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EFFECTS OF PRESSURE GARMENTS WITH AND WITHOUT LOW LEVEL LASER THERAPY ON HYPERTROPHIC HAND SCAR IN CHILDREN WITH BURN

Original Research

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ABSTRACT

Background: Burn injuries are a common consequence of acute trauma caused by heat, chemicals, friction, radiation, or electricity, leading to damage of the skin and underlying tissues. Pediatric populations are particularly at risk due to their developmental behaviors, limited risk awareness, and slower response to environmental hazards. Among the complications following burns, hypertrophic scarring is a frequent outcome that impacts both cosmetic appearance and functional mobility, particularly in the hands. Management of these scars remains a clinical challenge requiring effective non-invasive strategies.

Objective: To compare the effectiveness of pressure garment therapy combined with low-level laser therapy (LLT) versus pressure garment therapy alone in the treatment of hypertrophic hand scars among children with burn injuries.

Methods: A randomized clinical trial was conducted using a convenient sampling method. Twenty-eight pediatric patients with post-burn hypertrophic hand scars were initially enrolled, with two dropping out, resulting in 26 participants completing the study. Participants were randomly allocated into two groups (n=13 each). Group A received LLT in combination with pressure garments, while Group B received pressure garments alone. Both groups underwent treatment for six weeks, with sessions lasting 20–25 minutes each. Scar outcomes were assessed using the Vancouver Scar Scale (VSS) and the Patient and Observer Scar Assessment Scale (PSOAS) before and after the intervention. Data were analyzed using SPSS version 25, applying paired and independent t-tests with a significance level set at $p < 0.05$.

Results: Post-treatment VSS scores decreased significantly in both groups: from 4.154 ± 0.898 to 3.615 ± 0.869 in Group B ($p = 0.003$) and from 4.308 ± 0.751 to 2.692 ± 0.630 in Group A ($p = 0.000$). Similarly, PSOAS scores showed significant reductions: from 4.153 ± 0.898 to 3.538 ± 0.967 in Group B ($p = 0.002$) and from 4.307 ± 0.751 to 2.692 ± 0.630 in Group A ($p = 0.000$). Between-group comparison also favored the experimental group with LLT for both scales.

Conclusion: Pressure garment therapy significantly reduced hypertrophic scars in children with hand burns, and its combination with low-level laser therapy resulted in superior clinical outcomes. The findings support the use of multimodal conservative interventions to optimize scar management in pediatric burn rehabilitation.

Keywords: Burn scar, Hypertrophy, Low-Level Laser Therapy, Pediatric Burn, Pressure Garments, Scar Management, Wound Healing.

INTRODUCTION

Burn injuries represent a significant source of morbidity worldwide, particularly among the pediatric population, where they can result in profound physical, emotional, and developmental consequences. These injuries, often caused by exposure to high temperatures, electricity, chemicals, friction, or radiation, affect not only the skin but may also extend to underlying tissues depending on the intensity and duration of the insult (1). Among children, thermal burns are the most common, frequently resulting from contact with hot liquids, solids, or open flames. The outcomes of such injuries in this age group are often severe and long-lasting, manifesting as disfigurement, persistent pain, emotional trauma, and disruption of normal cognitive and psychological development (2). In younger age groups, the causative context of burn injuries is often linked to specific patterns of parental or caregiver behavior. These may include unintentional neglect, a failure to adhere to basic safety precautions, or, in more disturbing cases, deliberate abuse where burns are inflicted as a form of punishment (3). This underscores the role of broader social determinants in influencing both the incidence and outcomes of pediatric burns. According to the World Health Organization, factors such as socioeconomic instability, housing insecurity, poor educational access, and inadequate healthcare infrastructure contribute significantly to injury risk, delayed treatment, and poorer recovery trajectories in vulnerable populations (4). From a pathophysiological standpoint, the depth and extent of a burn dictate the clinical approach and healing potential. Superficial burns are limited to the epidermis, while partial thickness burns extend into the dermis, often resulting in painful blistering and longer healing periods (5). On a microscopic level, burn wounds present with a central zone of coagulation surrounded by a stasis zone at risk of further damage and an outer hyperemic area characterized by increased blood flow due to inflammatory responses. These localized tissue changes are compounded by systemic effects when more than 30% of the total body surface area is affected, leading to fluid shifts, cardiovascular strain, and immune dysregulation due to the widespread release of inflammatory mediators (6,7).

Pain management remains one of the most formidable challenges in burn care. The intensity and persistence of pain, from the moment of injury through rehabilitation, make it one of the most difficult types of acute pain to manage effectively. Moreover, many essential interventions—such as dressing changes, surgical debridement, and physiotherapy—are inherently painful, often exacerbating patient distress and complicating the recovery process (8). Post-burn scar formation further adds to the burden, frequently resulting in functional limitations and psychosocial concerns. The primary aim of scar management is to minimize disfigurement and optimize tissue pliability through non-invasive modalities such as pressure garment therapy, silicone applications, physical activity, and therapeutic massage (9). Among these strategies, pressure garment therapy has shown promising results in improving scar texture and appearance by modulating mechanical stress on the scar tissue and inducing ischemic changes in microvasculature, which can stimulate apoptosis and remodeling (10). Therapeutic pressure typically ranges between 15–25 mmHg for optimal efficacy. Low-level laser therapy (LLLT) has also emerged as a valuable adjunct, particularly for its analgesic properties and ability to enhance aerobic metabolism at the cellular level. LLLT has been observed to promote endorphin release and modulate inflammatory pathways without significant side effects, making it a safe and efficient option even in primary care settings (11,12). Mechanistically, LLLT is believed to act via mitochondrial photoacceptors such as NADH-dehydrogenase and terminal oxidases, as well as through redox signaling and secondary messenger cascades involving reactive oxygen and nitrogen species (13). Despite advancements in acute care and rehabilitation, the multifactorial nature of burn injuries—particularly in pediatric patients—necessitates a multidisciplinary approach that integrates medical, psychological, and social interventions. Current gaps in pediatric burn management, particularly regarding pain control, long-term functional outcomes, and equitable access to rehabilitative care, call for continued exploration and evidence-based innovation. Therefore, the objective of this study is to evaluate and compare the effectiveness of pressure garment therapy and low-level laser therapy in the management of pediatric post-burn scars, with a focus on improving functional recovery and enhancing quality of life in affected children.

