Range of Motion Exercises Effect during and after Hydrotherapy on Patients Burned Hand Function and Pain Intensity: A Comparative Study

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Abstract

Hand burn injuries can result in devastating functional impairments and hamper quality of life. One of the rehabilitation program components is hydrotherapy, which help in cleaning the burn surface, debriding wounds, facilitating the separation of eschar, facilitating physiotherapy, and improving patients' comfort. This study aimed to evaluate range of motion exercises effect during and after hydrotherapy on patients burned hand function and pain intensity. A quasi-experimental comparative research design was conducted on three equal group of 15 adult patients having second degree burn of the hand (superficial and deep partial-thickness burns). Three tools were used for collecting the data: Tool I: Burn patient Assessment interview schedule. Tool II: Burned Hand functional assessment. Tool III: Pain Visual Analogue scale (VAS). Significant improvement was noticed among the three groups subjects in relation wrist and finger joint measurements, manual muscle testing, functional ability of the hand, and pain intensity. Hydrotherapy is an effective, alternative intervention that can be used by care providers as a non-pharmacological method in most burn centers.

Keywords: Range of motion exercises, hydrotherapy, hand function, and pain intensity

Introduction:

Hand burns affect less than 3 % of the total body surface area (per hand), and are classified to be severe injuries, which will require treatment in a specialized burn center. Although, hand burns do not play a major role concerning mortality; they are important factors for a successful reintegration into society and professional life after hospital discharge (Kitzinger et al., 2012).

Hand burn injuries can result in devastating functional impairments with biological, social, and psychological consequences that limit community and professional reintegration, and can hinder quality of life (Johnson & Chung, 2017). Changes in regenerating and damaged nerve fibers and tissues may result in the development of chronic pain syndromes. Control of pain is required to allow further wound management, stabilize the sleep/wake cycle and to improve morale. (Norman, et al 2004).

Accurate assessment of hand function following a burn is important for patient's impairment and disability determination (Parry, et al 2010). Outcome assessment in hand therapy is focused on measures of range of motion (ROM), strength, and sensation. (Schoneveld, et al 2009).

Patients with significant burns require long-term care and a prolonged period of rehabilitation. (Mayer &Werman 2019). In burned hands rehabilitation, the primary goal following a burn is to maximize ROM of the affected area (Ardebili, et al 2014). The best time to increase the ROM is when the scar is still maturing. Scar begins forming within days after injury and can continue to form for years. Incomplete rehabilitation or delayed rehabilitation is an important factor for impairing function of hands and negative consequences resulting from it (Moore & Schmidt 2012).

Application of physical therapy and splinting after burned hand injuries is very important in prevention of edema & contracture, dysfunction, disfigurement, psychological problems, and other discomforts due to burns. Moreover, it helps in maintaining or improving ROM & functional recovery, preventing of development of keloids scars, improve muscle force and good cosmetic results (Rrecaj, et al 2015, Cen, et al 2015).

One of the rehabilitation program components is hydrotherapy, which has been used to describe medical use of water, either for early wound cleansing or for post-rehabilitation and treatment of scars. It continues to play an important role in burns' management. The benefits of hydrotherapy include, reduction of wound bacterial load, cleaning the burn surface, debriding wounds, facilitating the separation of eschar, facilitating physiotherapy, and improving patients' comfort (Langschmidt, et al 2014, Moufarrij, et al 2014). The therapy uses specific mineral enriched hot spring water and water jets with varied hydro-pressure to combat hypertrophy, inflammatory reaction signs, abnormal pigmentation, and, more specifically, redness and scarring (Moufarrij, et al 2014).

Hydrotherapy treats the patient through the medium of water. Water can provide warmth and coldness, moistens the soft tissues, and supports the tissues. In addition to the thermal benefits of reducing pain, edema, and muscle spasm. (Chmidt , et al 2013).

Nurses play an important role in the overall management of a burn patient. They must be well versed with the various protocols available that can be used to rationally manage a given situation. The management not only involves medical care but also a psychological assessment of the patient and the family. The process uses a scientific method to combine systems theory with the art of nursing, entailing both problems solving techniques and a decision-making process. (Greenfield 2010**).**

Hydrotherapy as a mode of treatment for burns has been advocated or criticized by several authors, and undoubtedly it is widely used. We can 'scarcely imagine a Burn Unit without a properly equipped hydrotherapy room (Lochaitis.1992**).** To date, there has not been a published study regarding hydrotherapy practices and effect of ROM on burned hand in Egypt. The researchers identified this as a worthwhile subject to investigate.

Aim of the study:

Aim of the present study was to evaluate of range of motion exercises effect during and after hydrotherapy on patients burned hand function and pain intensity.

Research hypothesis:

Burned hand function will be improved in patients who are receive range of motion exercises during and after hydrotherapy than those who do not.

Burned hand pain intensity will be decreased in patients who receive range of motion exercises during and after hydrotherapy than those who do not.

Significance of the study:

Significance of the study from the researcher's experience, it has been noticed that burned patients can expose to joint stiffness as a result of burn injury which impair the range of motion, function of joints, so range of motion exercise program using hydrotherapy plays an important role for improving function of joints, facilitating physiotherapy, improving patients' comfort and decrease complications.

Materials and Method

Materials

Research design: A quasi- experimental comparative research design was used to conduct the present study.

Setting: The present study was conducted at the Burn Unit (in-patient and out-patient clinic) in the Main University Hospital, Alexandria, Egypt.

Subjects:

- A convenient sample of 45 adult (21-60 years old), male and female patients, having second degree burns of the hand (superficial and deep partial-thickness burns), with body surface area (BSA) of 15-45%, able to communicate, were hospitalized at time of the study, and suffered burns for 72 hours were included in the study.
- Exclusion criteria were patients with diabetes mellitus (due to probability of having motor and sensory neuropathy), dermal allergy, malignancy, record of mental diseases, deformation and motor disorders of hands and fingers.
- A power calculation estimated that in order to detect an effect size of one group with a p-value< 0.05 and 80% power, confidence

level 0.95, so a sample size of (45) patients was needed.

