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Original article

A Comparative Study of the Effectiveness of Kinesiotaping and Mirror Therapy on Hemiplegic Hand

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Abstract

Background: Hemiplegia, often caused by stroke, leads to loss of motor control and spasticity, severely impacting quality of life (QoL). Kinesiotaping (KT) and Mirror Therapy (MT) are emerging neuro-rehabilitation techniques that offer non-invasive, low-cost methods to improve motor function in hemiplegic patients. The purpose of this study was to compare the effectiveness of KT and MT in improving spasticity and hand function in chronic hemiplegic patients. **Methods:** This interventional study was performed on 42 chronic hemiplegic patients selected from Benha University Hospitals. Patients were divided into two groups: KT (n=21) and MT (n=21). Both groups received regular rehabilitation twice a week for six successive weeks. The Fugl-Meyer Assessment Scale for the Upper Limb (FMA-UE), Modified Ashworth Scale (MAS), and the Box and Block Test (BBT) were used to evaluate outcomes before and after treatment. **Results:** Significant differences were observed regarding MAS, FMA-UE, and BBT scores among both groups ($p<0.001$). The KT group showed greater reduction in spasticity (MAS: 2.29 ± 1.15 to 1.52 ± 0.75, $p<0.001$) compared to the MT group (MAS: 2.52 ± 1.21 to 2.38 ± 1.32, $p=0.083$) and also superior improvement in manual dexterity (BBT: 9.43 ± 3.53 to 14.24 ± 3.87, $p<0.001$) compared to MT group (BBT: 8.05 ± 5.36 to 11.24 ± 5.89, $p<0.001$). Linear regression analysis confirmed KT's superiority in predicting MAS ($\beta=20.238$, $p=0.002$) and BBT ($\beta=36.812$, $p<0.001$) improvement. **Conclusion:** KT is more effective than MT in reducing spasticity and enhancing manual dexterity in chronic hemiplegic patients, supporting its use as a superior therapeutic option.

Keywords: Kinesiotaping, Mirror Therapy, Hemiplegic Hand, Stroke, Motor Function Neuro-rehabilitation.

Introduction

Hemiplegia is a condition that causes loss of motor control in one side of the body, leading to the inability to move the affected arm and leg, and the development of spastic mass patterns. This paralysis, usually caused by a stroke, that negatively impacts the patient's health and quality of life [1] (QoL).

Stroke, the most common cause of hemiplegia, has an estimated incidence of 150 per 100,000 in developing countries [2]. Many stroke survivors experience cognitive, motor, lingual, and psychological impairments, resulting in significant activity limitations [3].

Patients with stroke face severe problems in both sides of the body, as the side effects spread to all brain functions, affecting sensory perception, memory, behaviour, thus complicating the rehabilitation process [4]. Motor impairment is a primary cause of disability after stroke, with 60–70% of survivors experiencing upper limb paresis [5].

Post-stroke spasticity (PSS) commonly leads to limb weakness, reducing the range of motion (ROM) in the hand, wrists, and finger flexors, and interfering with daily activities such as reaching, grasping, and releasing [6] causing secondary limb deformities and further impair functional abilities and QoL [4, 5].

Recently, Kinesiotaping (KT) and mirror therapy (MT) have been introduced as neuro-rehabilitation techniques for hemiplegic patients. These non-invasive, low-cost methods are effective in improving motor function after stroke [7, 8].

Hence, the goal of this study was comparing the effectiveness of KT and MT in improvement of spasticity and hand function in chronic hemiplegic patients.

Patients and methods

This interventional study involved 42 hemiplegic patients recruited from Neurology Outpatient Clinic and carried out in Rheumatology and Rehabilitation Department, Benha University Hospitals, throughout the period from July 2023 till January 2024. The study was presented to the research Ethics Committee of faculty of medicine- Benha University and approved with approval code Ms 24-1-2023). Informed consent was obtained from the patients before participating in this study.

