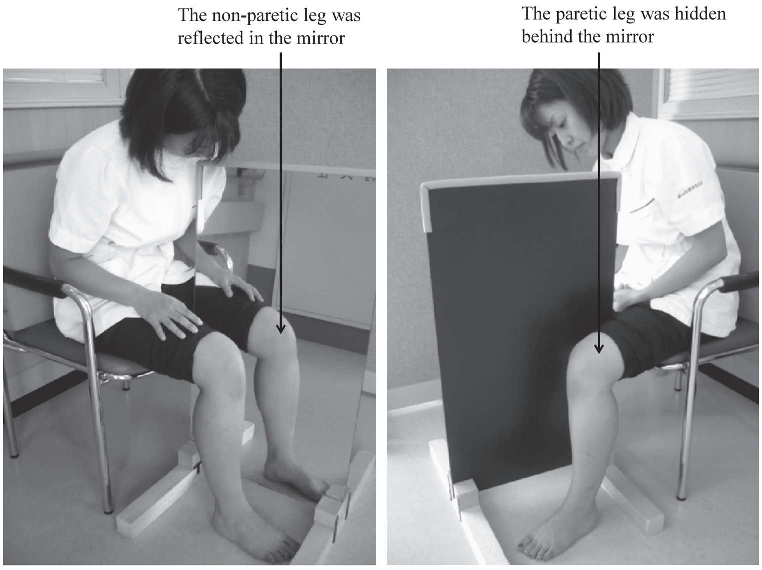

Figure 1. Mirror therapy setup (for left paralysis)

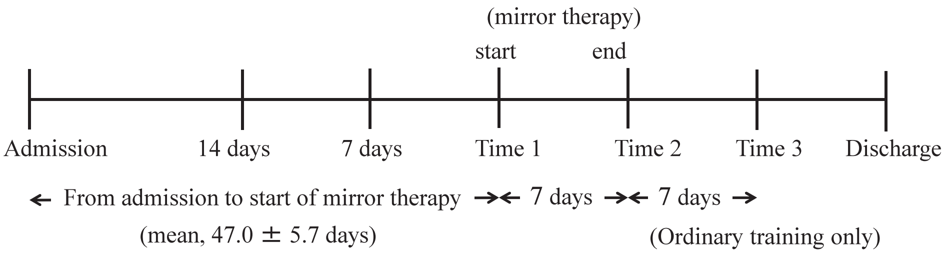

Figure 2. Evaluation schedule
Admission, 14 days, 7 days, Start, Time 1, End, Time 2, Time 3, Discharge
(mean, 47.0 ± 5.7 days), (Ordinary training only)
Patients were evaluated 5 times, at 14 and 7 days before training, and at Times 1, 2, and 3.

asked to dorsiflex the non-paretic leg. The examiner counted the number of dorsiflexions. The examiner did not assist in any way. The patients paced their dorsiflexion movements to the rhythm of a metronome, which generated a sound every 2 seconds for 100 seconds, for a total of 50 dorsiflexion movements. This was considered 1 set, and 4 sets were carried out in a day. Therefore, 1,400 dorsiflexion movements were performed in 1 week.

2. Evaluation items and evaluation time

SIAS-F and the foot-floor angle were evaluated at 14 and 7 days before the mirror therapy training, 1 day (Time 1) and 7 days (Time 2) after starting the mirror therapy, and 7 days after the mirror therapy ended (Time 3). The foot-floor angle was measured on video images (Fig. 2). The patient sat on a chair, and the whole sole of the patient's foot was in contact with the floor. The height of the chair was adjusted to achieve a knee angle of 60 degrees. Videos were taken 90 cm lateral from the paretic malleolus. The maximum dorsiflexion angle between the floor and the sole of the foot was measured using the Dart Trainer software. The median value of 3 trials was used. During dorsiflexion, the movement of the non-paretic ankle joint was not restricted. The rater was a different from the daily training therapist.

The scores were analyzed using non-repeated 2-way analysis of variance, and the significance level was set at 5%.