- The study subjects were recruited and assigned randomly into three equal groups; 15 patients each, as follows:

- Group (1): Control patients were subjected only to routine hospital treatment; range of motion (ROM) hand exercise once daily before wound dressing.
- Group (2, 3): Experimental subjects, in group "2" were subjected to ROM hand exercises post hydrotherapy sessions daily, and those in group "3" were subjected to ROM hand exercises during hydrotherapy sessions daily, before wound dressing for two months, thereafter as a follow up period.

Tools:

Three tools were used in the present study:

Tool I: Burn patient Assessment Interview Schedule

This tool was developed based review of related literature (Ahmed et al., 2019, Espinoza et al., 2020) to obtain patient baseline data. It consisted of two parts:

Part I: Patient's sociodemographic characteristics such as age, sex, educational level, marital status, occupation, and area of residence.

Part II: Burn assessment sheet: This part included certain items as time and mechanism of injury, depth and severity of burn, any associated illnesses or injuries, patient's chief complaints, prescribed and over counter medications.

Tool II*:* Burn Hand Functional Assessment

This tool was adapted from (Hislop, & Montgomery, 1995) and adopted from (Duruoz et al, 1996, and Nizamis et al., 2018). It consisted of three parts as follows:

Part I: Wrist and Finger joint measurements using Goniometer: This part was adopted from (Nizamis et al., 2018) and included 3items:

(a) Wrist measurements which comprised 3 estimations, were scored as follows:

(1): Wrist flexion (2)***:*** Wrist Extension. (***3):*** Wrist ulnar and radial deviations.

Wrist flexion values were graded (0 to 80) degrees, wrist extension values were graded (0 to 70) degrees, wrist ulnar deviation ranged from (0 to 30) degrees.

(b) Finger measurements which comprised 4 estimations:

(1): Finger flexion. ***(2)****:* Finger extension. (***3):*** Finger abduction. (***4):*** Finger adduction. Normal finger flexion values are (0 to 50) degrees.

Normal values for finger extension are (0 to 45) degrees. Normal finger adduction values are (0 to 20) degrees.

(c) Thumb movement: These movement were estimated by moving thumb to touch the tip of each finger and the base or pad of each finger.

Thumb movements were assessed on 3 points rating scale ranging from (2) done, (1) = Limited, and (0) = Not done.

Part II: Manual Muscle Testing (MMT), Gradings of Fingers, Thumb, and Wrist:

- This part was adapted from (Hislop, & Montgomery,1995), and used to assess muscle strength of patient's hand, and provide details that can assist in planning appropriate interventions or therapy. It includes three items to be tested.

(*a) Manual Muscle Testing of the Fingers as*; metacarpophalangeal (MCP) flexion, extension, proximal interphalangeal (PIP) flexion, extension, as well as distal interphalangeal (DIP) flexion, extension, abduction, and adduction.

(b) Manual Muscle Testing of the Thumb as; abduction, adduction, thumb IP extension, and flexion, thumb MP extension, flexion, thumb opposition.

(c) Manual Muscle Testing of the Wrist as; abduction, adduction, flexion, and extension.

- The MMT grading scale ranges from; grade5– 0:

- Grade "5" indicating (normal or 100%) muscle strength; the patient can complete the whole range of motion against gravity with maximum resistance applied by researcher at end of range.
- Grade "4" (Good; 75%); the patient can complete the whole range of motion against gravity with moderate resistance applied by the researcher at end of range.
- Grade "3" (Fair; 50%); the patient can only complete the range of motion against gravity. When external (outside) force is applied by the researcher, the patient gives way.
- Grade" 2" (Poor; 25%); the patient cannot perform the movement against gravity, but can-do complete range of motion when pull of gravity is eliminated. No resistance is applied.
- Grade "1" (Trace); patient is not able to move the joint even with gravity eliminated.
- Grade "0" (No trace), no contraction is noticed, even with researcher ‘s palpation (touch).

Part III: **Hand Function Scale:**

This scale was adapted from (Duruoz et al., 1996), it was used to measure functional ability of the hand. It includes 16 items with 5 subscales: “kitchen, dressing, hygiene, office, and others”. Items are rated on a 4-point scale 0-3; (0= yes without difficulty, 1= yes with difficulty, 2= yes with assistance, and 3= impossible to do). Scores for each subscale are summed to yield subscale scores that are then summed to yield a total score that ranges from 0-90. A higher score indicates more difficulty in hand function or greater disability.

Tool III: Pain Visual Analogue scale (VAS) assessment: The VAS is a scale for assessing pain regarding its severity; it was adopted from (Hawker et al.,2011). It is a straight line that comprises “10 points scale”. With the left end of the line “0” representing no pain and the right end of the line “10” represent the worst degree of pain. 0=no pain, 1-3 mild pain, 4-6 moderate pain, 7-9 severe pain, and 10 worst pain.

Method

- Approval of the Ethical Committee of Faculty of Nursing, Alexandria University was obtained.
- An official letter from the Faculty of Nursing was submitted to the general director of Alexandria Main University Hospital and to the Head of the Burn Unit at the above-mentioned hospital, for obtaining permission to carry out the study after complete explanation of the study aim.
- Tool **I, II** (part II) were developed by the researchers and submitted to five experts in the field of burn injuries, and Medical Surgical Nursing for content and construct validity and the necessary modifications were introduced accordingly., tool **II** (Part I, III), **Tool III,** were adopted.
- The reliability of tools was tested by means of Cronbach's alpha. Reliability coefficient for tool I was (0.804), tool II was (0.907), and tool III was (0.904).
- A pilot study was initially carried out prior to the actual data collection phase on six patients to check clarity, feasibility and applicability of the tools and determine obstacles that may be encountered during period of data collection, accordingly, needed modifications were done. Pilot study subjects were excluded from the study.
- Data collection started at the beginning of March 2019 and ended of September 2019.

The study was carried out through the following four phases:

I. *Assessment Phase:*

- Initial assessment was carried out for control subjects followed by the experimental, individually after his/her admission to the Burn Unit using tool I for approximately 30-45 minutes after explaining the aim of the study to collect sociodemographic and burn assessment data.
- Initial assessment of the burned hand function was carried out using tool II items. Patient’s pain intensity was measured using tool III items.

- Initial nursing assessment lasted for; 30-45 minutes on individual basis.