Inclusion criteria: Participants were patients diagnosed with stroke of duration more than six months resulting in unilateral hemiplegia, and who could perform at least minimal hand grasp. Additionally, they needed to have normal cognitive function to follow therapy instructions and report any adverse effects, such as pain or fatigue, during the sessions, had to be capable of maintaining a seated position in a chair. Finally, the Brunnstrom stage of the distal hand should be between 2 to 4. Stroke patients were diagnosed by a neurologist according to the history, physical examination, and brain imaging.

Exclusion criteria: Participants were excluded if they were younger than 18 or older than 80 years, had other neurological conditions, malignancies, infections, or cellulitis. Those with a history of allergy to

KT or with joint contractures in the upper extremities were also excluded.

Patients were divided into two equal groups: the KT group, which included 21 patients with chronic hemiplegia, and the MT group, which also included 21 patients. Both groups received regular rehabilitation twice a week for six successive weeks, totalling 12 sessions for each group. They were age and sex matched.

All patients underwent a comprehensive medical history. General examination and a detailed neurological examination were performed including; cognitive function, speech, cranial nerve examination, motor system examination, sensory system examination, coordination, and gait. Muscle strength was assessed using the Medical Research Council scale (0: no contraction, 1: flicker of contraction, 2: movement without gravity, 3: movement against gravity, 4: movement against resistance but weaker than normal, 5: normal strength).

Assessment of muscle spasticity: The Modified Ashworth Scale (MAS), defined by Jim Lance in 1980 [9], was used to measure muscle spasticity. The MAS grades muscle spasticity from 0 to 4 (0: no increase in tone, 1: slight increase with catch and release or minimal resistance at the end of the range, 1+: slight increase with catch and minimal resistance through less than half the range, 2: marked increase through most of the range with easy movement, 3: considerable increase making passive movement difficult, 4: rigidity in flexion or extension) [10].

Assessment of hand motor impairment: The Fugl-Meyer Assessment Scale for the Upper Limb (FMA-UE) quantitatively measures motor recovery in stroke patients, focusing on the shoulder, elbow, forearm, wrist, and hand [11]. It uses a 3-point scale: 0 (no function), 1 (partial function), and 2 (full function), with scores ranging from 0 to 66. The scale includes five domains: motor function (upper and lower limbs), sensory function, balance (0-14 points; 6 for sitting, 8 for standing), range of motion (0-44 points), and joint pain (0-44 points) [12].

Assessment of hand function: Hand function was evaluated using the Simple Test for Evaluating Hand Function (STEF), also known as the Box and Block Test (BBT), originally designed in Japan for stroke patients. In this test, patients transport 10 different objects of various shapes and sizes to a target location. It includes subtests with spheres, rectangles, cubes, small disks, thin pieces of cloth, and pins [13]. Patients move the maximum number of blocks from a full box to an empty box within 60 seconds, with scores based on the number of blocks transferred. Each hand is scored separately, with higher scores indicating better manual dexterity [14].

Technique:

All patients received evaluations before and after completeness of the intervention.

Kinesiotaping (KT): KT from Nitto Kogyo Corporation, Japan, was applied as an additional treatment on the dorsal side of the affected upper limbs by an occupational therapist. The tape was placed from the proximal one-third of the forearm to the wrist and split into five straps extending to the distal interphalangeal joints of the fingers. The forearm was fully pronated, with the wrist in a neutral position and the fingers in a resting position. To ensure adhesion, 3M paper tape surrounded the fingertips without tension. The KT was applied with varying tensions: 20-30% over the muscle belly, 50% over tendon areas, and neutral tension at the anchors. It was applied twice a week for six weeks, generally covering the extensor muscle from the upper forearm to the dorsal hand and fingertips [15].

Mirror Therapy (MT): A closed wooden box (35x30 cm) with a mirror on one side and a hollow space for the paretic hand on the other was used. During MT, participants sat in front of the mirror box, with the non-paretic upper limb facing the mirror and the paretic upper limb inside the box. They observed the reflection of their non-paretic limb while moving their wrist and fingers at a self-directed speed, perceiving the reflection as their affected limb. Trained occupational therapists supervised all sessions [16]. The MT group received 1 hour of MT, split into two 30-minute sessions, 4 days per week for 3 weeks, in addition to conventional stroke rehabilitation therapy.

