Assiut Scientific Nursing Journal
http://asnj.journals.ekb.eg *http://www.arabimpactfactor.com*
DOI: 10.21608/asnj.2023.199995.1544 *http://olddrji.lbp.world/indexedJournals.aspx*
https://vlibrary.emro.who.int/journals/assiut-scientific-nursing-journal

Classical Hydrotherapy versus Ultrasonic Hydrotherapy in a Partial-Thickness Burned Patient: Comparative Study

Eshrak Salama Hashem[1], Shaimaa Mohamed El-hadary[2], Eman Abdelaziz Rashad Dabou[3] & Engy AbdelRhman Khames[4]

1. Lecturer of Medical- Surgical Nursing Department, Faculty of Nursing, Alexandria University, Egypt
2. Assistant Professor, Medical Surgical Nursing Department, Faculty of Nursing, Cairo University, Egypt.
3. Lecturer, Medical-Surgical Nursing department, Faculty of Nursing, Alexandria University, Egypt.
4. Lecturer of Medical and Surgical Nursing Department, Faculty of Nursing, Modern University for Information & Technology, Egypt

Abstract

Background: Burns remain a significant health problem throughout the world. It has a detrimental effect on the quality of life**.** Both hydrotherapy and low-frequency ultrasound had a beneficial impact on burn healing. **Aim:** This study aimed to compare between the hydrotherapy and ultrasonic hydrotherapy of a partially-thickness-burned patient. **Methods:** An experimental comparative study was conducted at the Alexandria Main University Hospital burn unit. Sixty patients were included and alternatively assigned into two equal groups of 30 patients in each group. The researchers used four tools for data collection. An assessment was performed after one month to evaluate the patient's progress. **Results:** Patients who received ultrasonic hydrotherapy had a higher median healing percentage score (83.3) of the burned area than those who received hydrotherapy (70.5). There was a significant difference between both groups where p= 0.000**.** In the fourth week of the follow-up, (53.4 %) of the hydrotherapy patients did not have pain. In comparison, 90% of ultrasound hydrotherapy patients had no pain**,** with significant differences between both groups at the second, third, and fourth weeks (p =0.000). **Conclusions:** Ultrasonic hydrotherapy strongly affects the burn-healing process. Furthermore; it reduced patients' pain severity **Recommendation:** Conduct further research to assess the effect of ultrasonic hydrotherapy on other types of wounds.

Keywords:* *Burn, Hydrotherapy, Partial thickness, Quality of life & Ultrasonic hydrotherapy.

Introduction

Hydrotherapy is one of the therapies that lead to recovery and health promotion using water properties that aid active movements of the joints and improve blood circulation. Hydrotherapy in burns mainly means washing patients in a shower or tank. Current practice has moved from traditional bath hydrotherapy toward "shower cart-hydro-therapy." **(Deniz and Arslan, 2017; Mathew et al., 2016 & Ghaedi et al., 2017).**

The benefits of hydrotherapy include the reduction of the bacterial wound load, providing an opportunity to clean the burning surface, debriding wounds, facilitation of eschar separation, removal of exudates and residual topical agents, facilitation of physiotherapy, and improving patient comfort **(Langschmidta et al., 2014; Aly Yakout & Khlosy, 2020).**

Interactions between hydrotherapy and ultrasound waves showed promising therapeutic outcomes in the burn as Ultrasound (US) is a physical method of transmitting non-ionizing radiation in mechanical sound waves into the tissues for generating heat in the body. US waves can go through the wound bed and reach more deep tissues, relieving pain **(Mesquita, 2016).** The choice of US parameters depends on the density and location of the tissue being treated and the desired effect **(Yadollahpour et al., 2014).**

Ultrasound energy produces a mechanical pressure wave through soft tissue that initiates two particular processes; the first effect is the generation of microscopic bubbles in living tissue, intracellular activity, and the distortion of the cell membrane. The mechanism of this distortion can be achieved through microstreaming, bubble formation, and acoustic streaming. The second effect is that the US can produce tissue thermal and non-thermal physical effects. Non-thermal results can be achieved with or without thermal effects. The thermal impact of US on the tissue can enhance blood flow, decrease muscle spasms, increase the extensibility of collagen fibers, and create a pro-inflammatory response. Thermal effects happen when the tissue temperature rises to 40–45°C for at least five minutes **(Quarato et al., 2023; Yadollahpour & Rashidi., 2017). (Fig.1)**

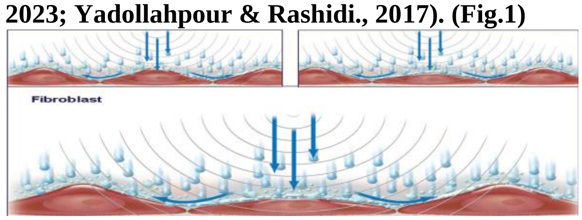


Fig. (1) Acoustic energy deforming fibroblasts

Therefore, this study aims to compare which healing modality improves burn healing, decreases pain associated with a burn injury, and enhances the quality of life.