***II. Planning phase*:** Control & experimental subjects were notified individually regarding steps of implementation phase. Handouts were provided to patients in the experimental groups before discharge, regarding the taught exercises that should be continued at home, to promote hand function and ensure continuity of the given instructions.

III. Implementation phase

A. Routine hand exercises by hospital staff were carried out once daily before, wound dressing for group I subjects.

B. ROM exercise post hydrotherapy were implemented with all subjects as follows**.**

1. Old dressing of the patient's burned hand (s) wound (s) was removed &cleansing carried out with normal saline.
2. Immersion of the burned hand (s) in warm water (38-40°) was continued for 15-20 minutes (Dumitraşcu et al, 2012)
3. Active range of motion exercises (AROM) of the patient 's burned hand (s) were carried out, immediately after the hydrotherapy session immediately as follows; (Wrist extension and flexion, wrist supination/pronation, wrist ulnar/radial deviation, and thumb flexion/extension). These AROM exercises were done for every joint ten times for a period of 15-20 minutes (Procter 2010). The exercise was discontinued if the patient experienced discomfort during the exercise protocol.
4. After completing the session there were about 10-20 minutes for explanation and feedback. Reinforcement was assured according to patient's needs to ensure their commitment.
5. These former steps were repeated daily, before wound dressings for two months follow up on an in- or out - patient burn.
6. Passive ROM exercises of every joint were also taught and emphasized for every patient.

C. ROM exercises during hydrotherapy were executed with GIII subjects as follows:

1. Steps (1, and 2) were repeated as mentioned before with group II.
2. Group III subjects were instructed to practice active ROM exercise, while immersing their burned hands in warm water and asked to do each motion ten times over a period of 15-20 minutes. as follow;(Wrist extension and flexion, wrist supination/pronation, wrist ulnar/radial deviation, thumb flexion/extension, thumb flexion/extension, hand/finger tendon glide). These AROM exercises were executed for every joint ten times for a period of 15-20 minutes. Any of these exercises, were discontinued if the patient experienced discomfort during the exercise protocol.,
3. After completing the session there were about 10-20 minutes for explaining and feedback. Reinforcement was carried out as needed, to ensure subjects commitment.
4. Passive ROM exercises of every joint were taught for every patient.
5. These steps were repeated daily, before wound dressing, for two months follow up.

***IV. Evaluation phase*:**

- Burned hand function of the control and experimental was re-evaluated 10 days, one and two months as the follow up periods using tools II, III, and IV, items
- If the patient was discharged from the Burn Unit, he/she informed the next time of follow up at Burn Out- patient clinic, and telephone call was done to remind him/her of the appointments.
- Before patient's discharge, he/she and one of his family members were informed and taught about all types of exercises they should do daily at home and the steps of implementation phase for every group

subjects.

- Small colored pictured leaflet was given to every patient before discharge regarding all types of exercises that the patient should follow at home to promote their hand function to enhance patient's understanding and compliance.
- Comparisons between the findings of each subjects were carried out using appropriate statistical analysis to determine the effect of hand exercise after and during hydrotherapy on promoting patients' hand function after burn injury (ies).

Ethical considerations:

- Research proposal was approved from Ethical Committee in the Faculty of Nursing.
- The study was following common ethical principles in clinical research.
- Written informed consent was obtained from every patient, after explanation of aim of the study.
- Patients 'anonymity, confidentiality and privacy, were ascertained.
- Patients' right to withdraw at any time was considered and respected.

Limitations of the study:

Some patients did not attend at the time of follow-up, so the researcher had to make a phone call before that to make sure of the follow-up time**.**

Statistical analysis of the data

Data were computer fed and analyzed using IBM SPSS software package version 20.0**. (**Armonk, NY: IBM Corp**)** Qualitative data were described using numbers and percentages. Quantitative data were described using range (minimum and maximum), mean, and standard deviation. Significance of the obtained results was judged at the 5% level.

The used tests were.

1- Chi-square test: Was used for categorical variables, to compare between different groups.

2- Fisher's Exact or Monte Carlo correction: Was used for correction for chi-square when more than 20% of the cells have expected count less than 5

3- F-test (ANOVA): Was used for normally distributed quantitative variables, to compare between more than two groups.

Results:

Graph (1), shows distribution of burn patients of the control and experimental groups according to sociodemographic characteristics. It can be noticed that less than half of the control and experimental subjects (40%, 33.3%, and 46.7%) respectively were among the age group of (30 - 50 years). 53.3%of the control group were female, while (66.7%, and60.0%) of group 2 and 3 respectively. Around two thirds of the control and group 2 experimental subjects were married. Regarding level of education, it was observed that less than half of the study subjects (46.7%, and 26.7%) consecutively in group 1 and 2, and more than half of group 3 subjects had secondary education. Concerning occupation and residence, more than one third of the patients in the three groups (33.3%, 46.7%) respectively had manual work, and more than half of them (53.3%, 66.7%, and 60%) respectively were from rural area. No significant differences were noticed between the three groups regarding sociodemographic characteristics.

Graph (2), displays distribution of patients in the control and experimental groups according to burn assessment items. It was observed that thermal cause of burn (flame) was the most causative agent (80%, 53.3%, and 26.7) respectively of patients in the three groups. Regarding the depth of burn, the graph conveys that more than one third of the patients in the three groups had deep partial thickness burns (40.0%, 53.3%, and46.7%) consecutively. In relation to the type of first aid that patients received, the findings shows that more than half of the patients in both control and experimental groups did not receive any type of first aid (53.3%, 73.3%, and 66.7%) sequentially.

Graphs (3a, b), show comparisons between the control and experimental subjects

regarding thumb movements on initial assessment and throughout the two months follow up periods. The graph shows significant improvement in the thumb movements in the three groups after one, and two months follow up periods, where p value <0.001. On the other hand, there were significant differences in thumb movements ,10 days, one month, and two months later between group I and III where $p_{2 =}$ (0.020, <0.001) respectively, and between group II, and III, where p_3 = (0.003, and 0.020) respectively. 73.3% of patients in group III showed improvement in their thumb movements after 10 days after, while all of them 100% showed improvement one, two months after, compared to those in other groups.

