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ORIGINAL RESEARCH

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Therapeutic effect of upper extremities exercise based on mirror therapy in the postoperative recovery of shoulder function in breast cancer patients

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Abstract

This study aims to investigate the effect of upper extremities exercise based on mirror therapy in the postoperative recovery of shoulder function in breast cancer patients. A total of 120 patients were selected from January 2021 to December 2021 and randomly divided into the control group (60 cases) and the observation group (60 cases) by random number table method. The control group was given conventional intervention, while the observation group was additionally given mirror therapy. The Constant-Murley Score (CMS), Disability of the Arm, Shoulder and Hand (DASH) Score, compliance of shoulder exercise, and arm circumference were compared between the two groups before the intervention and at 2 weeks, 4 weeks or 8 weeks after surgery. After 2 weeks, 4 weeks and 8 weeks of intervention, patients in the observation group showed higher scores of CMS, lower scores of DASH and better compliance of shoulder exercise than those in the control group. There was no significant difference regarding the bilateral circumference difference of upper limbs between the control group and the observation group. The application of mirror therapy is beneficial to the mobility of shoulder joint, and it promotes the functional recovery of shoulder joint, reduces the occurrence of upper limb dysfunction and increases the compliance of shoulder exercise, whereby preventing lymphedema of the upper extremities in the postoperative shoulder exercise of breast cancer patients.

Keywords

Breast cancer survivors; Free movement of upper extremity; Mirror therapy; Shoulder function

1. Introduction

Breast cancer is one of the most common cancers in women, with approximately 2.3 million new cases each year, accounting for 11.7 % of global cancer cases [1]. Approximately 685,000 people die from breast cancer each year, accounting for 6.9 % of cancer-related deaths worldwide [2]. The prevalence and survival of breast cancer have been increasing in recent years [3], and shoulder complications are one of the most common sequelae of breast cancer survivors (BCS) after breast cancer treatment, with typical symptoms including limited range of motion (ROM), stiffness, weakness and pain in shoulder [4]. It has been reported that the prevalence of limited ROM in shoulder is 32.9 % at 1 year after axillary lymph node dissection, and the incidence rate of pain and numbness is 51.1 % in BCS 2 years after breast cancer surgery [3, 5]. Therefore, shoulder complications could adversely affect the daily activities, medical burden, social life and living quality of BCS. As a result, the recovery of upper limb function has become a research hotspot. However, many survivors are afraid of postoperative activity, making the concern about arm injuries one of the common barriers in BCS rehabilitation [6]. Mirror therapy (MT) is a classic rehabilitation therapy based on visual feedback of planar mirror, which helps patients to restore the motor and sensory functions of the limbs [7]. In addition, it has been reported that MT plays a positive role in patients with shoulder dysfunction, including increasing the shoulder's ROM, improving the shoulder's functional score, and lowering the pain score [8]. Therefore, this study aims to explore the effect of upper extremities exercise based on mirror therapy in the postoperative recovery of shoulder function in breast cancer patients and its influence on postoperative shoulder function after long-term intervention in BCS.

2. Materials and methods

2.1 General information

A total of 120 patients were selected from January 2021 to December 2021 and randomly divided into control group (60 cases) and observation group (60 cases) by random number table method. The control group was given conventional intervention to do free movement of upper limbs, while the

observation group was additionally given mirror therapy. Inclusion criteria include, (1) women aged ≥18 years; (2) breast cancer was first clinically diagnosed by imaging examination and/or pathological examination; (3) patients received modified radical resection, mastectomy, or preservation surgery regarding breast surgery; (4) axillary lymph node dissection (ALND) or sentinel lymph node biopsy (SLNB) was given as for axillary surgery; (5) patients were able to use social software such as WeChat; (6) patients signed an informed consent form. Exclusion criteria include, (1) bilateral breast cancer or metastasis was diagnosed clinically; (2) patient with shoulder diseases, upper extremity fractures, neurological dysfunction, lymphangitis and any upper extremity injuries; (3) patients with severe cardiovascular disease, cognitive limitations, or psychiatric disorders with visual defects.

2.2 Methods

2.2.1 Conventional intervention in control group

During preparation stage, a quiet and comfortable room was prepared for patients. For those who have taken antihypertensive drugs, a rest for 30 minutes was required before exercise. Exercise should be paused when dizziness, nausea or low back pain occurs. Furthermore, if shoulder stiffness is more than 30 minutes in the morning, before exercise for 5–10 minutes arm stretching training combined with massage should be performed before exercise.

