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Effect of Constraint Induced Movement Therapy on Burned Dominant Hand Function

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ABSTRACT

Background: Hand burns are very challenging and many therapeutic interventions have been introduced to enhance hand function post-burns, however, poor outcomes are still seen.

Aim: This aimed to explore the effect of a constraint induced movement therapy (CIMT) on burned dominant hand function.

Patients and methods: This prospective randomized controlled trial included thirty-four patients with dorsal dominant hand burn. They ranged in age from 20 to 35. The patients were gathered from Hospitals of Cairo University and split into two groups at random; 17 patients in group (A) who received CIMT in addition to traditional therapy, and 17 patients in group (B) who only received traditional therapy, which included range of motion (ROM) exercises, positioning, strengthening exercises, stretching exercises, and occupational activities. Metacarpophalangeal (MCP) joint ROM, hand grip strength, and function were assessed using a finger goniometer, hand dynamometer, and Michigan Hand Questionnaire (MHQ) respectively prior, following 4 weeks, and 8 weeks of therapy.

Results: Both groups showed significant improvement in terms of MCP joint ROM, hand grip strength and MHQ scales after 4 and after 8 weeks of therapy (p=0.001). There was a significant variation in mean value of MCP joint ROM and MHQ scales only in favor of CIMT group after 8 weeks of therapy.

Conclusion: Eight weeks of Constraint induced movement therapy can greatly enhance the burned dominant hand range of motion and function.

Keywords: Constraint Induced Movement Therapy, Burned Hand Function.

INTRODUCTION

Physical impairment and a reduced quality of life (QoL) following a burn injury remain major challenges, even with continuous advancements in burn care [(1)].

The most frequent locations for burn damage are the distal portions of the upper limbs. Joint stiffness, sensory affection, scar contracture, and post-burn edema are frequent side effects following a hand burn. It has been observed that one of the predictors of hand contracture is injury to the dominant hand. Following a burn, hand function loss can significantly impact fine motor skills like typing and writing as well as occupational activities and activities of daily living (ADL) like eating, dressing, and grooming. According to researches, hand functional disorders lead 75% of patients with deep hand burns to change careers [(2)].

The traditional therapy for hand burn involved: Proper positioning, exercise therapy and therapeutic massage, however, the outcomes are still unsatisfactory. Constraint-induced movement therapy is a rehabilitation technique that consists of restricting the sound upper extremity (UE), while intensively exercising the affected one to enhance practice on functional motor tasks [(3, 4)]. The CIMT showed significant improvement on upper limb and hand functions when added to traditional therapy for patients with motor impairments [(5)].

Up to current study researchers' knowledge and search, no previous trials investigated the efficacy of adding CIMT to the traditional therapy on burned hand function. Hence, the need of our study has been established. Therefore, the present trial was introduced to explore the effect of a constraint induced movement therapy on burned dominant hand function.

PATIENTS AND METHODS

Participants: Thirty-four patients, aged between 20 and 35 years, who had a deep partial thickness dorsal hand burn "within one month after wound closure", took part in the study. They were gathered from the Hospitals of Cairo University.

Exclusion criteria: Those who had concurrent significant vascular injuries, crush injuries, nerve injuries, fractures, and any diseases or disorders that affected their hands' skills other than hand burn were not allowed to participate. Additionally, those with uncontrolled cardiovascular, metabolic, or pulmonary problems, impaired cognitive function, contralateral upper limb burns and those with more than 20% of their total body burned surface area (TBSA).

Study Design: The present trial was designed to be a prospective, randomized, single-blind, and controlled one.

Randomization: Through the use of sealed opaque envelope processes, participants were assigned at random to either group A or B. Block randomization was used to guarantee that each group had an equal number of patients. After being randomly assigned, no subjects were

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dropped out. The patients' flow is demonstrated in figure (1) regarding CONSORT 2010 [6].