Table (1), depicts comparisons between the control and experimental groups according to goniometric wrist and finger joint measurements on initial assessment and throughout the two months follow up periods. Regarding wrist measurements, the table showed that significant differences were noticed among the three group subjects after one and two months follow up periods in relation to wrist joint flexion measurement, where p = (0.001, <0.001) respectively. Also, significant differences were detected between the control subjects (group I) and the experimental subjects (groups II, III), where $p_{1,}$ $_{=}$ (0.049, and 0.002) respectively, and p_2 = (<0.001) in the late follow up periods. No statistically significant differences were found between groups II, and III in the follow up periods regarding improvements in wrist joint flexion measurements.

The results showed that significant differences were elicited between the three groups one, two months later, p= (0.002, and <0.001) consecutively. Statistically significant improvements were noted between group I and group III after one, two months after since, p_2 = (0.002, and<0.001) respectively. In relation to the comparison between the two experimental groups along the follow up periods, significant differences were found, patients in group III showed improvement in their wrist joint extension than those in group II, where p_3 = (0.018, and 0.023) respectively, one month and two after.

Concerning Ulnar and radial deviations, the table shows significant differences between the three groups 10days, one, and two months after, where p value (0.039, and<0.001) consecutively. A significant difference was found between G 1&2, p_1 value = 0.032, and between group I and group III, where p_2 value = (0.001, <0.001) respectively. Significant differences were found also, between the two experimental groups 10 days, one, and two months after, since p_3 value = (0.048,0.001, and 0.021) consecutively.

Significant differences were observed between the three subjects, in relation to finger flexion one and two months after, where p value = (0.026, and<0.001) respectively. Regarding comparisons between group, I and II one month and two months, the table showed significant differences, where p_2 value = (0.029, and <0.001) respectively. Concerning finger extension measurements using goniometry, significant differences were found between the three subjects one month only later, where p value was 0. 013.Also, significant differences were detected between group II and III subjects, where p_3 = 0.014 after one month.

Significant differences in finger abduction were found between the three groups subjects after one and two months, where p value (0.017, and <0.001) consecutively. Also, statistically significant differences were noticed two months later between group I, II, where p value =0.026, one and two months later between group I and III, where p= (0.015, and <0.001) respectively. Concerning finger adduction measurement, the table shows significant differences among the three groups 10days, one and two months after, where p = (0.001, and<0.001) respectively. In relation to the comparison between the group I, II, and III, significant differences were observed, where $p_{1=}$ (0.001, and<0.001) respectively after one and two months follow up periods, and $p_{2 =}$ (0.001, and<0.001) respectively after 10 days, two, and three months.

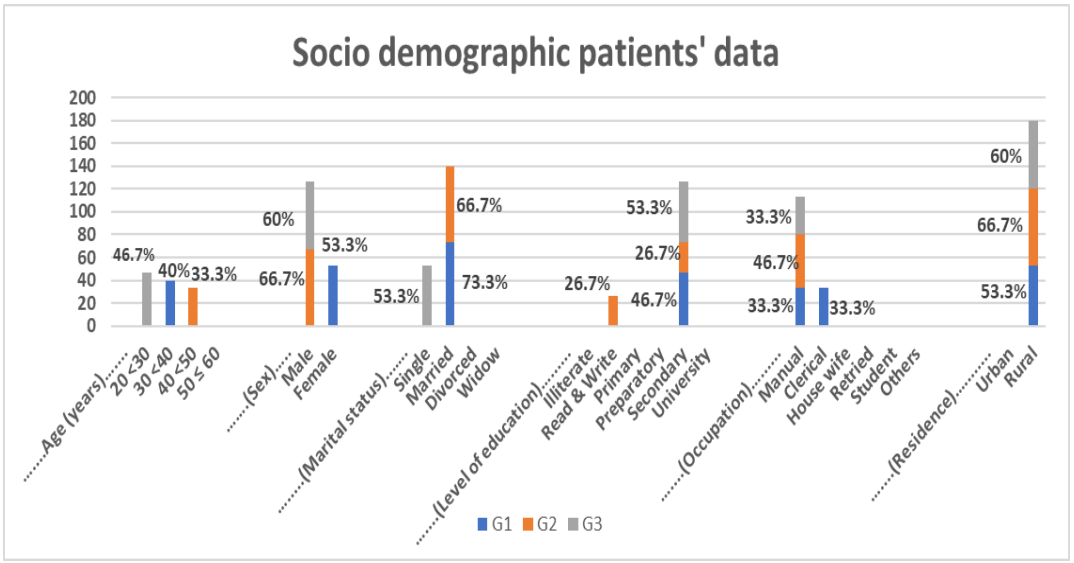
Table (2), shows comparisons between the control and experimental subjects regarding Manual Muscle Testing (MMT) of fingers, thumb, and wrist on initial assessment and throughout two months

follow up periods. Significant differences were observed among the three groups one and two months after, where p value = (0.027, and <0.001) respectively. The table showed significant differences in MMT score value between group I and III and between group II, and III one month, thereafter, where p_2 =0.003, and p_3 = 0.254, respectively. Significant differences were also detected between group I, II, and III, as well as between group II, and III two months, where p_1 = 0.001, p_2 = <0.001, and p_3 =0.001 consecutively. More than half of the patients in experimental group III (66.7%, and 80%) comparatively had good MMT scores on initial assessment, 10 days, and one month later, while most of them 86.7% had normal score after two months.