Significant of study

Burns remain a significant health problem throughout the world. It is considered a traumatic experience resulting in deformities and impairments; it affects a person's physical and psychological aspects and social activities that cause social isolation. Deformities, scar contractures, changes in skin colour and body shape and loss of body parts may restrict the patient's ability to return to previous activities **(Mahmoud, 2016; Do Amaral Zorita et al., 2016)**.

Patients experience pain daily, immediately after the injury, and during therapeutic measures, similarly wound dressing changes, debridement, and rehabilitation **(Vuola, 2020)**. Repeating these painful measures usually contributes to anticipatory anxiety in burn patients **(Ardabili et al., 2014; Varaei et al., 2017; Jain et al., 2017).** Furthermore, severe pain associated with burn injuries also affects patients' activities of daily living. Hydrotherapy and low-frequency ultrasound have a vulnerable effect on burn healing and enhance patients' quality of life.

Aim of study

This study aimed to compare between the hydrotherapy and ultrasonic hydrotherapy of a partially-thickness-burned patient.

Research Hypothesis

- Partial-thickness burn patients who received ultrasound hydrotherapy exhibit more significant wound healing than classical hydrotherapy.
- Partial-thickness burn patients who received ultrasound hydrotherapy exhibit less pain than classical hydrotherapy.
- Partial-thickness burn patients who received ultrasound hydrotherapy exhibit a more significant improvement in quality of life than those who received classical hydrotherapy.

Materials and Method

Design:

The researchers exploited a comparative design

Settings:

This study was carried out in the burn unit of Alexandria Main University Hospital.

Sample:

A purposive sample of sixty adult patients with a partial-thickness burn was selected. The samle size calculated based on the Roasoft calculation program with a response rate of 50% and a confidence interval (CI) of 95%, with an error margin of 5%, and the total population (70) who were admitted to the burn unit three months ago (Sample Size Calculator by Roasoft, Inc, 2014). The researchers followed a randomized block sampling to divide the sample into relatively homogeneous subgroups. The experimental designs were then implemented within each block or homogeneous subgroup (Bigot, Boyer, & Weiss, 2013); 30 patients were assigned to two identical groups, **Group (I):** this group was exposed to hydrotherapy and usual care in the burn unit, while **Group (II)** was exposed to ultrasonic hydrotherapy and routine care in the burn unit.

Inclusions / Exclusion criteria:

The researchers included only patients according to the following criteria: Adult patients who could communicate and burn owing to flame, scald, or contact caused. The patients complained of partial thickness burn. The total body surface area is $10 \leq TBSA \leq 45$. After completing fluid therapy, patients with acute-stage burn care were selected to be hemodynamically stable. Patient free from any other associated diseases that affect patient's wound healing, pain sensation, and activities of daily living such as diabetes mellitus, heart diseases, musculoskeletal or neurological disorders. Patients with mental disorders and drug addiction and burn patients due to chemical or electrical causes were excluded.

Tools and Instruments:

Four tools were utilized as follows:

Tool I: Burned patient assessment sheet

The researchers developed this tool after reviewing the literature to obtain baseline data. It entailed two parts as follows:

Part I: Patient sociodemographic characteristics. It included age and gender.

Part II: Burned area assessment, including the burn site, cause, and total boy surface area using modified Lund and Browder's chart that modified by Murari (2017) and used in Alexandria burn center **(Shantkumar, 2019; Murari, 2017).**

Tool II: Burned area healing percentage

It included two parts as follows:

Part I: Wound Healing Percentage:

The researchers adopt it from **(Houghton 2000).** It was calculated by dividing SAI= surface area on admission by SAC = surface area currently

Burn healing percentage $\frac{\text{SAI-SAC} \times 100}{\text{SAI}}$ =........... Reduction %

Part II: Photographic Wound Assessment Tool (PWAT).

This tool was developed by Houghton, P.E *et al.* (2000) and revised by Thompson et al. (2013). It is used to assess wound status and the effectiveness of treatment for all wounds. It evaluates six domains: wound edges, necrotic tissue type, necrotic tissue amount, skin color surrounding the wound, granulation tissue type, and epithelialization. Each item of the six domains was scored from zero to four. The total PWAT score for each wound photograph was calculated by summing the scores assigned to each of the six domains. Thus, the range of possible total PWAT scores was between 0 and 24, with zero representing a completely healed wound.

Tool III: Visual Analog pain Scale (VAS):

This tool was developed by Cline et al. (1992) and validated by Delgado et al. (2018); the researcher adopted it to assess pain intensity.VAS is a 10 cm horizontal line with two ends; the left end represents "no pain," whereas the right end usually represents "worst possible pain." The researcher asked the patient to mark the line indicating the current pain. A ruler is positioned along the line, measuring the distance from the left or low end. It was recorded in centimeters to quantify the degree of pain as 0, representing no pain, and 10 representing the worst degree of pain. 0 = no pain, 1-3 mild pain, 4-6 moderate pain, 7-9 severe pain, and 10 worst pain. The reliability coefficient is (0.904), which means a reliable tool.