During the rehabilitation stage, (1) 1–2 days after surgery, the patient stood in a relaxed manner, placing the bouncy ball in the palm of the hand with the arm in the position where the elbow was bent and the shoulder was slightly extended. Then, squeezed the ball as hard as possible for 2–3 seconds, followed by stretched the fingers and relaxed. The arm position is the same as above, and the wrist rotated clockwise and counterclockwise at a frequency of 10 times/set, 2 sets/round and 2 rounds/day, to promote muscle contraction and blood and lymph flow to avoid swelling of the upper extremities; (2) 3–7 days after surgery, the patient stood in a relaxed manner, with arms placed on either side of the body, and alternately touched the ipsilateral and contralateral shoulders with affected hand. Keep the exercises in Phase 1 with a frequency of 10 times/set, 2 sets/round and 2 rounds/day, to promote recovery of rotation and adduction; (3) 8–14 days after surgery, the patient stood in a relaxed way with arms placed on either side of the body, then the arm was lifted forward by about 120° and backwards by about 60°. The arm was placed in a position where the elbow was bent and the shoulder was slightly extended (neutral position), followed by abduction and adduction of the shoulder. The arms were placed on either side of the body, then shoulder abduction and adduction was performed within a range of about 120°, and the shoulders were turned back and forth. The patient stood in front of the wall, and palm of the affected arm was placed on the wall and fingers were moved along the wall until they could not be moved anymore, then kept still for 1 minute, followed by sliding down of the fingers, to promote flexion, abduction and adduction of the shoulders. The frequency of this exercise was 10 times/set, 3 sets /round and 2 rounds/day; (4) 2–8 weeks after surgery, the patient stood in a relaxed way with arms placed on either side of the body, and arms were then lifted forward and backwards to achieve maximum ROM. Both arms outstretched at shoulder level, and elbows were bent 90 degrees in the abduction position, and then the forearms rotated up and down. The arms were placed on either side of the body and then shoulders were abducted and adducted at a maximum ROM. The frequency was 10 times/set, 3 sets/round, 2 rounds/day and 4 days/week. It mainly promoted the stretching and softened of the anterior chest wall to avoid tightness. Make sure that elbow was not bended when doing shoulder joint flexion and abduction. If the pain persisted after exercise, the patient should contact the interventional nurse as soon as possible.

2.2.2 Mirror therapy in the observation group

Patients in mirror therapy group received mirror therapy-based free movement of upper extremity from the first day after surgery, and the exercise protocol was the same as that of the control group. The vertical mirror designed for this experiment consisted of a planar mirror, an adjustable bracket and two wheels. The mirror size was 70 cm × 50 cm and the height of the adjustable bracket was from 1.2 m to 2 m. The process of mirror therapy intervention was as follows:

(1) Preparation: Mirror therapy was carried out in a separate and quiet room. All accessories including watch, bracelet, ring, and hair band, must be removed from both upper extremities prior to intervention. Participants chose to sit or stand by themselves. Along the median sagittal plane, the vertical mirror was placed in front of the subject, with the reflective side facing the healthy limb, and the affected limb hidden behind the mirror. Participants leant forward slightly as required to observe the complete reflexes of the unaffected limb in the mirror; (2) Warm-up: Participants were totally relaxed and focused on the reflection in the mirror, and imagined it as the affected limb, and then moved the upper limb freely for 2 to 3 minutes. This process would be repeated 3 times; (3) Exercise: The therapist instructed the participants in upper limb exercises with a free ROM, which was consistent with the control group. Participants were asked to observe the reflections of their unaffected limbs in the mirror and treated them as affected upper limbs, during which participants were required to focus on reflections in the mirror; (4) Nurses were requested to regularly record drainage, observe wounds, and measure arm circumference. Adverse events include, but are not limited to, an increase in wound drainage of more than 50 mL in the postoperative week, delayed wound healing, seroma, flap necrosis, and persistent shoulder pain. Any adverse events that occurred would be truthfully recorded. Participants who encountered adverse events had the right to opt out and receive free treatment and evaluation. If participants wished to continue the intervention, exercise would be provided, but their data were not included in our findings.

2.3 Observational index

The indexes were measured without being informed with the group allocation at baseline (T0) and at 2 weeks (T1), 4 weeks (T2), and 8 weeks (T3) after surgery.

As for Constant-Murley Score (CMS) [9], the scale mainly

TABLE 1. Comparisons of general information between the control group and observation group ($\bar{x} \pm s$, n).