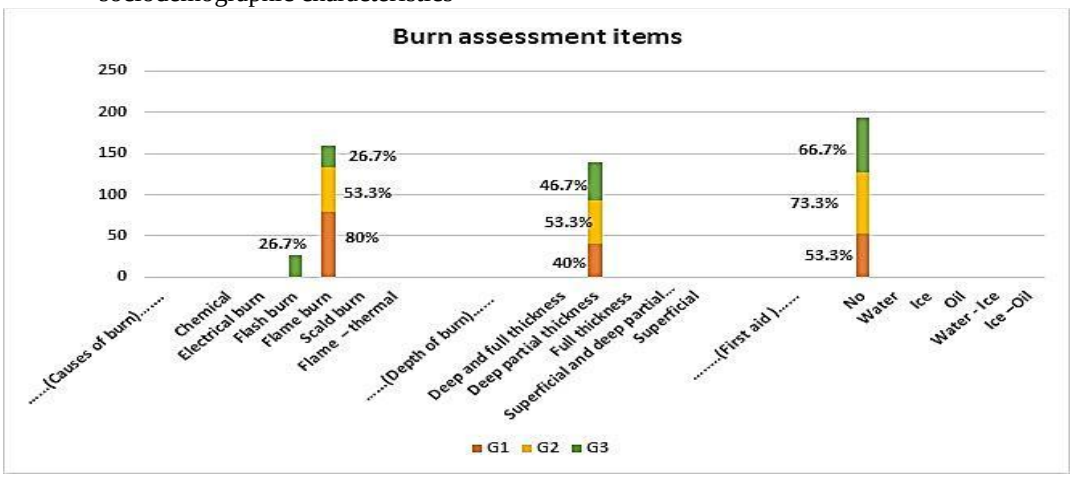
Table (3) demonstrates comparisons between the control and experimental subjects in relation to Cochin hand functions on initial assessment and throughout two months follow up periods. No significant improvements were found among the three groups on the initial assessment, and after 10 days follow up periods in relation to 16 Cochin hand function scale questions which measure the ability of the patient to; " hold a bowl without difficulty, grasp a full bottle and raise it, hold a plate full of food, pour liquid from a bottle into a glass, unscrew the lid from a jar that has been opened before, cut meat with a knife, prick things well with a fork, peel fruits, squeeze a new tube of toothpaste, hold a toothbrush efficiently, write a short sentence with an ordinary pen, write a letter with an ordinary pen, turn around doorknob, cut a piece of paper with scissor, pick up coins from a table top, and turn a key in a lock". On the other hand, significant differences were noticed among the three groups after one as well as two months, where p =<0. 001.

Significant differences were found between group I and II, more than third of patients in group II (73.3%, and 93.3%) respectively had an improvement in their ability to do hand functions without difficulty than those in group I after one, and two months follow up periods, where p_1= (0.001, <0.001). In relation to comparison between group I, and III, the table showed that the majority of patients in group III (93.3%,100.0%) consecutively had a significant improvement in their ability to do their tasks without difficulty after one, and two months follow up periods as compared to 33.3% of patients in the control group , p_2 = <0.001

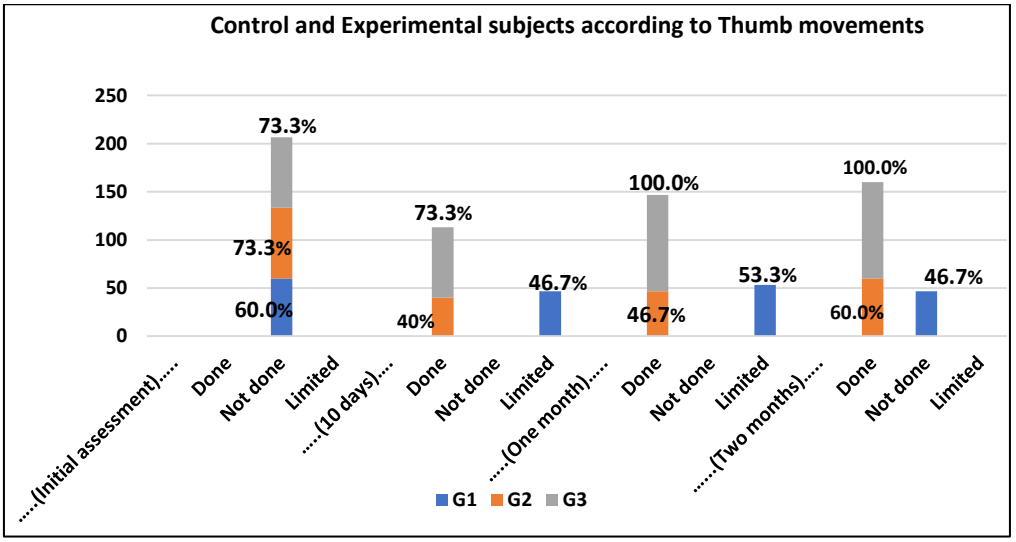
Table (4): Illustrates comparisons between the control and experimental subjects according to pain intensity on initial assessment and throughout two months follow up periods. Significant differences were noted between the three groups after 10 days, one, and two months, p value = (0.001, <0.001) respectively. In relation to comparisons between the control and experimental group subjects in relation to pain intensity, significant differences between groups were observed. Patients in group II, and III showed significant reduction in pain intensity from moderate to mild pain level compared to group I, where p_1 = (0.065, <0.001, and 0.001), after 10 days, one, and two months respectively, and p_2 = <0.001 after10 days, and one month. Significant differences were found between G1 ,GII, and III subjects in relation to pain intensity, patients in group III reported decrease in pain intensity from moderate to mild along follow up periods, where $p_3$value = (<0.001, and 0.006) one, and two months correspondingly.



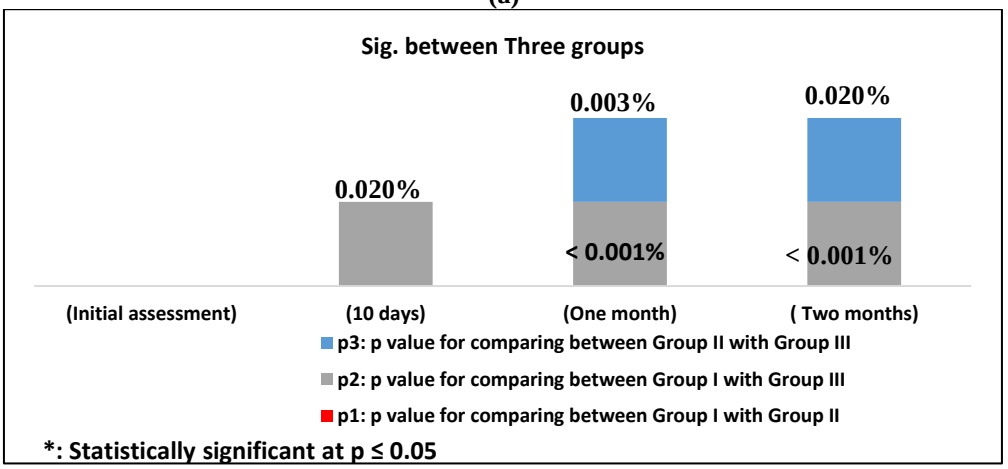
Graph (1): Distribution of burn patients of the control and experimental groups according to sociodemographic characteristics