Tool IV: Burn-specific health scale (BSHS-B):

Kildal et al. developed a burn-specific health scale to assess the quality of life following a burn injury **(Kildal et al., 2001)**. It includes 40 items covering nine different domains; simple abilities (questions 1-3); hand function (questions 4 - 8), affect (questions 9 -15), interpersonal relationship (questions 16-19), sexuality (questions 20-22), body image (questions 23-26), heat sensitivity (questions 27- 31), treatment regimen (questions 32- 36), and work (questions 37-40). The patient can rate each item on a five-point Likert scale, (0) extremely to 4 (none/not at all). The final score indicated an alteration of the QOL; a higher mean score indicated a more optimistic evaluation of function and a higher QOL. The researchers adopted the translated Arabic version of the tool to evaluate the quality of life after applying hydrotherapy / ultrasonic hydrotherapy for partial thickness burn patients. The reliability coefficient was (0.935), which means a reliable tool **(Abd Latif, Emam & El Awady, 2019)**. The total score for every patient was converted into a percentage score. The percentage score of this scale was classified as the following: below 50% means a low quality of life, 50% to less than 75% means the average quality of life, and 75% or more means having a high quality of life.

Pilot study: A pilot study was conducted on 10 % of the sample size (seven patients) to test the feasibility and applicability of different elements of the tools.

Data collection: Data collection started after administrative approval was obtained and continued for six months. Each patient was under treatment and observation for one month.

The study was carried out through three phases:

Assessment Phase:

The same researcher performed a weekly wound assessment using the bedside wound assessment to calculate the percentage of healing of the burned area using tool II part 1 and assess the PWAT scores using tool II part II. Subsequent assessment for pain intensity was done weekly using tool III. The assessment session took 30 minutes individually using tool I (parts I and II) and tool IV. After one month, the final assessment evaluated the patient's progress, including wound healing percentage, pain intensity, and quality of life for burn patients using tools II (part I, II), III, and IV.

Implementation phase: The intervention was applied as follows;

Group I: Receive a daily classical hydrotherapy session using the Hubbard tank for 15 minutes. The patients were immersed in the Hubbard tank, and the air was injected to remove gross contaminants, toxic debris, and dilute bacteria. The warmth of the water is generally 35.5 ^{o}C to 39 ^{o}C. (Figure 2)

Fig. 2: Hubbard tank

Group II: Receive a daily ultrasonic hydrotherapy session for 15 min, using BTL-4000 (non-contact ultrasound) and Hubbard tank. Patient immersion in a hydrotherapy tank with a temperature of 35.5- 39^{o}C combined with a low 3MHz ultrasonic wave at a distance from the patient of about 3-5 cm **(Fonder et al., 2008; Golshan, Patel, & Hyder, 2013)**. (Figure 3)

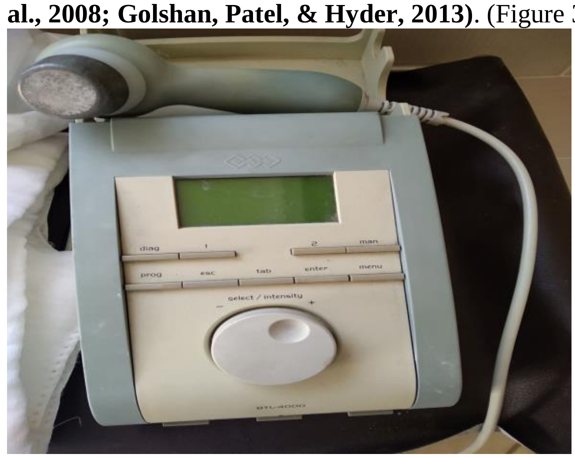


Fig. 3: BTL-4000

The second researcher is an expert nurse in the burn care unit who implemented the interventions for both groups, including assessing each patient's progress, instructing patients to perform a range of motion during the sessions, and doing conventional dressing as hospital policy for each patient.

Evaluation phase:

Every patient in both groups was evaluated weekly and re-evaluated after one month. The researchers used tool II to evaluate wound healing, tool III (VAS) to assess pain severity, and tool IV (Burn specific health scale) to re-assess the patient's quality of life.

Ethical Consideration

The researchers received approval from the research ethics committee on 14-10-2020 to conduct the research. Before the study's conduction, an official letter from the Faculty of Nursing was submitted to the general director of Alexandria Main University Hospital and the head of the hospital's burn unit to obtain permission to conduct the study after a complete explanation of the study's aim. Written formal consent was obtained from each patient following a description of the study's aim. The anonymity, confidentiality, and privacy of the patients were ascertained. The right of the patient to withdraw from any research participation was considered and respected.

Statistical Analysis

The statistical package for social science (SPSS) version 25 was used for data analysis. Data were presented in frequency, percentage, median, and Interquartile Range (IQR). Chi-square was used to compare the groups regarding their age, burned area &quality of life. The Mann-Whitney test was used to compare the percentage of burn area healing and photographic wound healing.