Statistical methods

The acquired data underwent meticulous revision, coding, and analysis utilizing SPSS version 25.0 (IBM, Armonk, New York, United States). Data normality was evaluated using the Shapiro-Wilk test, which revealed the data to be significantly nonparametric. Descriptive statistics comprised the calculation of the mean, standard deviation (± SD), median, and range for numerical data, alongside frequency and percentage for categorical data. Analytical procedures included the Student's T-Test to compare differences in means of parametric variables between two groups, the Mann-Whitney U Test for comparing nonparametric variables between two groups, and the Wilcoxon Signed-Rank Test for assessing nonparametric variables across two time periods. The Chi-Square test, along with Fisher’s Exact Test or the Monte Carlo simulation method, was employed to investigate relationships between qualitative variables, with the latter two applied in cases of low expected counts. Linear regression analysis was utilized to predict risk factors, with beta coefficients elucidating the direction and magnitude of the relationships. Statistical significance was determined at a p-value of less than 0.05 within a 95% confidence interval.

Results

Statistically insignificant differences were reported between the studied groups regarding age and sex distribution ($p>0.05$). Most participants had right-side weakness (90.5% in KT, 85.7% in MT; $p>0.05$). The mean disease duration was 2.21 years for KT group and 1.90 years for MT group ($p = 0.692$). The mean shock stage duration was 20.90 days for KT group and 26.43 days for MT group ($p>0.05$). Thrombotic hemiplegia was the most common type in both groups (52.4% in KT, 61.9% in MT), followed by embolic and hemorrhagic types, with no significant difference in distribution ($p>0.05$). **Table 1**

In the KT group, 23.8% of participants had clonus compared to 9.5% in the MT group, though this difference was not statistically significant ($p>0.05$). Regarding associated comorbidities, there were no significant differences in the distribution of diabetes mellitus (p = 0.747) and hypertension (p = 0.753) between the studied groups. However, there was a significant difference in hyperlipidemia, with 95.2% of the KT group not suffering from hyperlipidaemia compared to 66.7% in the MT group (p = 0.045). Smoking rates were lower in the KT group (28.6%) than the MT group (47.6%), but this difference was not statistically significant (p>0.05). Most participants were right-handed, with 95.2% in the KT group and 90.5% in the MT group, with no significant difference in handedness (p>0.05). **Table 2**

MAS score significantly improved after treatment in KT group (p<0.001), while it was not significantly improved after treatment among the MT group (p=0.083), with a significant difference favouring KT (p=0.035). The mean FMA-UE score improved significantly from 0.43 to 1.38 in the KT group (p<0.001) and from 0.48 to 1.24 in the MT group (p<0.001) after treatment, with no significant post-treatment difference (p>0.05) between both groups.

The mean BBT score highly significantly improved (p<0.001) from 9.43 to 14.24 in the KT group and from 8.05 to 11.24 in the MT group (p<0.001) post treatment, with a significant difference favouring KT (p=0.039). **Table 3.** KT was superior to MT for prediction of MAS improvement with statistically significant difference (p=0.002). **Table 4**

Linear regression analysis predicted FMA-UE improvement, considering different variables. Significant associations with lower FMA-UE improvement were found for smoking (β = -7.420, p = 0.034) and higher initial FMA-UE scores (β = -21.968, p = 0.044). KT showed a marginally significant association with FMA-UE improvement (p = 0.081), but it did not reach statistical significance. **Table 5.** Linear regression analysis for predicting BBT improvement. Lower BBT scores before treatment were significantly associated with greater BBT improvement. Additionally, KT was found to be superior to MT in predicting BBT improvement. **Table 6**

Table 1: Comparison between disease duration, clinical data and type of hemiplegia**.**