Graph (2): Distribution of patients in the control and experimental groups according to burn assessment items. (n = 45)



(a)



(b)

Graph (3 a, b): Comparisons between the control and experimental subjects according to thumb movements on initial assessment and throughout the two months follow up periods. (n = 45)

Table (1): Comparisons between the control and experimental subjects according to goniometric wrist and finger joint measurements on initial assessment and throughout the two months follow up periods. (n =45)

Types of measurement	ROM Exercise / Follow up periods	(Control) Group I (n = 15)	(Experimental) Group II (n = 15)	(Experimental) Group III (n = 15)	F	p	Sig. between groups p_1	Sig. between groups p_2	Sig. between groups p_3
wrist measurements	**(Flexion)**								
	Initial assessment	71.49±7.82	71.27±6.49	70.46±4.69	0.105	0.900	0.996	0.901	0.937
	10 days	66.39±9.50	68.35±6.50	69.47±5.83	0.659	0.522	0.753	0.498	0.910
	One month	63.43±10.59	69.75±5.34	74.26±3.23	**8.805***	**0.001***	**0.049***	**<0.001***	0.202
	Two months	60.25±11.99	70.88±6.03	76.80±2.42	**17.02***	**<0.001***	**0.002***	**<0.001***	0.111
	(Extension)								
	Initial assessment	71.51 ± 6.51	68.63 ± 8.06	69.31 ± 5.32	0.747	0.480	0.478	0.648	0.959
	10 days	66.31 ± 8.22	63.50 ± 8.79	68.44 ± 5.10	1.618	0.210	0.569	0.721	0.184
	One month	64.62 ± 9.68	66.91 ± 7.28	74.51 ± 3.51	**7.588***	**0.002***	0.667	**0.002***	**0.018***
	Two months	60.89± 11.94	67.75 ± 9.18	76.75 ± 3.58	**11.879***	**<0.001***	0.102	**<0.001***	**0.023***
	(Ulnar and radial) deviations								
	Initial assessment	20.07 ± 6.58	15.92 ± 7.67	18.27 ± 5.46	1.474	0.241	0.213	0.739	0.600
	10 days	17.56 ± 5.83	13.18 ± 7.30	18.29 ± 3.30	**3.500***	**0.039***	0.103	0.936	**0.048***
	One month	14.97 ± 3.94	15.03 ± 4.50	20.35 ± 2.66	**10.007***	**<0.001***	0.999	**0.001***	**0.001***
	Two months	13.22 ± 5.46	17.35 ± 4.54	21.77 ± 2.36	**14.671***	**<0.001***	**0.032***	**<0.001***	**0.021***
Finger measurements	**(Flexion)**								
	Initial assessment	83.23± 16.74	77.59± 20.93	83.07 ± 6.41	0.612	0.547	0.598	1.000	0.616
	10 days	76.73± 15.21	73.59±16.0	81.94 ± 7.28	1.482	0.239	0.798	0.542	0.215
	One month	74.28± 15.72	76.77± 14.92	87.47 ± 9.20	**3.983***	**0.026***	0.871	**0.029***	0.091
	Two months	71.17± 17.42	81.17± 11.20	92.37 ± 9.50	**9.748***	**<0.001***	0.106	**<0.001***	0.062
	(Extension)								
	Initial assessment	20.41 ± 3.05	18.57 ± 6.03	18.63 ± 3.05	0.896	0.416	0.473	0.496	0.999
	10 days	18.51 ± 3.29	16.17 ± 5.60	18.30 ± 3.44	1.393	0.259	0.297	0.990	0.365
	One month	16.95 ± 3.88	15.92 ± 7.11	21.17 ± 2.49	**4.848***	**0.013***	0.834	0.058	**0.014***
	Two months	15.27 ± 5.68	16.73 ± 7.70	20.95 ± 6.34	2.966	0.062	0.821	0.061	0.201
	(Abduction)								
	Initial assessment	25.60 ± 4.76	25.55 ± 5.44	25.93 ± 3.29	0.031	0.969	0.999	0.978	0.971
	10 days	22.07 ± 4.79	22.29 ± 4.87	24.70 ± 4.30	1.467	0.242	0.991	0.281	0.343
	One month	20.84 ± 4.89	22.53 ± 5.51	26.10 ± 4.29	**4.464***	**0.017***	0.617	**0.015***	0.129
	Two months	18.43 ± 6.43	23.65 ± 5.70	27.63 ± 3.16	**11.437***	**<0.001***	**0.026***	**<0.001***	0.110
	(Adduction)								
	Initial assessment	2.33 ± 6.78	1.47 ± 3.50	0.87 ± 1.81	0.398	0.674	0.860	0.651	0.930
	10 days	7.38 ± 5.81	3.67 ± 3.99	1.27 ± 2.19	**7.827***	**0.001***	0.055	**0.001***	0.282
	One month	8.83 ± 6.71	2.67 ± 3.20	0.67 ± 1.76	**13.981***	**<0.001***	**0.001***	**<0.001***	0.435
	Two months	9.47 ± 6.69	1.47 ± 2.26	0.13 ± 0.52	**22.894***	**<0.001***	**<0.001***	**<0.001***	0.647

F: F for ANOVA test, Pairwise comparison between each two groups was done using Post Hoc Test (Tukey)

p: p value for comparing the three studied groups.

p_1: p value for comparing between Group I with Group II

p_2: p value for comparing between Group I with Group III

p_3: p value for comparing between Group II with Group III

***: Statistically significant at $p \leq 0.05$**

Table (2): Comparisons between the control and experimental subjects regarding Manual Muscle Testing (MMT) of fingers, thumb, and wrist on initial assessment and throughout the two months follow up periods. (n= 45)