Assessment Procedures: The MCP joint motion range, the grip strength, and MHQ scales for the burned dominant hand were evaluated before therapy, after 4 weeks and after 8 weeks of therapy in both groups. Active MCP joints ROM was measured by using the finger goniometer (ORTOPRO, Made in Lithuania). Adults typically have MCP motion values between 90 and 100 degrees. A hand dynamometer (Healthy Hands electronic Hand Grip Strength Dynamometer GRIP-A General Type, China) was used to evaluate hand grip strength. Hand grip strength and MCP joint range of motion were measured using the standard operating procedure [7, 8]. Each patient was given an Arabic version of MHQ to complete the six scales' questions (Overall of hand function, activity of daily life, work, pain, anesthetics, and satisfaction). The MHQ scoring system was used to normalize the raw scale score to a scale score that spans from 0 to 100 [9, 10]. All measurements and scores were documented for all patients in both groups.

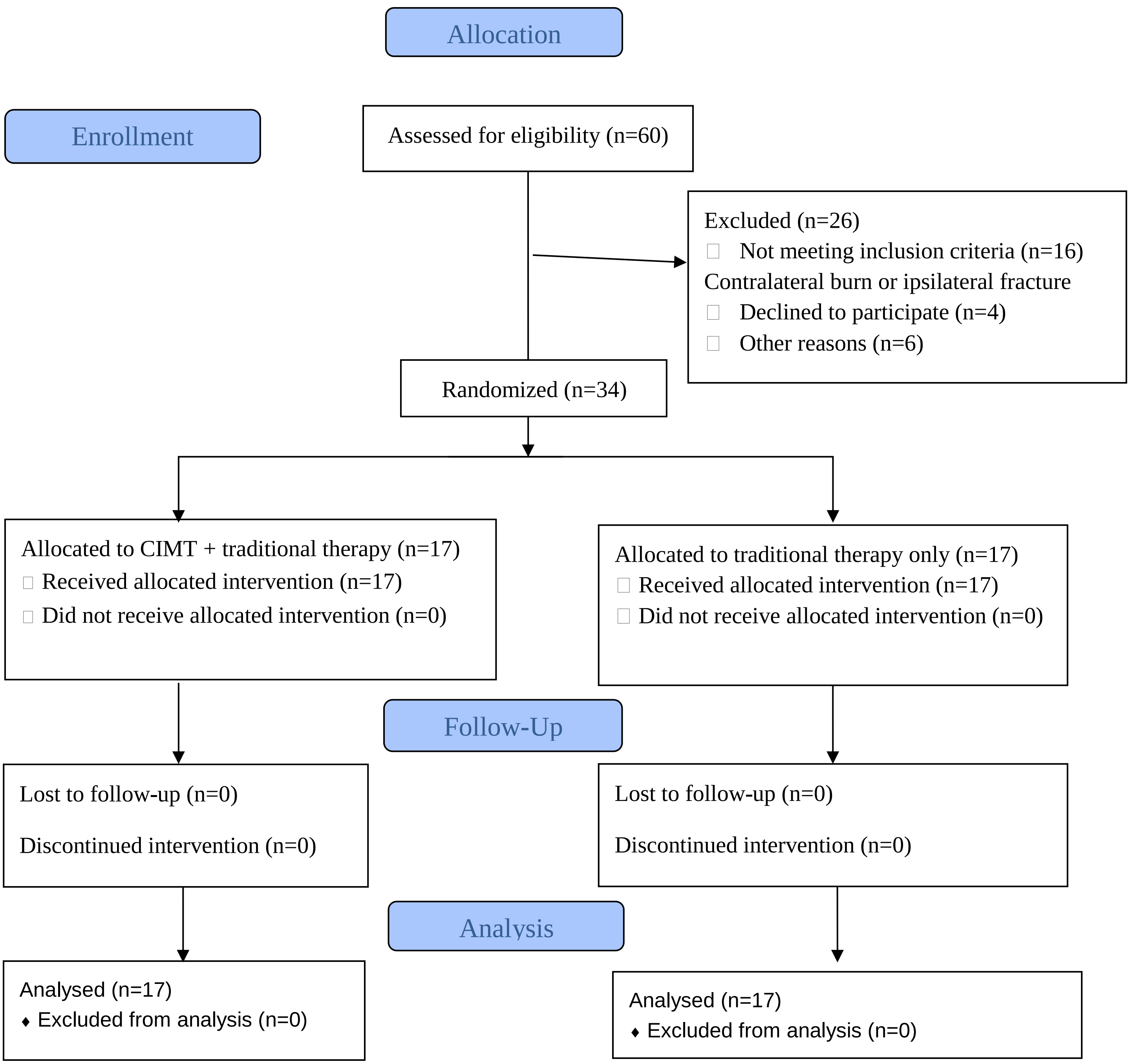

Figure (1): CONSORT flow chart of trial.

THERAPEUTIC PROCEDURES

Constraint induced movement therapy: The CIMT involved restraining the contralateral limb by a padded mitt (Figure 2) and the patients were instructed to do activities of daily living for 6 h per day. These activities included: Dressing, grooming, eating and drinking. They also included occupational therapy specific tasks (Training focused on tasks) with a lot of repetitions like writing, cutting and other tasks that typically employ materials, which are commonly available (Foam & Rubber). Otherwise, the patients were instructed to keep the non-burned upper limb in the padded mitt to engage in the regular activities of their daily live during 90% of the total hours awake [11].

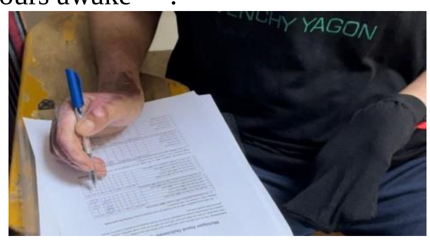

FIG. 2: Writing with restraining contralateral limb.