Results

1. SIAS-F (Table 2 and Fig. 4)

SIAS-F was significantly higher at Time 2 than at Time 1; but, SIAS-F at Times 2 and 3 did not differ significantly. SIAS-F was significantly higher at Time 3 than at Time 1. At Time 1, 6 patients scored 0 and 3 scored 1, and these scores did not differ significantly from those 14 days before the first evaluation when all 9 patients scored 1. Five patients had improved scores: 1 patient went from 0 to 1, 1 from 0 to 2, 2 from 1 to 2, and 1 from 1 to 3. The other 4 patients showed no improvement. In 1 patient, the score decreased from 2 at Time 1 to 1 at Time 3.

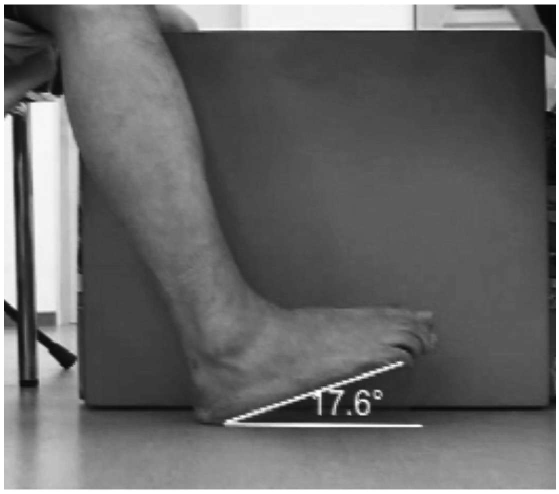

Figure 3. Typical example of the foot-floor angle
Foot-floor angles were measured 3 times, and the median was used in the analysis.

Table 2. Change of ankle dorsiflexion

	SIAS-F score			SIAS-F angle		
Case no.	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
1	0	0	0	0°	0°	0°
2	0	1	1	0°	0°	0°
3	1	3	3	0°	12.2°	4.6°
4	0	2	1	0°	0°	0°
5	1	2	2	0°	7.3°	6.2°
6	1	2	2	0°	7.9°	0°
7	0	0	0	0°	0°	0°
8	0	0	0	0°	0°	0°
9	0	0	0	0°	0°	0°

SIAS-F, Foot functions of the Stroke Impairment Assessment Set

2. Foot-floor angle (Table 2)

The average foot-floor angle of the 9 patients was 0 degrees at both 14 days and 7 days before training (Time 1). The average foot-floor angle improved to 3.0 degrees at Time 2, and then dropped to 1.2 degrees at Time 3. For all patients, the dorsiflexion angle improved from Time 1 to Time 2, but decreased from Time 2 to Time 3; however, these differences were not significant.

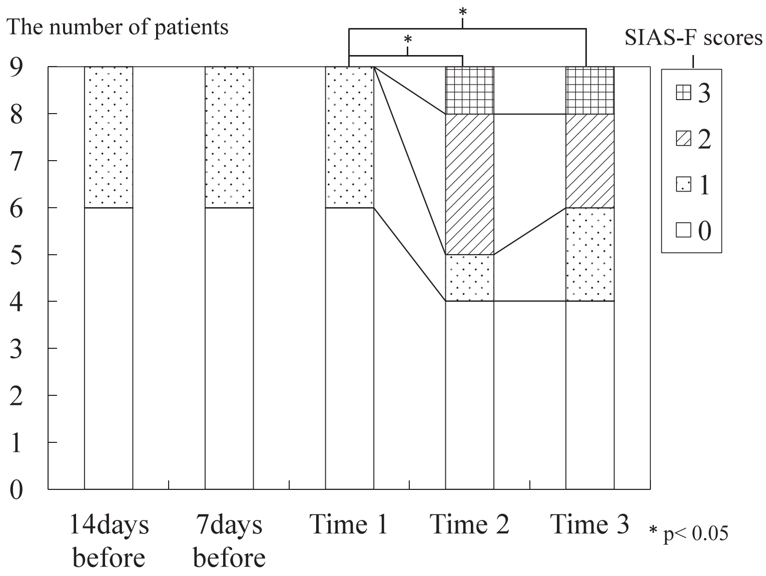

Figure 4. Foot functions of the Stroke Impairment Assessment Set (SIAS-F) score changes
A significant difference was observed between the evaluations at Times 1 and 2.