MMT / Follow up periods	Control Group I (n = 15)		Experimental Group II (n = 15)		Experimental Group III (n = 15)		χ^2	^{MC}p	Sig. between groups		
	No.	%	No.	%	No.	%			$^{MC}p_1$	$^{MC}p_2$	$^{MC}p_3$
Initial assessment											
5 (Normal)	6	40.0	1	6.7	0	0.0					
4 (Good)	1	6.7	5	33.3	**10**	**66.7**					
3 (Fair)	0	0.0	1	6.7	0	0.0	5.436	0.480	0.711	0.706	0.187
2 (Poor)	**8**	**53.3**	**8**	**53.3**	5	33.3					
1 (Trace)	0	0.0	0	0.0	0	0.0					
0 (No trace)	0	0.0	0	0.0	0	0.0					
10 days											
5 (Normal)	0	0.0	0	0.0	1	6.7					
4 (Good)	**12**	**80.0**	**11**	**73.3**	**10**	**66.7**					
3 (Fair)	3	20.0	3	20.0	4	26.7	4.121	0.933	1.000	0.686	1.000
2 (Poor)	0	0.0	1	6.7	0	0.0					
1 (Trace)	0	0.0	0	0.0	0	0.0					
0 (No trace)	0	0.0	0	0.0	0	0.0					
One month											
5 (Normal)	0	0.0	2	13.3	3	20.0					
4 (Good)	6	40.0	**10**	**66.7**	**12**	**80.0**					
3 (Fair)	**8**	**53.3**	3	20.0	0	0.0	**11.519***	**0.027***	0.213	**0.003***	**0.254***
2 (Poor)	1	6.7	0	0.0	0	0.0					
1 (Trace)	0	0.0	0	0.0	0	0.0					
0 (No trace)	0	0.0	0	0.0	0	0.0					
Two months											
5 (Normal)	0	0.0	3	20.0	**13**	**86.7**					
4 (Good)	5	33.3	**11**	**73.3**	2	13.3					
3 (Fair)	**9**	**60.0**	1	6.7	0	0.0					
2 (Poor)	1	6.7	0	0.0	0	0.0	**37.309***	**<0.001***	**0.001***	**<0.001***	**0.001***
1 (Trace)	0	0.0	0	0.0	0	0.0					
0 (No trace)	0	0.0	0	0.0	0	0.0					

χ^2: Chi square test **MC: Monte Carlo**

p: p value for comparing the three studied groups. **p_1:** p value for comparing between Group I with Group II

p_2: p value for comparing between Group I with Group III **p_3:** p value for comparing between Group II with Group III

***: Statistically significant at $p \leq 0.05$**

Table (3) : Comparisons between the control and experimental subjects in relation to Cochin hand function scale on initial assessment and throughout the two months follow up periods. (n= 45)

Follow up periods	Control Group I (n = 15)		Experimental Group II (n = 15)		Experimental Group III (n = 15)		Test of sig.	^{MC}p	Sig. between groups p_1	Sig. between groups p_2	Sig. between groups p_3
	No.	%	No.	%	No.	%					
Initial assessment											
Without difficulty	9	60.0	7	46.7	7	46.7					
With difficulty	1	6.7	3	20.0	7	46.7	χ^2=9.496	^{MC}p=0.095	^{MC}p=0.684	^{MC}p=0.053	^{MC}p=0.146
With assistance	1	6.7	0	0.0	0	0.0					
Impossible to do	4	26.7	5	33.3	1	6.7					
Mean ± SD.	2.03 ± 1.31		2.22 ± 1.29		1.78 ± 0.80		F=0.537	0.588	0.893	0.831	0.560
10days											
Without difficulty	4	26.7	2	13.3	5	33.3					
With difficulty	4	26.7	8	53.3	10	66.7	χ^2=11.291	^{MC}p=0.051	^{MC}p=0.430	^{MC}p=0.017*	^{MC}p=0.078
With assistance	3	20.0	1	6.7	0	0.0					
Impossible to do	4	26.7	4	26.7	0	0.0					
Mean ± SD.	2.53 ± 1.11		2.46 ± 1.04		1.76 ± 0.52		F=3.162	0.053	0.976	0.071	0.109
One month											
Without difficulty	4	26.7	11	73.3	14	93.3					
With difficulty	2	13.3	3	20.0	1	6.7	χ^2=18.391*	^{MC}p<0.001*	^{MC}p=0.017*	^{MC}p=0.001*	^{MC}p=0.335
With assistance	5	33.3	0	0.0	0	0.0					
Impossible to do	4	26.7	1	6.7	0	0.0					
Mean ± SD.	2.61 ± 1.06		1.55 ± 0.67		1.11 ± 0.29		F=16.127*	<0.001*	0.001*	<0.001*	0.239
Two months											
Without difficulty	5	33.3	14	93.3	15	100.0					
With difficulty	2	13.3	1	6.7	0	0.0	χ^2=19.057*	^{MC}p<0.001*	^{MC}p=0.001*	^{MC}p<0.001*	^{MC}p=1.000
With assistance	3	20.0	0	0.0	0	0.0					
Impossible to do	5	33.3	0	0.0	0	0.0					
Mean ± SD.	2.55 ± 1.16		1.15 ± 0.29		1.01 ± 0.03		F=22.702*	<0.001*	<0.001*	<0.001*	0.850

χ^2: Chi square test **MC: Monte Carlo**

F: **F for ANOVA test**, Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (Tukey)**

p: p value for comparing the three studied groups.

p_1: p value for comparing between Group I with Group II

p_2: p value for comparing between Group I with Group III

p_3: p value for comparing between Group II with Group III ***: Statistically significant at p ≤ 0.05**

Table (4): Comparisons between the control and experimental subjects according to pain intensity. (n=45)

Follow up periods / Pain intensity	Control Group I (n = 15)		Experimental Group II (n = 15)		Experimental Group III (n = 15)		χ^2	p	Sig. between groups $^{MC}p_1$	$^{MC}p_2$	$^{MC}p_3$
	No.	%	No.	%	No.	%					
Initial assessment											
Mild	1	6.7	0	0.0	0	0.0					
Moderate	**10**	**66.7**	**8**	**53.3**	**13**	**86.7**	5.734	^{MC}p= 0.132	0.444	^{MC}p= 0.386	^{MC}p= 0.109
Severe	4	26.7	7	46.7	2	13.3					
10days											
Mild	0	0.0	0	0.0	0	0.0					
Moderate	4	26.7	**9**	**60.0**	**14**	**93.3**	**13.889***	**0.001***	0.065	**<0.001***	^{MC}p= 0.080
Severe	**11**	**73.3**	6	40.0	1	6.7					
One month											
Mild	0	0.0	2	13.3	**11**	**73.3**					
Moderate	3	20.0	**13**	**86.7**	2	13.3	**41.065***	^{MC}p **<0.001***	^{MC}p **<0.001***	^{MC}p **<0.001***	^{MC}p **<0.001***
Severe	**12**	**80.0**	0	0.0	2	13.3					
Two months											
Mild	3	20.0	6	40.0	**8**	**53.3**					
Moderate	1	6.7	**8**	**53.3**	1	6.7	**18.338***	^{MC}p= **0.001***	^{MC}p= **0.001***	0.697	^{MC}p= **0.006***
Severe	**11**	**73.3**	1	6.7	6	40.0					