Traditional therapy: The traditional therapy program included: (I) Post burn upper limb ROM exercises: Active free ROM exercise within the available range of the involved limb (wrist flexion, extension, ulnar deviation, radial deviation, MCP joint flexion, MCP joint extension, flexion abduction, finger adduction, finger flexion, finger extension and thumb opposition), were carried out with 15 reps for three times/day. Active assisted and passive ROM exercises were done if needed to complete the available range. (II) Positioning: Positioning was carried out together with proper ROM training. During rest, the hand was kept in intrinsic plus position using foam or medical gauze to keep hand position. (III) Strengthening exercises for hand intrinsic muscles: The patient started to perform progressive strengthening exercises for hand intrinsic muscles using therapy putty or foam to squeeze in intrinsic plus hand position. Squeezing as much as possible, holding the squeeze for five seconds, relaxing, and then repeating were the instructions given to the patient. Three times a day, the patient performed three sets of fifteen squeezes, with 30 seconds to 1 minute rest in between. (IV) Stretching exercises: For the burned hand, the MCP joints were passively stretched toward flexion, while the interphalangeal joints were passively stretched toward extension. The stretch was maintained for 30 seconds, relax for same time and then was repeated. The stretch cycles were repeated 3 times for 3 times/day. (V) Occupational activities: The patients were encouraged to engage with their hands in their regular activities of daily living in addition to other occupational tasks like writing, cutting and picking [11-15].

Ethical approval: Each patient completed an informed consent sheet after being fully informed of their rights before taking part in the trial. The Institutional Review Board of Cairo University's Faculty of Physical Therapy granted ethical permission (No. P.T. REC/012/005218) prior to the study execution, and the National Library of Medicine registered the study on Clinical trial.gov (NCT06708273). The Declaration of Helsinki Guidelines for Human Research was followed in the conduct of the current investigation.