Results

Table (1): Frequency distribution of partial-thickness burn patients of both groups according to their demographic characteristics (n = 60)

Demographic characteristics	Hydrotherapy Group		Ultrasonic Hydrotherapy Group		Significance test
	No= 30	%	No= 30	%	
Gender					
Male	10	33.3	16	53.3	$\chi2$ = 2.44 *P* = .11
Female	20	66.7	14	46.7	
Age (years)					
20 –9	8	26.7	6	20.0	$\chi2$ = 2.62 *P* = .45
30 –9	8	26.7	6	20.0	
40 –9	4	13.3	2	6.7	
50-60	10	33.3	16	53.3	
Median **Minimum-Maximum**	38 22-55		44 21-60		

$\chi2$ = Chi-square test

Table (2): Frequency distribution of partial-thickness burn patients of both groups concerning the assessment of the burned area (n = 60)

Burned area assessment	hydrotherapy Group		Ultrasonic Hydrotherapy Group		Significance test
	No = 30	%	No = 30	%	
Site of burn					
Head, neck, and arms	18	60.0	20	66.7	$\chi2$ = 0.36 *P* = .83
Trunk & Genitalia	9	30.0	8	26.7	
Lower extremities	3	10.0	2	6.6	
Cause of burn					
Dry heat	20	66.7	22	73.3	$\chi2$ = 0.31 *P* = .57
Scald	10	33.3	8	26.7	
Body surface area (BSA)					M-W Z = -.77 *P* = .44
Median **Minimum-Maximum** **IQR**	19 4- 45 22		20 6- 40 20		

IQR = Interquartile Range *M-W Z= Mann-Whitney test* *Significant difference at P level ≤ 0.05*

Table (3): Comparison between partial-thickness burn patients of both groups regarding Burned area healing percentage after applying hydrotherapy /ultrasonic hydrotherapy (n = 60)

Burned area healing percentage	Hydrotherapy Group (No= 30)	Ultrasonic hydrotherapy Group (No= 30)	Significance test
Median	70.50	83.30	M-W Z = - 4.03 *P* = .00*
Minimum-Maximum	33-100	67-100	
IQR	17	29	

IQR = Interquartile Range *M-W Z= Mann-Whitney test* ** Significant difference at P level ≤ 0.05*

Table (4): Comparison between partial-thickness burn patients of both groups regarding photographic wound assessment pre and post-hydrotherapy / ultrasonic hydrotherapy

photographic wound assessment		Hydrotherapy group Group (No= 30)	Ultrasonic hydrotherapy Group (No= 30)	Significance test between the groups
Pre	**Median**	19.0	16.0	M-W Z = -1.09 *P* = .27
	Minimum-Maximum	18 23	8 21	
	IQR	3	4	
Post	**Median**	9	3	M-W Z = - 4.39 *P* = .00*
	Minimum-Maximum	3 13	0 11	
	IQR	8	4	
Significance test within the group		Wil Z= - 4.795 *P* = .00*	Wil Z= - 4.795 *P* = .00*	

Wil Z= Wilcoxon Signed test *M-W Z = Mann -Whitney test* ** Significant difference at P level ≤ 0.05*

Fig. (4): Partial thickness upper limb burn after one week of receiving daily hydrotherapy, Hubbard tank session, for 15 min.

Fig. (5): Partial thickness upper limb burn after four weeks of receiving daily hydrotherapy, Hubbard tank session, for 15 min.

Fig. (6): Partial thickness lower limb burn after one week of receiving a daily ultrasound hydrotherapy session for 15 min, using BTL-4000 (non-contact ultrasound) and Hubbard tank.

Fig. (7): Partial thickness lower limb burn after four weeks of receiving a daily ultrasound hydrotherapy session for 15 min, using BTL-4000 (non-contact ultrasound) and Hubbard tank.

FET= Fisher's exact test. **Significant difference at P level ≤ 0.05.*

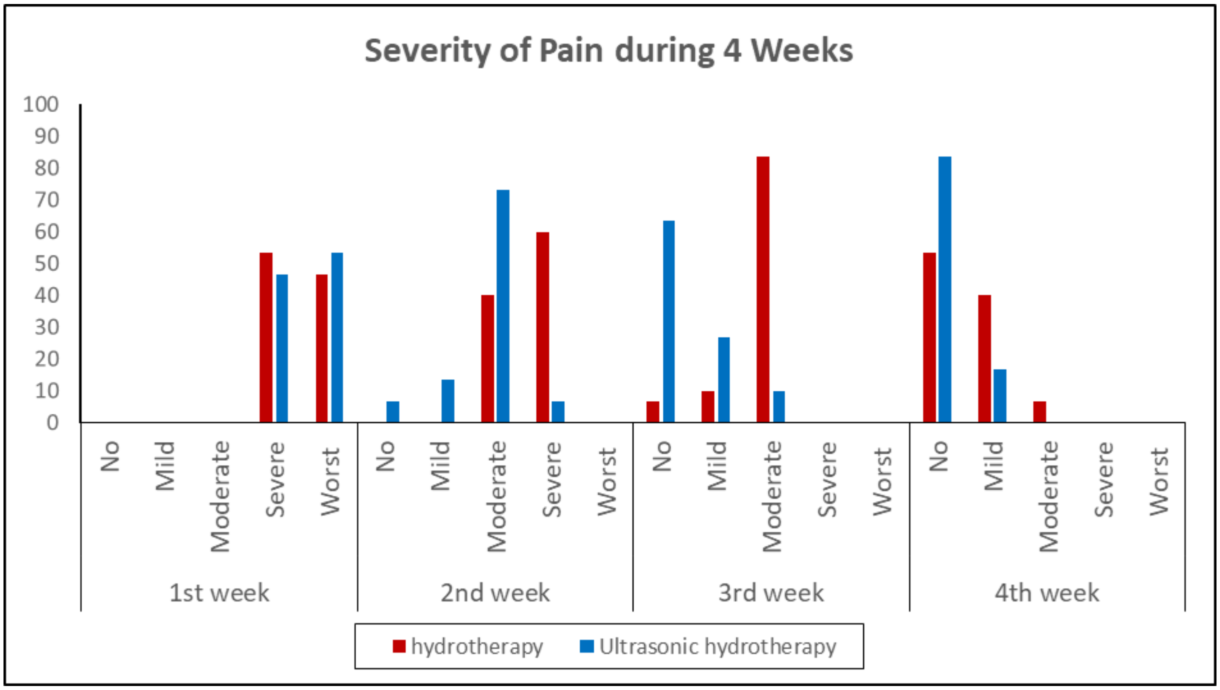
Table (5): Comparison between partial-thickness burn patients of both groups regarding the quality of life pre and post-application of hydrotherapy and ultrasonic hydrotherapy