Item	Control group (n = 60)	Observation group (n = 60)	χ^2/t	p
Age (year)	47.83 ± 5.58	48.22 ± 6.14	0.358	0.781
Education				
Junior high school or blow	29 (48.3%)	23 (38.3%)		
Senior high school or above	16 (26.7%)	22 (36.7%)	1.640	0.441
College degree or above	15 (25.0%)	15 (25.0%)		
Pathological grade				
I	26 (43.3%)	23 (38.3%)		
II	28 (46.7%)	33 (55.0%)	0.994	0.609
III	6 (10.0%)	4 (6.7%)		
Affected extremity				
Left	21 (35.0%)	28 (46.7%)	1.690	0.194
Right	39 (65.0%)	32 (53.3%)		
Surgery				
Modification + prosthesis	10 (16.7%)	7 (11.7%)		
Modified radical mastectomy	46 (76.7%)	48 (80.0%)	0.683	0.711
Breast conserving surgery	4 (6.7%)	5 (8.3%)		

includes a total score of 100 points, with 15 points for pain, 20 points for daily living ability, 40 points for shoulder ROM and 25 points for myodynamia. The higher the score, the better the functional recovery of upper limbs, and Cronbach's α coefficient is 0.827.

As for Disability of the Arm, Shoulder and Hand (DASH) Score [10], 11 items are included to make self-rating in social function, physical activity and symptoms of upper limbs. Each item is divided into 5 grades based on the difficulty of the patient's completion, with a total score of 100 points, and the higher the score, the greater the degree of upper limb dysfunction. The internal consistency of the scale Cronbach's α coefficient is 0.721~0.914, and the retest reliability is 0.882.

As for compliance of shoulder exercise, the way of exercise, exercise frequency, duration of each time or exercise willingness was investigated using self-designed questionnaires.

As for bilateral circumference difference of upper limbs, breast cancer related lymphedema is diagnosed by measuring the wrist joint and 15 cm below and 10 cm above the olecranon with any cross-section diameter exceeding the healthy side by 2 cm.

2.4 Statistics

SPSS 22.0 (IBM Corporation, Armonk, NY, USA) was used for data analyses. The quantitative data and enumeration data were respectively represented as mean ± standard deviation ($\bar{x} \pm s$) and proportion (%), with the use of t test for the quantitative data and Chi-square test for the enumeration data. A p value less than 0.05 was considered statistically significant.

3. Results

3.1 Comparisons of general information between the control group and observation group

Before intervention, patient's general information in control group and observation group was compared. As shown in Table 1, there was no significant difference in patient's general information (age, education level, pathological grade, affected extremity and surgery) between the two groups.

3.2 Comparisons of constant-murley score (CMS) between the control group and observation group

The scores of pain, Activity of Daily Living Scale (ADL), Range of motion (ROM), myodynamia and total score were similar before intervention between the control group and observation group ($p > 0.05$), which were significantly different at 4 weeks or 8 weeks after intervention ($p < 0.05$), and details were shown in Table 2.

3.3 Comparisons of disability of the arm, shoulder and hand (DASH) score between the control group and observation group

The Disability of the Arm, Shoulder and Hand (DASH) Score was similar before intervention between the control group and observation group ($p > 0.05$), which showed significant difference at 2 weeks, 4 weeks or 8 weeks after intervention ($p < 0.05$), and details were shown in Table 3.

TABLE 2. Comparisons of Constant-Murley Score (CMS) between the control group and observation group ($\bar{x} \pm s$).

Item	Cases	Before intervention	2 weeks after intervention	4 weeks after intervention	8 weeks after intervention
Pain					
Control group	60	5.68 ± 1.13	7.83 ± 1.18	9.07 ± 0.97	12.20 ± 0.97
Observation group	60	5.25 ± 1.09	7.33 ± 1.13	10.78 ± 1.18	13.55 ± 1.03
t		2.132	2.369	−8.697	−7.380
p		0.789	0.778	0.013	0.045
ADL					
Control group	60	6.35 ± 0.61	8.48 ± 0.62	11.48 ± 0.83	14.80 ± 0.73
Observation group	60	6.27 ± 0.52	8.62 ± 0.67	12.07 ± 0.78	16.80 ± 0.94
t		0.811	−1.131	−3.963	−13.046
p		0.117	0.361	0.046	0.005
ROM					
Control group	60	12.85 ± 1.12	19.88 ± 1.06	25.58 ± 0.996	33.60 ± 0.96
Observation group	60	12.55 ± 0.96	20.98 ± 1.17	27.03 ± 1.15	35.83 ± 1.45
t		1.575	−5.395	−7.384	−9.939
p		0.127	0.314	0.303	0.001
Myodynamia					
Control group	60	7.62 ± 0.96	10.85 ± 1.12	13.85 ± 1.42	17.68 ± 1.86
Observation group	60	7.58 ± 0.96	11.93 ± 1.90	14.97 ± 2.05	19.53 ± 2.55
t		0.190	−3.750	−3.621	−4.532
p		0.870	0.001	0.001	0.004
Total					
Control group	60	32.50 ± 2.02	47.05 ± 1.86	59.93 ± 2.15	78.28 ± 2.51
Observation group	60	32.65 ± 2.00	48.87 ± 2.73	64.86 ± 2.75	85.72 ± 3.56
t		2.312	−4.260	−10.907	−13.213
p		0.988	0.002	0.11	0.003