	Kinseotaping n = 21		**Mirror therapy n = 21**		**Test**	**P**
	No.	**%**	**No.**	**%**		
Sex						
Female	12	57.1	12	57.1	X^2= 0.0	1.000
Male	9	42.9	9	42.9		
Age (years)						
Mean ± SD.	54.05 ± 6.75		55.52 ± 5.66		t= 0.768	0.447
Side weakness						
Right side	19	90.5	18	85.7	X^2=	FE= 1.000
Left side	2	9.5	3	14.3	0.227	
Disease duration (y)						
Mean ± SD.	2.21 ± 2.05		1.90 ± 1.78		U= 205.0	0.692
Shock stage (days)						
Mean ± SD.	20.90 ± 19.10		26.43 ± 19.62		U= 262.5	0.284
Type of hemiplegia						
Hemorrhagic	1	4.8	2	9.5	X^2=	MC=

Embolic	9	42.9	6	28.6	1.179	0.624
Thrombotic	11	52.4	13	61.9		

SD.: Standard deviation, Min.: Minimum, Max.: Maximum, t: Student t test, X^2: Chi Square, p: Comparing the two studied groups, FE: Fisher Exact.

Table 2: Comparison between the studied groups regarding clonus, risk factors, special habits and handed.

	Kinseotaping n = 21		**Mirror therapy n = 21**		**Test**	**P**
	No.	**%**	**No.**	**%**		
Clonus						
No	16	76.2	19	90.5	X^2= 1.543	FE= 0.410
Yes	5	23.8	2	9.5		
DM						
No	13	61.9	14	66.7	X^2= 0.104	0.747
Yes	8	38.1	7	33.3		
HTN						
No	13	61.9	12	57.1	X^2= 0.099	0.753
Yes	8	38.1	9	42.9		
Hyperlipidemia						
No	20	95.2	14	66.7	X^2= 5.559*	FE 0.045*
Yes	1	4.8	7	33.3		
Special habit						
Non-smoker	15	71.4	11	52.4	X^2= 1.615	0.204
Smoker	6	28.6	10	47.6		
Handed						
Right	20	95.2	19	90.5	X^2= 0.359	FE= 1.000
Left	1	4.8	2	9.5		

X2: Chi Square, FE: Fisher Exact, p: Comparing the two studied groups, *: Significant when p value <0.05.

Table 3: Comparison between Kinesiotaping and mirror therapy regarding the outcome measures [Modified Ashworth scale (MAS), Fugl-Meyer Assessment (FMA-UE) and Box and Block Test (BBT)].

MAS	**Kinseotaping n = 21**	**Mirror therapy n = 21**	**Test**	**p1**
Before				
Mean ± SD.	2.29 ± 1.15	2.52 ± 1.21	U= 245.5	0.515
After				
Mean ± SD.	1.52 ± 0.75	2.38 ± 1.32	U= 297.5*	0.035*
Z	3.557*	1.732		
p2	<0.001*	0.083		
FMA-UE				
Before				
Mean ± SD.	0.43 ± 0.51	0.48 ± 0.51	U= 231.0	0.759
After				
Mean ± SD.	1.38 ± 0.50	1.24 ± 0.54	U= 193.0	0.408
Z	4.472*	4.000*		
p2	<0.001*	<0.001*		
BBT				
Before				
Mean ± SD.	9.43 ± 3.53	8.05 ± 5.36	U= 159.0	0.120
After				
Mean ± SD.	14.24 ± 3.87	11.24 ± 5.89	U= 138.5*	0.039*
Z	3.926*	4.051*		
p2	<0.001*	<0.001*		

SD.: Standard deviation, Min.: Minimum, Max.: Maximum, U: Mann Whiteny, t: Student t test, p1: Comparing the two studied groups, p2: Comparing before and after, *: Significant when p value <0.05.