Quality of life Level	Hydrotherapy Group (n= 30)				Ultrasonic hydrotherapy Group (n= 30)				Significance test between the groups	
	Pre		Post		Pre		Post		Pre (before applying hydrotherapy and ultrasonic hydrotherapy)	Post (after applying hydrotherapy and ultrasonic hydrotherapy)
	No	%	No	%	No	%	No	%		
Low quality of life	28	93.3	5	16.7	22	73.3	3	10.0	$\chi2$ = 4.320 *P* = 0.377	$\chi2$ = 6.346 *P* = 0.041*
Average quality of life	2	6.7	10	33.3	8	26.7	3	10.0		
High quality of life	0	0.0	15	50.0	0	0.0	24	80.0		
Significance test within the group	$\chi2$ = 36.363 P = 0.000*				$\chi2$ = 33.440 P = 0.000*					

Table (6): Correlation between total body surface area and burner area percentage and photographic wound assessment among partial-thickness burn patients of both groups

Parameter	total body surface area	
	Hydrotherapy Group (n= 30)	Ultrasonic hydrotherapy Group (n= 30)
Burn healing percentage	τ = - .388** p = .005	τ = - .367* p = .012
photographic wound assessment	τ = - .264* p = .05	τ = - .495** p = .001

τ =Kendall's tau ** Significant at ≤ 0.05*



FET= Fisher's exact test. **Significant difference at P level ≤ 0.05.*

Figures (8): Comparison between partial-thickness burn patients in both groups regarding pain severity during four weeks of hydrotherapy / ultrasonic hydrotherapy application.

Table (1): Shows both groups' sociodemographic data of patients with partial-thickness burns. It is distributed as 33.3% in the hydrotherapy group and 53.3% in the ultrasonic hydrotherapy group. More than half of the patients in both groups were females (66.7%, 46.7%). The highest percentage was among the age group (50 - 60 years). Neither group had a statistically significant difference ($\chi 2$ = 2044 *P* = 0.45).

Table (2): Presents the frequency distribution of patients with partial-thickness burns concerning burned area assessment in both groups. More than half of the patients complained of head, neck, and arm burns (60, 66.7 %) in both groups. All patients were affected by thermal burn as dry heat (66.7, 73.3 %). The median surface area of the total body was (MD = 19) among the hydrotherapy group ،and 20 among the ultrasonic hydrotherapy group. The two groups had no significant difference (*p* = .44).

Table (3): Compares both groups regarding burned area healing percentage after applying the intervention; patients who received ultrasound hydrotherapy had a higher median score of the healed site of the burned area (83.3) than those who received hydrotherapy alone (70.5). Both groups had a highly significant difference (*p* = .00).

Wound assessment using photographic wound assessment pre and post-interventions after one month (illustrated in **Table 4) and (Figures 4, 5, 6 and 7)**. Both groups had a significant difference in the assessment of photographic wounds (Wil Z= - 4.39 *P*= .00).

Figure (8): Reveals a significant decrease in pain severity within both groups after hydrotherapy/ultrasound hydrotherapy application with superiority to the ultrasonic hydrotherapy group patients. More than half (53.3%) of patients in the hydrotherapy group suffered severe pain in the first week (FET=.26 p =.65). In the second week, more than half of the patients who received hydrotherapy (70%) suffered from severe pain in compared to (80%) of the patients who received ultrasound hydrotherapy had moderate pain (FET= 21.74 p =.00) . In the third week, patients receiving hydrotherapy (83.4%) suffered moderate pain. However, more than 60 % of ultrasound hydrotherapy patients did not have pain (FET=33.32 p =.00). In the fourth week, more than half (53.4%) of the hydrotherapy patients did not have pain. More than (90%) of ultrasound hydrotherapy patients had no pain (FET= 6.57 p =.00).