Statistical analysis

Both groups' descriptive data were presented as mean ± SD. The TBSA and age of both groups were compared using the unpaired t-test. Both groups' gender distribution was compared using the Chi square test. The normal data distribution was examined using the Shapiro-Wilk test. To assess the effects of the measured variables (MCP joint ROM, hand grip strength, and MHQ scores) within and between groups, MANOVA was used. Data analysis was conducted using the statistical package for the social sciences computer program (SPSS Inc., Chicago, Illinois, USA; version 20 for Windows). A P-value of 0.05 or less was considered significant.

RESULTS

Table (1) indicated that the mean values of the individuals' ages and TBSAs for the two groups did not differ significantly (p=0.581 and 0.826 respectively). The distribution of sexes in the two groups did not differ significantly also (p = 0.728). Every measured variable had a normal distribution, according to the Shapiro-Wilk test (p>0.05).

Table (1): Demographic data of patients of both groups

Demographic data	Group A (n=17)	Group B (n=17)	t-value	p-value
Age (years)	26.9±4.7	27.8±3.9	-0.56	0.581
TBSA (%)	7.9±5.1	8.4±5.7	-0.22	0.826
Sex	N (%)	N (%)	χ^2	
Males	6 (35)	8 (47)	0.86	0.728
Females	11 (65)	9 (53)		

Data was expressed as mean ± standard deviation or number (percentage), TBSA: Total body surface area, χ^2: chi square, p-value: significance.

Metacarpo-phalangeal joint ROM:

For within group comparison, there was a statistically significant increase of MCP joint ROM after 8 weeks than pre-therapy by 62% in group A, and 52% in group B (p = 0.001). Post hoc test for MCP joint ROM in groups A and B showed that there was statistically significant variation (improvement) between pre-therapy and after 4 weeks, between pre-therapy and after 8 weeks and between after 4 weeks and after 8 weeks (P = 0.001).

Regarding between groups comparison, there was no statistically significant variation in the mean values of MCP joint ROM pre-therapy and after 4 weeks between both groups (p= 0.688 and 0.466), while there was statistically significant difference after 8 weeks (p=0.001) in favor to group A with a mean difference of 9 between both groups (Table 2).

Hand grip strength:

For within group comparison, there was a statistically significant increase of hand grip strength after 8 weeks than pre-therapy by 43% in group A and 37% in group B (p = 0.001).

Post hoc test for hand grip strength in groups A and B showed that there was statistically significant variation (improvement) between pre-therapy and after 4 weeks, between pre-therapy and after 8 weeks and between after 4 weeks and after 8 weeks (P = 0.001). Regarding between groups comparison, there was no statistically significant difference in the mean values of hand grip strength pre-therapy, after 4 weeks or after 8 weeks (p= 0.622, 0.442 and 0.291 respectively) (Table 2).

Table (2): Mean ±SD of MCP joint ROM and Hand grip strength pre and post therapy of both groups

	Group A Mean ±SD	**Group B Mean ±SD**	**Mean difference (95% CI)**	**P-value[1]**	**η^2**
MCP joint ROM (degrees)					
Pre-therapy	45.8 ± 23.5	42.9 ± 17.5	2.9 (-11.6, 17.4)	0.688	0.005
After 4 weeks	59.2 ± 19.8	54.5 ± 16.9	4.6 (-8.2, 17.5)	0.466	0.017
After 8 weeks	74 ± 14.3	65 ± 10.4	9 (0.3, 17.7)	0.044*	0.121
P-value	0.001*	0.001*			
Hand grip strength (kg)					
Pre-therapy	14.1 ± 7.5	13.1 ± 3.4	1 (-3.1, 5.1)	0.622	0.008
After 4 weeks	17.1 ± 7.2	15.5 ± 4.3	1.6 (-2.6, 5.7)	0.442	0.019
After 8 weeks	20.2 ± 7.2	18 ± 4.7	2.2 (-2, 6.5)	0.291	0.035
P-value	0.001*	0.001*			

Post-hoc test between measures for MCP joint ROM and Hand grip strength

	Group A			Group B		
	Pre versus 4 weeks	Pre versus 8 weeks	4 weeks versus 8 weeks	Pre versus 4 weeks	Pre versus 8 weeks	4 weeks versus 8 weeks
p-value	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*

SD: standard deviation, CI: Confidence interval, p-value: level of significance within group, MCP: metacarpo-phalangeal, p-value[1]: level of significance between groups, *: significant, η^2: partial eta square.