ROM: Range of motion; ADL: Activity of Daily Living Scale.

TABLE 3. Comparisons of Disability of the Arm, Shoulder and Hand (DASH) Score between the control group and observation group ($\bar{x} \pm s$).

Group	Cases	Before intervention	2 weeks after intervention	4 weeks after intervention	8 weeks after intervention
Control group	60	55.07 ± 1.84	47.07 ± 1.84	31.98 ± 1.82	16.98 ± 1.72
Observation group	60	54.92 ± 1.65	45.40 ± 2.49	29.28 ± 2.71	14.30 ± 2.65
t		0.470	4.175	6.415	6.575
p		0.596	<0.001	<0.001	<0.001

3.4 Comparisons of compliance of shoulder exercise between the control group and observation group

After intervention, patients in the observation group displayed right ways of exercise, high exercise frequency, long exercise duration and strong exercise willingness compared with patients in the control groups ($p < 0.05$), and details were shown in Table 4.

3.5 Comparisons of arm circumference between the control group and observation group

As for bilateral circumference difference of upper limbs, no significant difference was observed between the control group and observation group before intervention ($p > 0.05$). However, at 2 weeks, 4 weeks or 8 weeks after intervention, significant differences were observed ($p < 0.05$), and details were shown in Table 5.

4. Discussion

4.1 Functional exercise of upper limbs based on mirror therapy is beneficial to the functional recovery of affected limb

Breast cancer surgery significantly affects the ROM and strength of the shoulder, where shoulder dysfunction is one of the common postoperative complications in breast cancer patients, and upper limb functional exercise (ULFE) plays a positive role in promoting the functional rehabilitation of upper limb [11–13]. The results of this study showed that before intervention, there was no statistically significant difference in pain, ADL, ROM, myodynamia, and upper limb dysfunction scores between the two groups before intervention ($p > 0.05$), and obvious difference was observed regarding these parameters between the two groups at 4 or 8 weeks after intervention ($p < 0.05$). The main reason is that, patients saw their healthy hands and reflected mirror images of these healthy hands through mirror therapy, then the patient's attention was distracted from the healthy hand to the affected one by the formation of optical illusions, thereby helping patients complete the basic and functional movements of the upper limb, improving joint flexibility and the speed and accuracy of upper limb movements [14, 15]. Consistently, studies have shown that mirror therapy-based functional exercise of the upper limbs could reduce pain and increase shoulder ROM after breast cancer therapy [13, 16]. Therefore, when guiding patients to carry out limb exercise, it is necessary to take strict nursing and gradually carried out functional exercises on the basis of patient's actual situation, evidence-based skills, and clinical experience to help patients restore normal limb function.

4.2 Functional exercise of upper limb based on mirror therapy contributes to the compliance of exercise

Dysfunction is an independent factor influencing survival in breast cancer survivors [17, 18]. It has been reported that the occurrence of numbness above the waist is 63%, significant swelling to 35%, varying degrees of pain 13%–15%, and shoulder abduction restriction and myasthenia is 1%–4% [19, 20]. Shoulder dysfunction and pain during exercise significantly affect patient's compliance of functional exercises, and also have a negative psychological impact on patients [19]. This study demonstrated that patients in the observation group displayed right ways of exercise, high exercise frequency, long exercise duration and strong exercise willingness compared with patients in the control groups after intervention ($p < 0.05$), which is manly explained by the characteristics of mirror therapy of low intensity and high frequency in exercise time, step by step in exercise intensity and moderate amount in practice. And, the quality and quantity of exercise are guaranteed, and the enthusiasm of patients for exercise is stimulated under the nurse's direct supervision. Secondly, the functional exercise of upper limb based on mirror therapy activates the neuronal system of the brain through visual feedback and motor observation, which effectively improves the patient's daily living activities and stimulates the patient's interest in taking exercise [21, 22].