χ^2: Chi square test **MC:** Monte Carlo
p: p value for comparing the three studied groups
p_1: p value for comparing between Group I with Group II
p_2: p value for comparing between Group I with Group III
p_3: p value for comparing between Group II with Group III
***: Statistically significant at p ≤ 0.05**

Discussion

Hydrotherapy is an effective, alternative intervention that can be used by care providers as non-pharmacological pain relief method (Younesse & Moustafa ,2012). Findings of the present study revealed that less than half of the studied patients' age was more than thirty in both the control group and experimental subjects. This result is congruent with the results of (Alavi et al., 2012& Honnegowda et al., 2019) who reported that the mean age of their studied patients was more than thirty. In relation to sex, more than half of the patients were females and male in the three studied groups. These results were matched with the results of Daffu et al., 2018&, Magdy et al., 2016.

It was found that around two thirds of patients in group one and two were married and had secondary education. These study findings were in line of a study conducted at burn and plastic surgery department at Assuit University Hospital by (Ahmed et al., 2019) who pointed out that the highest percent of their patients were married and had secondary education level. More than one third of the patients in the three groups were manual workers, and more than half of them were from rural area. This may be due to that more than half of the studied patients were males in both experimental groups, and all the patients who

were admitted to the Main University Hospital were from rural areas.

The current study revealed that flames were the most frequently encountered reason in the studied three groups of patients. The high incidence of flame burns in rural areas implies the need for safer alternatives or precautions during cooking. This result was in line with (Faris & Al Naser, 2019 &Tripathee & Basnet, 2017), who reported that flame burns were the most common cause of burn injuries. On the other hand, this finding is not in line with (Hosseini et al., 2017) who demonstrated that the most common causes of burns in their studied patients, were hot liquids, gas explosion, and fire.

In relation to the type of first aid received, the findings indicated that more than half of the patients in both control and experimental groups did not receive any type of first aid. Tripathee & Basnet, 2017 found that only less than one third of their studied patients received first aids after their burn injuries. Low socioeconomic status use of unsafe flames, inadequate health education and nearly absence of first aid supplies at homes, probably explain this form finding.

Regarding comparisons between the control and experimental subjects regarding goniometric wrist and finger joint measurements on initial assessment and throughout the two months follow up periods, significant differences were noticed among the three groups. Patients in group three showed improvement in wrist and finger joint measurements than those in the other two groups throughout the follow up periods. These results were in line with (Zoubine et al., 2007) who reported that physiotherapy programs in patients with hand burns considerably reduced complications of burning, particularly contractures. Likewise (Ardebili et al., 2014) supported the findings as they demonstrated that significant improvements in range of motion and hand function balance from admission to discharge was noticed.

Manual Muscle Testing (MMT) of fingers, thumb, and wrist, revealed significant differences among the three groups after one and two months. In addition, significant changes in MMT score value between group I and III and in group II, and III after one month follow up. Patients in group III who practiced hand ROM during hydrotherapy session, daily before wound dressing showed more improvement in MMT than those in the other two groups. Heinmann et al., 2007 demonstrated that water-based exercise proves effective in alleviating the pain and improving the quality of life through strengthening the muscles around the joints and lifting off the pressure on them.

Comparisons among the control and experimental group subjects in relation to Hand Function, the results showed significant improvement among the three studied groups one, and two months thereafter, in addition, significant differences between group I and III subjects after one, and two months, and between group I and II two months, later. The patients showed great improvement in their ability to hold a bowl without difficulty, grasp a full bottle and raise it , hold a plate full of food, pour liquid from a bottle into a glass, unscrew the lid from a jar that has been opened before, cut meat with a knife, prick things well with a fork, peel fruit. squeeze a new tube of toothpaste, hold a toothbrush efficiently, write a short sentence and a letter with an ordinary pen, turn around doorknob, cut a piece of paper with scissors, pick up coins from a tabletop, as well as turn a key in a lock.

Mattos et al; 2016 had similar findings, they concluded that water-based exercises are recommended due to the beneficial effects on physical function, quality of life and symptoms reduction. Also, Sizoo et al; 2021 concluded that only after a few sessions of aquatic exercise therapy, the participants were less anxious to move, and showed improvements in their physical functioning.

For the comparisons between the control and experimental subjects in relation pain intensity, significant differences were detected, since patients in group two and three showed significant reduction in pain intensity from moderate to mild pain as compared to group one. Patients in group three reported decrease in pain intensity from moderate to mild along follow up periods than those in the other two groups. These results were in line with Mazloum et al., 2014 in their study regarding

the effects of therapeutic exercise and hydrotherapy on pain severity and knee range of motion in patients with hemophilia, they reported that using hydrotherapy in addition to usual rehabilitation training, can result in beneficial effects in terms of pain and knee joint ROM. However, it appears that hydrotherapy is more effective in reducing pain. Mooventhan & Nivethitha, 2014 claimed that, hydrotherapy is not only naturally warm, but its mineral contents are also significant. Hydrotherapy has mechanical, thermal, and chemical effects, and is widely used to improve immunity and for the management of pain.

Conclusion

The study findings supported the two study hypotheses as it has been proven that there were improvements in joint functions one, and two months from admission. Burned hand joint function was improved in patients who were received range of motion exercises, and pain intensity was decreased during and after hydrotherapy.

Recommendations:

Simple instruction handouts have to be available for burned patients on hydrotherapy, in addition to the usual rehabilitation activities in burn units can result in beneficial effects in terms of pain reduction and to burned hand joint function

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