Table 4: Linear regression analysis for prediction of MAS improvement**.**

	β	***P***
Gender (male vs female)	1.852	0.795
Age	0.178	0.758
Side weakness (right vs left)	8.243	0.449
Disease duration	-1.727	0.355
Shock stage	-0.050	0.787
Type of hemiplegia		
Hemorrhagic	-0.641	0.963
Embolic	4.259	0.563
Thrombotic	-3.819	0.592
Clonus	6.429	0.497
DM	-8.704	0.234
Hypertension	3.118	0.665
Hyperlipidemia	1.838	0.838
Smoker	-1.897	0.406
Right-handed vs left-handed	-9.615	0.482
MAS before treatment	2.790	0.359
Kinseotaping vs mirror therapy	20.238	0.002*

B, regression coefficient; *: Significant when p value <0.05.

Table 5: Linear regression analysis for prediction of FMA-UE improvement.

	β	***P***
Gender (male vs female)	15.278	0.169
Age	-0.272	0.765
Side weakness (right vs left)	-29.189	0.084
Disease duration	-0.448	0.880
Shock stage	0.313	0.279
Type of hemiplegia		
Hemorrhagic	15.385	0.475
Embolic	22.222	0.050
Thrombotic	-25.000	0.026
Clonus	-17.143	0.247
DM	1.481	0.899
Hypertension	-15.529	0.166
Hyperlipidemia	-13.235	0.348
Smoking	-7.420	**0.034***
Right-handed vs left-handed	-20.513	0.340
FMA-UE before treatment	-21.968	**0.044***
Kinseotaping vs mirror therapy	19.048	0.081

B, regression coefficient; *: Significant when p value <0.05.

Table 6: Linear regression analysis for prediction of BBT improvement.

	β	*P*
Gender (male vs female)	32.266	0.054
Age	-0.935	0.498
Side weakness (right vs left)	-16.631	0.524
Disease duration	-4.616	0.302
Shock stage	0.003	0.995
Type of hemiplegia		
Hemorrhagic	40.849	0.210
Embolic	33.119	0.055
Thrombotic	32.396	0.123
Clonus	-16.555	0.465
DM	24.932	0.154
Hypertension	9.115	0.597
Hyperlipidemia	17.626	0.412
Smoker	-1.696	0.757
Right-handed vs left-handed	45.248	0.164
BBT before treatment	-6.515	<0.001*
Kinseotaping vs mirror therapy	36.812	<0.001*

B, regression coefficient; *: Significant when p value <0.05.

Discussion

In recent years, KT and MT have been implemented as non-invasive, easy and cheap therapeutic technique for Hemiplegic patients. To our knowledge, this is the first study comparing the effect of KT and MT on hand function in hemiplegic patients, This present study was conducted on 42 patients divided in two groups KT (21 patients) and MT groups (21 patients).

In our study, there was no significant difference between both groups in all variables at baseline.

The outcomes of our study revealed that both KT and MT achieved significant improvement in pain, range of motion (ROM) & motor impairment and manual dexterity of the hand after 6 weeks of treatment evaluated FMA-UL and STEF or BBT, this was in concordance with a previous study that showed increase motor function of the hand (increase FMA_UL) and improve manual dexterity of the hand (increase BBT) in chronic hemiplegic patients treated with KT or MT technique [13].

KT showed a decrease of spasticity (decrease MAS). Moreover, KT is superior to MT in improving spasticity and manual dexterity of the hand with non-significant difference between both groups in improving motor function of the hand [13, 17, 18].

Many studies have investigated the effect of KT on hemiplegic hand. Interestingly, **Huang and his colleagues** agreed with our results, they reported significant improvement in spasticity and motor function of the hand after 3 weeks of treatment, patients in this study received regular rehabilitation program 5 days /week for 3 weeks [13].

Hassan et al., concurred with our results that showed significant improvement in spasticity and motor function of the hand [17].