Table (3): Mean ±SD of MHQ scales pre, after 4 and 8 weeks of both groups

MHQ	Group A Mean ±SD	Group B Mean ±SD	Mean difference (95% CI)	P-value[1]	η^2
Overall hand function					
Pre-therapy	45.2 ± 21.6	42.3 ± 18.4	2.9 (-11.1, 16.9)	0.678	0.005
After 4 weeks	58.6 ± 17.7	53.9 ± 17.5	4.6 (-7.7, 17)	0.448	0.018
After 8 weeks	73.4 ± 13.5	64.5 ± 11.7	8.9 (0.1, 17.7)	0.048*	0.116
P-value	0.001*	0.001*			
Activities of daily living					
Pre-therapy	14.1 ± 5.4	13.1 ± 3.7	1 (-2.2, 4.2)	0.525	0.013
After 4 weeks	17.1 ± 5.5	15.4 ± 4	1.7 (-1.7, 5.1)	0.309	0.032
After 8 weeks	20.8 ± 5.4	17.2 ± 3.9	3.6 (0.3, 6.9)	0.034*	0.133
P-value	0.001*	0.001*			
Work					
Pre-therapy	50.3 ± 19	39 ± 21.8	11.3 (-3, 25.6)	0.117	0.075
After 4 weeks	59.6 ± 17.7	45.9 ± 21.8	13.7 (-0.2, 27.6)	0.053	0.112
After 8 weeks	77.4 ± 14.6	57.4 ± 19.3	19.9 (8, 31.9)	0.002*	0.266
P-value	0.001*	0.001*			
Pain					
Pre-therapy	52.1 ± 25.9	62.1 ± 24.4	-10 (-27.6, 7.6)	0.255	0.04
After 4 weeks	27.6 ± 15	49 ± 22.2	-21.3 (-38, -4.7)	0.014*	0.175
After 8 weeks	12.8 ± 7	39 ± 19.3	-26.2 (-38, -14.4)	0.001*	0.389
P-value	0.001*	0.001*			
Anesthetics					
Pre-therapy	49.1 ± 29.2	44.5 ± 27.9	4.6 (-15.4, 24.6)	0.641	0.007
After 4 weeks	67.8 ± 24	60 ± 22.9	7.8 (-8.6, 24.3)	0.338	0.029
After 8 weeks	84.5 ± 12.9	70.6 ± 20.7	13.9 (1.8, 25.9)	0.026*	0.146
P-value	0.001*	0.001*			
Satisfaction					
Pre-therapy	62.2 ± 22.2	52.9 ± 22.2	9.3 (-5.4, 24)	0.207	0.049
After 4 weeks	73.1 ± 18.5	62.9 ± 20.2	10.2 (-3.4., 23.7)	0.138	0.067
After 8 weeks	90.2 ± 8.4	74 ± 17.6	16.2 (6.5, 25.9)	0.002*	0.266
P-value	0.001*	0.001*			

Post-hoc test between measures of MHQ domains

	Group A			Group B		
p-value	Pre versus 4 weeks	Pre versus 8 weeks	4 weeks versus 8 weeks	Pre versus 4 weeks	Pre versus 8 weeks	4 weeks versus 8 weeks
	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*

SD: standard deviation, CI: Confidence interval, p-value: level of significance within group, MHQ: Michigan Hand Questionnaire, p-value[1]: level of significance between groups, *: significant, η^2: partial eta square.

DISCUSSION

Hand burns are considered severe injuries even though they only damage less than 3% of the body's surface area (per hand). Despite not being a significant cause of death, hand burns are crucial for a patient's effective reintegration into society and the workplace following hospital discharge [(16)].