4.3 Functional exercise of upper limbs based on mirror therapy effectively prevents the occurrence of lymphedema

Upper extremity lymphedema is a chronic progressive disease that accumulates fluid in the interstitial space due to damage to lymph nodes during axillary anatomy and radiation in breast cancer therapy [23]. Studies have shown that exercise is a planned, structured, and repetitive activity that is effective in preventing the incidence of upper extremity lymphedema [24, 25]. Upper extremity lymphedema is diagnosed by measuring the wrist joint and 15 cm below and 10 cm above the olecranon with any cross-section diameter exceeding the healthy side by 2 cm [26]. The results of this study showed that there was significant difference regarding the bilateral circumference difference of upper limbs after intervention ($p < 0.05$). The main reason may be that mirror therapy was used in the observation group to help patients adhere to functional exercise. Good exercise could increase the muscle strength, reduce the thickness of subcutaneous tissue, and thus increase the muscle thickness, resulting in the reduction of the circumference of the upper limb through the drainage of muscle pump, the amelioration of edema, and the enhancement of motor function of the affected limb. Studies have shown that there is a high incidence (13%–40%) of lymphedema after breast cancer surgery, and lymphedema may occur 2 to 3 years after surgery. Therefore, there is no limit to the occurrence time point of upper extremity lymphedema. Thus, nurses should extend the time of follow-up and establish a continuous home exercise team to urge patients to exercise the upper limbs to increase lymphatic reflux of upper limbs and prevent the occurrence of lymphedema [27, 28].

5. Conclusions

Functional exercise of the upper limb based on mirror therapy is helpful to the recovery of upper limb function in patients

TABLE 4. Comparisons of compliance of shoulder exercise between the control group and observation group (n, %).

Item	Control group	Observation group	χ^2	*p* value
Right way				
Yes	54 (90%)	57 (95%)	1.081	0.298
No	6 (10%)	3 (5%)		
Frequency				
<3	6 (10%)	0 (0%)		
3–10	46 (75%)	57 (95%)	10.412	0.005
>10	9 (15%)	3 (5%)		
Duration				
10–30	60 (100%)	26 (43%)	47.442	<0.001
>30	0 (0%)	34 (57%)		
Willingness				
Active	41 (68%)	54 (90%)		
Passive	13 (22%)	6 (10%)	10.358	0.006
None	6 (10%)	0 (0%)		

TABLE 5. Comparisons of arm circumference between the control group and observation group ($\bar{x} \pm s$).

Item	Cases	Before intervention	2 weeks after intervention	4 weeks after intervention	8 weeks after intervention
Wrist joint					
Control group	60	4.75 ± 0.95	4.17 ± 0.89	3.25 ± 0.87	2.46 ± 0.83
Observation group	60	4.90 ± 1.01	3.96 ± 0.51	2.88 ± 0.99	1.67 ± 0.99
t		−0.838	−1.117	−1.349	−1.296
p		0.499	0.448	0.001	0.004
15 cm below olecranon					
Control group	60	5.36 ± 1.14	4.75 ± 1.02	3.98 ± 1.00	2.30 ± 0.97
Observation group	60	5.50 ± 1.01	3.93 ± 1.04	2.15 ± 1.04	2.07 ± 1.05
t		−1.198	−0.965	−0.912	−0.949
p		0.360	0.678	0.001	0.001
10 cm above olecranon					
Control group	60	6.73 ± 0.94	5.04 ± 0.94	3.87 ± 0.96	3.34 ± 0.96
Observation group	60	6.83 ± 1.04	5.19 ± 0.98	3.04 ± 0.93	2.81 ± 0.91
t		−0.560	−0.808	−2.079	−2.792
p		0.268	0.356	0.001	0.001

with breast cancer surgery as it increases the compliance of functional exercise of upper limb, and prevents the occurrence of upper limb lymphedema. Besides, mirror therapy has the advantages of low cost, strong practicality, convenient application, *etc.*, and is worth promoting in the restoration of shoulder function in breast cancer surgery. In addition, the sample type of this study is single, limited to breast cancer patients in our hospital. Besides, the observation time is short. In the future, multi-center and large sample in-depth study should be considered to provide a more reliable reference for clinical practice, and health-related quality of life measurement and follow-up should be conducted regularly after discharge.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

JLZ and RJ—designed the study and carried them out. JLZ, RJ, FH, XMD and CC—supervised the data collection, analyzed the data, interpreted the data. JLZ and JW—prepared the manuscript for publication and reviewed the draft of the manuscript. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Union Hospital, Tongji Medical College, Huazhong University of Science and Technology (Approval no. 2020221). Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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