Table (5): Illustrates the quality of life of both groups' pre and post-application of hydrotherapy / ultrasonic hydrotherapy. Most of the patients in the hydrotherapy group (93.3%) and more than two-thirds (73.3%) of ultrasound hydrotherapy group patients had low quality of life before the application of hydrotherapy/ultrasonic hydrotherapy. On the other hand, about one-half (50%) of the hydrotherapy group patients and more than two-thirds (80%) of ultrasonic hydrotherapy group patients had a high quality of life, with superiority to the ultrasonic hydrotherapy group patients. The difference was statistically significant within both groups and between hydrotherapy and ultrasonic hydrotherapy group patients post hydrotherapy/ultrasonic hydrotherapy application only (P =.00, p =.00, p =.041).

Table (6): Shows a significant correlation between body surface area wound healing and wound healing characteristics using photographic wound assessment among two treatment modalities groups; burn healing percentage (τ = -.388, -.367), respectively. While photographic wound assessment (τ = - .264, -.495) respectively.

Discussion

Burns can have a long-term impact on people's quality of life, with chronic problems related to scarring, contractures, body image, thermoregulation, fatigue, scratching, discomfort, sleep, and psychosocial well-being. In conjunction with the burn's direct consequences, it can also cause cognitive, affective, or behavioral challenges **(Moi, Haugsmyr, and Heisterkamp, 2016; Xie et al., 2022).**

Regarding the burned area healing percentage, it is noticed that patients who received ultrasonic hydrotherapy had a higher percentage of healing of the burned area percentage than those who received hydrotherapy only; also, there was a correlation between body surface area and wound healing characteristics using photographic wound assessment among both treatment groups; with a highly significant to the ultrasound hydrotherapy group. This finding may be attributed to the fact that adding low-frequency US waves into hydrotherapy can penetrate the outside of the wound bed and enter deeper tissues compared to other methods. Furthermore, US enhances the blood flow, increases collagen fiber extensibility, and a pro-inflammatory response that stimulates macrophage-derived fibroblast mitogenic factors, accelerates angiogenesis and improves tissue strength **(Ghaedi et al., 2016) (Yadollahpour et al., 2014) (Mesquit, 2016).** Based on Vitro and in vivo studies of the mechanisms of action of US treatment on wound healing, **(Conner-kerr & Oesterle, 2017)** who made a review on therapeutic ultrasound in the management of chronic wounds, concluded that US has positive effects on healing rates in various wound types; this study portrays significant differences between both groups regarding burn severity in the second, third and fourth weeks; referring findings may be since hydrotherapy supplies fresh nutrients and oxygen to injured tissue, clean the surface of the burned area and remove debris, Provide a moist environment for wound healing, adjust the microbial flora of the wound, and Protect the healthy tissue around the burn from trauma. Additionally, the use of ultrasound also has been noted to affect fibroblasts which secrete collagen, which in turn leads to faster burn healing. These findings were congruent with **Gokulakrishnan1 et al. (2018)** who concluded that ultrasound therapy increases vascularity, enhances capillary growth, increases wound strength, and hastens wound closure.

Regarding pain severity during procedures, this study portrays a significant decrease in pain severity within both groups after applying hydrotherapy/ultrasound hydrotherapy, which is superior to patients in the ultrasonic hydrotherapy group. Furthermore, there was a significant difference between both groups in the second, third, and fourth weeks; this is evident from the fact that most patients reported decreased pain levels during each session and, after a month from therapy, had no pain during ultrasound hydrotherapy treatment and reducing the need for narcotics analgesics. These findings may be explained by hydrotherapy Endorphin stimulation, which helps relieve anxiety and control pain. Immersion in water and hydrostatic pressure increase, producing a greater return of blood to the heart and a reduction in heart rate due to the stretching of baroreceptors **(Mooventhan & Nivethitha, 2014).** On the other hand, water immersion decreases neuroendocrine response(cortisol and catecholamines) in healthy adults **(Podstawski et al., 2021)** the thermoneutral effect of 34.5 ^{o}C water reduces norepinephrine, leading to stress reduction **(Sramek et al., 2000).** Using ultrasound in combination with hydrotherapy has an impact on pain intensity as ultrasound uses pulses of sound waves to enter tissues; by preventing reflection of the waves away at the soft tissues/ air interface by removing air from between the patient and transducer, remain free air bubbles and permit easy motion of transducer, with coupling the effect of US that has a slight warming effect on the tissues, it induces soft tissue expansion. This technique helps to minimize the inflammatory response and tissue swelling and thus reduces pain **(Yadollahpour et al., 2014)** this is supported by **(Conner-kerr & Oesterle, 2017)** who found that symptomatic pain relief was achieved in all patients treated with ultrasound.

Concerning the quality of life of patients with partial-thickness burns, the present study illustrated that around three-quarters of hydrotherapy group patients and more than two-thirds of ultrasonic hydrotherapy group patients had low quality of life pre the application of hydrotherapy/ultrasonic hydrotherapy. On the other hand, about half of the hydrotherapy group patients and more than two-thirds of ultrasonic hydrotherapy group patients had a high quality of life, superior to the ultrasonic hydrotherapy group patients. These findings can be attributed to the fact that hydrotherapy and ultrasonic hydrotherapy have marked effects on enhancing burn healing and decreasing pain intensity. Water characteristics that help active movements of joints and improve blood circulation and motor abilities will enhance a patient's quality of life. This finding is consistent with **Almassmoum et al. (2018)** who found that the quality of life of most diseases and lifestyle-related parameters have been improved or enhanced with the alternative hydrotherapy system.