Discussion

The effect of mirror therapy was demonstrated in severely affected ankle joints of stroke patients. Mirror therapy was started an average of 47.0 days after admission (mean, 76.9 days after onset). This was considered such a long time period that the effect of autotherapy was very small. Because it was necessary to complete the mirror therapy and final evaluation (Time 3) before discharge, the average number of days after admission before initiation of mirror therapy was set to fit the average duration of admission at our hospital, which was 61.1 days [17]. Of the 9 study patients, 5 had improved function as demonstrated by the evaluations at Times 1 and 2, and no significant changes were found at the Time 3 evaluation. Since 4 of the 5 patients showed improvement between the evaluations at Times 1 and 2, and maintained their function 7 days after the mirror therapy, the effect of the therapy on dorsiflexion function was not only acute, but also long lasting. Although ordinary training was also performed, the effect of mirror therapy was notable. Previous studies [4–6, 10, 11] reported mirror therapy that was conducted from 4 to 12 weeks. However, in the present study, mirror therapy was conducted for 7 days due to the limitation of hospitalization. Patients who underwent mirror therapy had SIAS-F scores of 0 or 1, meaning that they had no active dorsiflexion. In such a brief intervention, the mirror therapy seemed to affect the neural networks related to movement, rather than strengthen the muscles.

The activity of the central neural networks appeared to be modified by seeing the movement, and then the activity of mirror neurons seemed to be modified by visual feedback. Increased blood circulation in the motor cortex reportedly can be achieved by merely imagining the motion [18]. Mirror neurons [19] have been reported in the ventral premotor cortex and the parietal lobe. Since imagining or observing the motion is said to increase activation of the cortex, observation of a motion image seemed to activate cortical function. In the mechanism of severe paralysis, the integrated function of sensorimotor loops and the important role of vision have been reported [20]. Stroke patients lose the opportunity to see their limbs “move as they wish,” and thus lose visual feedback. This phenomenon is related to “learned paralysis” in the brain, described by Ramachandran [21]. Visual feedback from the mirror image of the non-paretic leg projects from the visual cortex to the somatosensory area or to the motor area and its associated area. Oouchida et al. reported that the visual information of passive movement of adjusting the joint angle activated Brodmann area 2 in the higher sensory area of the parietal lobe [22]. In a study in monkeys, the area was reportedly not activated by visual stimulation [23], but was activated by training in visuomotor tasks [24, 25]. In addition to the visuomotor tasks, voluntary motor command was also reported to be important. Lotze et al. reported that passive movement did not improve either the function or the activity of the motor cortex [26]. Although improvement of paralysis requires repeated active movements [27], severely affected patients with poor or no movement soon would become bored by such simple repetitive movements. Mirror therapy presents the image of “My paretic leg is moving!” which motivates patients to continue with the training. From this perspective, mirror therapy prevents patients from developing “learned paralysis.”

We could measure the dorsiflexion angles of 3 severely affected stroke patients and also evaluated their foot-floor angles. Their angles at Time 3 decreased from those at Time 2. Since the SIAS-F scores of these 3 patients had improved at Time 2 and this improvement was maintained until Time 3, there seemed to be some hypofunction of the ankle joints that could not be detected by SIAS-F. There were 3 patients in whom we could measure the angle at Time 2. Four patients had an SIAS-F score of 2 or more. Since an SIAS-F score of 2 is defined as follows: "dorsiflexion movement exists and the foot sole can leave the floor but not sufficiently," the foot-floor angle had to be measured in these 4 patients. One patient with an SIAS-F score of 2 whose foot-floor angle could not be measured was carefully examined, and it was found that his score was on the border between scores 1 and 2. Therefore, his foot-floor angle was so small that it could not be measured. Furthermore, the accuracy of angle measurement based on video images is limited; therefore, its accuracy must be evaluated by increasing the number of cases.

We plan to develop a method to ensure that the foot-floor angle does not decrease after completing the intervention, and develop a more sensitive measurement method to evaluate mirror therapy.

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