This study's main goal was to examine the efficacy of constraint-induced movement therapy (CIMT) on the functionality of burned dominant hands. Given the significant impact that hand burns can have on an individual's ability to reintegrate into society and perform daily activities, understanding effective rehabilitation strategies is of utmost importance.

In present study, both groups of traditional therapy and CIMT showed an improvement of the outcome in terms of MCP joint ROM, the grip strength, and the all scales of MHQ post 4 and 8 weeks of therapy in comparison with the pre-therapy measurements. Our findings indicated that adding CIMT for 8 weeks to traditional therapy provides substantial improvements in MCP joint flexion ROM and hand function in comparison with traditional therapy only. These results align with previous studies that have highlighted the effectiveness of CIMT in enhancing function in the upper limbs in various patient populations, proposing interesting mechanisms of action. **Wang *et al.*** [(17)] reported that CIMT can improve the plasticity of dendrites and dendritic spines in the ipsilateral and contralateral sensorimotor cortex and enhance the expression of glutamate receptor 2 (GluR2), which has a great role in regulation of the ipsilateral sensorimotor cortex synapse. Additionally, **Omer *et al.*** [(18)] noted that the repetitive nature of CIMT facilitates the engagement of the most affected limb promoting cortical representation improvement. This neuroplasticity is crucial for recovery, particularly in patients with upper limb impairments. Similarly, **Shaheen Noor *et al.*** [(19)] reported that CIMT led to marked improvements in upper arm function and hand movements.

The shared outcomes across these studies reinforce the notion that CIMT is a robust intervention for improving motor function in patients with upper extremity impairments, including those resulting from burn injuries. Interestingly, while our study demonstrated significant improvements in MCP joint flexion ROM and hand function, the hand grip strength in the CIMT group and the control group did not differ statistically significantly.

This finding reflects that while CIMT is effective in enhancing certain aspects of hand function, it may not be sufficient on its own to improve grip strength. This finding resonates with **Terranova *et al.*** [(20)] who noted improvements in patient post-stroke regarding motor function and other relevant domains after 12 weeks of therapy, which may not directly translate to enhanced strength unless the intervention is sustained over time. Our findings also align with the observations of **Anjum *et al.*** [(21)] who emphasized how CIMT significantly affects daily life activities and upper extremity function immediately following treatment. This suggests that while CIMT may not directly improve grip strength, it plays a critical role in enhancing overall hand function and independence, which are crucial for activities of daily living (ADLs). The meta-analysis done by **Thrane *et al.*** [(22)] further supports the notion that CIMT can be superior to traditional rehabilitation approaches, emphasizing the need for continued exploration of its applications in diverse rehabilitation contexts.

Contrastingly, some studies, such as those done by **Corbetta *et al.*** [(23)] and **Hakkennes & Keating** [(24)] who reported limited enhancement in motor functioning and quality of life associated with CIMT. These discrepancies may be attributed to variations in study design, kind of upper limb affection, and the specific metrics used to assess outcomes. Furthermore, the differences in patient commitment to home exercise programs, and psychological and physical statuses may have contributed to the variability in outcomes observed in the literature.

Limitations: It is important to clarify the limitations of our trial including variability in patients' compliance, differences in physical and psychological statuses, and individual variations among participants, which may have influenced the outcomes. Additionally, human error in assessment and data collection processes cannot be discounted. Future studies must take into account greater sample numbers, extended follow-up times, and more controlled environments to mitigate these limitations and provide a clearer understanding of the efficacy of CIMT in burn rehabilitation. To sum up, our research adds to the increasing amount of data demonstrating the effectiveness of CIMT in rehabilitating hand function post-burn injury as it demonstrated significant improvements in joint mobility and hand function. Further investigation is warranted to explore the efficacy of integrating CIMT with other therapeutic modalities, which may provide a more comprehensive approach to rehabilitation, ultimately improving outcomes for individuals with hand burns.

CONCLUSION

Eight weeks of constraint-induced movement therapy can greatly enhance the burned dominant hand range of motion and function.

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