It is postulated that Kinesiotaping (KT) induces a prolonged stretch on muscles, potentially leading to autogenic inhibition in hypertonic muscles. Additionally, KT may enhance sensorimotor input during rehabilitation. Studies by Simoneau et al., [19] and Callaghan et al., [20], have demonstrated KT's beneficial impact on proprioception. These effects are likely due to cutaneous stimulation of the sensorimotor and proprioceptive systems, which can improve functional outcomes. Other researchers suggest that enhanced motor function may result from increased recruitment of motor units in the muscles due to heightened proprioceptive stimuli [21]. Various application methods of KT exist, tailored to achieve specific physiological outcomes.

On the other hand**, Galvão et al.** found that patients received rehabilitation program 2 days/week, 40 min/day, they reported 1-point improvement in the score of spasticity and no effect on gross manual dexterity of the hand (no change in BBT), they reported the same result with our study in improvement spasticity only [18].

In a pilot study by Fathollah et al., the efficacy of KT on hand spasticity and motor function was examined. The results indicated that KT could enhance extensor muscle function by providing a passive, low-intensity, continuous stretch to the flexor muscles [22]. Additionally, previous research has shown that applying KT in the direction of muscle fibres can facilitate muscle function, altering muscle recruitment patterns through improved proprioception by stimulating mechanoreceptors [23, 24]. It can be inferred that KT applied in the direction of the extensor muscle may enhance muscle function. However, these findings conflicted with our results regarding spasticity improvement; while they reported no improvement in flexor spasticity, they observed better motor function of the hand, as evaluated by MAS and BBT scores.

Yang et al. compared the effects of KT combined with Virtual-Reality (VR) versus VR alone in a study involving 43 patients. The participants were divided into an experimental group (KT and VR) and a control group (VR only). Both groups underwent training for 40 minutes per session, five times a week, for six weeks, totalling 30 sessions. FMA-UE was used for evaluation. The results indicated that the combination of KT and VR significantly improved upper hand function more effectively than VR alone [25].

Similarly, previous studies have consistently shown significant improvements in hand function following KT application [13, 26].

MT has been extensively studied in various aspects of post-stroke rehabilitation, particularly concerning the recovery of the ROM in affected limbs. In 2003, Stevens and Stoykov reported improvements in active ROM for wrist flexion/extension and forearm pronation/supination using this technique in stroke patients [27].

Regarding spasticity, no improvement was found with implementation of this technique, all previous studies **Stevens JA et al., and Souza WC et al.,** agreed with our results in improvement hand function with no effect in spasticity [27, 28].

Improvements in hand motor function facilitated by Mirror Therapy (MT) can be explained by several studies. Franz and Packman [28] concluded that MT enhances the movement and performance of both hands, while Bhasin et al. proposed that MT operates on the principle of mirror neurons [30].

Our MT group participants, who viewed their unaffected limb's reflection in the mirror and performed movements, aligned with Ezendam et al.'s findings that such activity activates the brain's motor imagery area, inducing neuroplasticity essential for stroke recovery. However, muscle tone showed no significant improvement [31].

The effectiveness of MT can be attributed to three hypotheses: Mirror neurons, which fire during observation or imitation of actions, facilitate motor learning and activate the cortico-spinal tract, crucial for neurorehabilitation [32]. MT may activate normally inhibited projections from the unaffected hemisphere in hemiparetic patients [30]. MT increases attention to the affected limb, activating motor networks by creating an illusory image of movement [33].

In our study the most common type of hemiplegia in both groups was thrombotic, with 52.4% in the KT group and 61.9% in the MT group, followed by embolic then hemorrhagic types.

The distribution of hyperlipidemia in patients of our study was 19% that comes in accordance with the study of **Ama Moor and colleagues** that revealed that hyperlipidemia is considered as a less common risk factor of hemiplegia [34].

Our study had several limitations, including a small sample size and a short intervention period of only 2 days per week for 6 weeks, which may have been insufficient to achieve significant progress. Additionally, the lack of long-term follow-up prevented us from measuring sustained improvements in functional outcomes. Future studies should involve larger sample sizes and extended follow-up periods.

Conclusions

KT demonstrates greater efficacy in reducing spasticity and enhancing manual dexterity compared to MT. This supports the use of KT as a superior therapeutic option for managing chronic hemiplegia.

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