Strengths / Limitations

The current study's findings add to the evidence from other research on the effect of ultrasound hydrotherapy that improves burn wound healing and the quality of a burn patient's life.

Conclusions

Based on promising results, the combination of ultrasound and hydrotherapy employs a wide range of effects on the wound-healing process. It has been accelerating the healing and shortened healing times of burn wounds, reducing patients' perception of the pain during wound care sessions and reducing the need for narcotic analgesics. Additionally, it impacted the improvement of burn patients' quality of life.

Recommendation

- Conduct further research to assess the effect of ultrasonic hydrotherapy on other types of wounds.
- More research is needed to confirm the most effective dose, frequency, and treatment duration for the intervention time and maximum healing.
- Provide an updated procedure manual about burn management and ultrasonic hydrotherapy.

Acknowledgments

The authors thank all of the participants.

Funding

There is no external funding for this research.

Conflict of interest

The authors declare that there is no conflict of interest.

References

- **Abd Latif, N., Emam, Z., & El Awady, M. (2019):** Validity and reliability of translated Arabic version of the burn specific health scale-brief. Curr Sci Int, 8(1), 168-177. https://doi.org/10.1016/j.burns.2016.04.011
- **Almassmoum, S., Balahmar, E., Almutairi, S., Albuainain, G., Ahmad, R., & Naqvi, A. (2018):** Current clinical status of hydrotherapy; an evidence-based retrospective six-year (2012–2017) systematic review. Bali Med. J, 7(3), 578-86. https://doi.org/10.15562/bmj.v7i3.1159
- **Aly Yakout, R., & Khlosy, H. (2020):** Range of Motion Exercises Effect during and after Hydrotherapy on Patients Burned Hand Function and Pain Intensity: A Comparative Study. Egyptian Journal of Health Care, 11(3), 670-687. doi: 10.21608/ejhc.2020.169807. 10.21608/EJHC.2020.169807
- **Ardabili, F., Purhajari, S., Ghezeljeh, T., & Haghani, H. (2014):** The effect of shiatsu massage on pain reduction in burn patients. World Journal of plastic surgery, 3(2), 115-18. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4236994/
- **Cline, M., Herman, J., Shaw, E., & Morton, R. (1992):** Standardization of the Visual Analogue Scale. Nursing Research, 41(6), 378–380. https://doi.org/10.1097/00006199-199211000-00013.
- **Conner-kerr T & Oesterle M. (2017):** Current perspectives on therapeutic ultrasound in the management of chronic wounds: a review of evidence. Chronic Wound Care Management and Research, 4:89–98.
- **Delgado, D., Lambert, B., Boutris, N., McCulloch, P., Robbins, A., Moreno, M., & Harris, J. (2018):** Validation of digital visual analog scale pain scoring with a traditional paper-based visual analog scale in adults. Journal of the American Academy of Orthopaedic Surgeons. Global research & reviews, 2(3): e088. DOI:10.5435/JAAOSGlobal-D-17-00088
- **Deniz, S., & Arslan, S. (2017):** Pain and anxiety in burn patients. International Journal of Caring Sciences, 10(3), 1723. http://www.internationaljournalofcaringsciences.org/Issue.aspx?issueID=46&pageIndex=0&pageReason=0
- **Do Amaral Zorita, L., Blanes, L., da Silva Augusto, F., & Ferreira, M. (2016):** Health-related Quality of Life and Self-esteem among Burn Patients. Wounds: a Compendium of Clinical Research and Practice, 28(1), 27-34. https://www.hmpgloballearningnetwork.com/site/wounds/article/health-related-quality-life-and-self-esteem-among-burn-patients
- **Ghaedi, F., Dehghan, M., Sheikhrabori, A., & Salari, M. (2016):** Hydrotherapy: Exploring the Healing Effects of Water. Asian Journal of Nursing Education and Research, 6(2), 9-254. DOI: 10.5958/2349-2996.2016.00048.3
- **Gokulakrishnan M, Ramani C, Kannan T, & Shafiuzamma M. (2018):** Preparation of Recipient

Wound Bed by Ultrasound Therapy for Skin Flaps in Dogs. International Journal of Livestock Research; 8 (6):123-132. DOI:10.5455/ijlr.20180226105043

- **Golshan, A., Patel, C., & Hyder, A. (2013):** A systematic review of the epidemiology of unintentional burn injuries in South Asia. Journal of public health, 35(3), 384-396. DOI: 10.1093/pubmed/fds102
- **Houghton, P., Kincaid, C., Campbell, K., Woodbury, M., & Keast, D. (2000):** Photographic assessment of the appearance of chronic pressure and leg ulcers. Ostomy Wound Management, 46(4), 20-35. https://europepmc.org/article/med/10788924.
- **Jain, M., Khadilkar, N., & De Sousa, A. (2017):** Burn-related factors affecting anxiety, depression and self-esteem in burn patients: an exploratory study. Annals of burns and fire disasters, 30(1), 30-4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5446905/
- **Kildal, M., Andersson, G., Fugl-Meyer, A., Lannerstam, K., & Gerdin, B. (2001):** Development of a brief version of the Burn Specific Health Scale (BSHS-B). Journal of Trauma and Acute Care Surgery, 51(4), 740-46. DOI: 10.1097/00005373-200110000-00020
- **Langschmidt, J., Caine, P., Wearn, C., Bamford, A., Wilson, Y., & Moiemen, N. (2014):** Hydrotherapy in burn care: a survey of hydrotherapy practices in the UK and Ireland and literature review. Burns, 40(5), 860-864. DOI: 10.1016/j.burns.2013.11.006
- **Mahmoud H. (2016):** Effect of applying a nursing staff development program on infection control nursing practices for patients with moderate degree burns. Published doctorate thesis, Faculty of Nursing, Alexandria University.
- **Mathew, C., Babu, B., Shanji, C., Pothan, N., Kutoor, D., & Abraham, E. (2016):** Hydrotherapy: A Review. International Journal of Pharmaceutical and Chemical Sciences, 5, 196-197. DOI: https://doi.org/10.3329/bjm.v32i2.53791
- **Mesquita, R., Silva, P., Oliveira, K., Fontes-Pereira, A., Freitas, J., Pereira, W., & Kietzer, K. (2016):** Effect of low-intensity therapeutic ultrasound on wound healing in rats subjected to third-degree burns. Acta Cirúrgica Brasileira, 31 (1), 36-43. https://doi.org/10.1590/S0102-865020160010000006
- **Moi, A., Haugsmyr, E., & Heisterkamp, H. (2016):** Long-term study of health and quality of life after burn injury. Annals of burns and fire disasters, 29(4), 295. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5336608/
- **Mooventhan, A., & Nivethitha, L. (2014):** Scientific evidence-based effects of hydrotherapy on various systems of the body. North American Journal of medical sciences, 6(5), 199. doi: 10.4103/1947-2714.132935
- **Murari A. A modified Lund and Browder chart. Indian J Plast Surg. (2017):** 50:220–1. doi: 10.4103/ijps.IJPS_77_17.
- **Podstawski R, Borysławski K, Pomianowski A, Krystkiewicz W, & Żurek P. (2021):** Endocrine effects of repeated hotthermal stress and cold water immersion in young adult men. American Journal of Men's Health. American Journal of Men's Health .15 (2); 1-8. DOI: 10.1177/15579883211008339
- **Quarato C, Lacedonia D , Salvemini M , Tuccari G , Mastrodonato G , Villani R, Fiore L , Scioscia G , Mirijello A , Saponara A & Sperandeo M.(2023):** A Review on Biological Effects of Ultrasounds: Key Messages for Clinicians. Diagnostics, 13: 855. https://doi.org/10.3390/diagnostics13050855.
- **Raosoft, Sample Size Calculator, Inc. (2004):** [Internet]. [Cited 2020 August 2]. Available from: http://www.raosoft.com/samplesize.html
- **Shahid, F., Ismail, M., & Khan, S. (2018):** Assessment of quality of life in post burn survivors: a cross-sectional single-center first validation study from Pakistan. Burns open, 2(1), 35-42. DOI:10.1016/j.burnso.2017.08.003
- **Shantkumar M. Burnt area assessment. (2019):** Puplished master thesis. Central University of Karnataka.Avaliavle at: https://nesac.gov.in/assets/resources/2020/12/Burn-Area-Assessment.pdf
- **Thompson, N., Gordey, L., Bowles, H., Parslow, N., & Houghton, P. (2013):** Reliability and validity of the revised photographic wound assessment tool on digital images taken of various types of chronic wounds. Advances in skin & wound care, 26(8), 360-373. .DOI: 10.1097/01.ASW.0000431329.50869.6f
- **Varaei, S., Ardabili, F., Irani, P., & Ranjbar, H. (2017):** The effect of Aloe vera gel and nitrofurazone on dressing related pain of superficial burn wounds. World journal of plastic surgery, 6(2), 254-6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5506367/
- **Vuola, J., Papp, A., Mankowski, P., Genoway, K., Gregory, S., Palmieri, L., & Middelkoop, E. (2020):** 18th European Burns Association Congress. 3–190. **https://doi.org/10.3390/ejbc1010002**
- **Xie, B., Hu J, Cheng Y, & Yao Z. (2022):** Researches on cognitive sequelae of burn injury: Current status and advances. Front Neurosci, 16: 1026152. DOI: 10.3389/fnins.2022.1026152

- **Yadollahpour A, Mostafa J, Samaneh R, Zohreh R. (2014):** Ultrasound therapy for wound healing: A Review of current techniques and mechanisms of action. Journal of pure and applied microbiology, 8(5), 4071-85. https://www.researchgate.net/publication/267926830_Ultrasound_Therapy_for_Wound_Healing_A_Review_of_Current_Techniques_and_Mechanisms_of_Action
- **Yadollahpour A & Rashidi S. (2017):** A review of mechanism of actions of ultrasound waves for treatment of soft tissue injuries. .International Journal of Green Pharmacy 11(1):S13-S20.