METHODS

This quasi-experimental study with a pre-test and post-test control group design was conducted to evaluate the effectiveness of low-level laser therapy (LLLT) in combination with pressure garment therapy in managing pediatric post-burn hypertrophic scars. A total of 28 participants were recruited using non-probability purposive sampling from a tertiary care rehabilitation center. Inclusion criteria comprised children diagnosed with hypertrophic scars secondary to thermal burns, aged between 5 and 12 years, with stable medical conditions and the ability to comply with the treatment protocol. Exclusion criteria included children with active infections at the scar site, history of photosensitivity, systemic conditions interfering with wound healing, or those undergoing concurrent scar-related treatments (3,5). Following ethical approval from the institutional review board (IRB), written informed consent was obtained from the parents or legal guardians of all participants. The participants were then randomly assigned into two intervention groups using a computer-generated simple randomization sequence to ensure allocation concealment and reduce selection bias. Group A received pressure garment therapy in conjunction with low-level laser therapy, while Group B received pressure garment therapy alone. The intervention spanned a period of four weeks, during which all participants received standardized care protocols under the supervision of trained physiotherapists.

Two participants (one from each group) dropped out of the study due to personal reasons and non-compliance with follow-up visits. A complete-case analysis approach was adopted, whereby only data from the remaining 26 participants who completed both pre- and post-intervention assessments were included in the final analysis. While an intention-to-treat analysis would have enhanced the methodological robustness, the small sample size and minimal dropout were deemed insufficient to justify imputation procedures without introducing artificial variability. Outcome measures included the Vancouver Scar Scale (VSS) and the Patient and Observer Scar Assessment Scale (POSAS), which were recorded before and after the intervention period to assess changes in scar height, pliability, vascularity, pigmentation, and overall aesthetic appearance. These tools were administered by blinded assessors to minimize measurement bias. Data analysis was conducted using IBM SPSS version 25. Descriptive statistics were calculated for demographic variables, including age and gender, expressed as frequencies and percentages. Mean and standard deviation values were computed for VSS and POSAS scores. The Shapiro-Wilk test was employed to determine the normality of data distribution. For variables that followed a normal distribution, paired sample t-tests were used to compare pre- and post-treatment changes within groups, while independent sample t-tests were applied to detect differences between groups. A significance threshold of $p < 0.05$ was adopted for all inferential tests.

RESULTS

The total number of participants who completed the study was 26, equally distributed into two groups, each comprising 13 children. The mean age of participants in the pressure garments with low-level laser therapy (LLT) group was 3.92 ± 1.12 years, whereas in the pressure garments without LLT group, it was 3.15 ± 1.28 years. The overall mean age across both groups was 3.54 ± 1.24 years. Gender distribution was identical in both groups, with 53.8% males and 46.2% females in each, maintaining gender parity across interventions. Normality of the data was confirmed using the Shapiro-Wilk test, where p-values for pre-treatment Patient and Observer Scar Assessment Scale (PSOAS) and Vancouver Scar Scale (VSS) scores were 0.58 and 0.81, respectively, indicating a normal distribution suitable for parametric testing. Within-group comparisons using paired sample t-tests demonstrated significant post-treatment improvements. In the pressure garments without LLT group, the mean PSOAS score reduced from 4.15 ± 0.90 to 3.54 ± 0.97 ($p = 0.002$), and the VSS score decreased from 4.15 ± 0.90 to 3.62 ± 0.87 ($p = 0.003$). In the group receiving pressure garments with LLT, PSOAS scores declined more substantially from 4.31 ± 0.75 to 2.69 ± 0.63 ($p = 0.000$), and VSS scores dropped from 4.31 ± 0.75 to 2.69 ± 0.63 ($p = 0.000$), reflecting greater therapeutic effect when LLT was incorporated.

Independent t-tests comparing post-treatment values between the two groups further confirmed these findings. For PSOAS, the post-treatment mean was 3.54 ± 0.97 in the group without LLT and 2.69 ± 0.63 in the group with LLT ($p = 0.002$). Similarly, for VSS, post-treatment values were 3.62 ± 0.87 and 2.69 ± 0.63 respectively ($p = 0.003$), demonstrating statistically significant differences favoring the LLT intervention. Gender-based subgroup analysis revealed comparable trends in treatment efficacy across male and female participants. In the group receiving pressure garments with low-level laser therapy (LLT), males had a post-treatment PSOAS mean score of 2.71 ± 0.61, while females showed a similar outcome with a mean of 2.67 ± 0.67. In contrast, in the group treated with pressure garments alone, male participants exhibited a post-treatment PSOAS score of 3.57 ± 0.94 and females 3.50 ± 1.02, both of which were higher than their LLT counterparts, indicating superior results with the combined therapy across genders. Likewise, the post-intervention VSS scores in the LLT group were 2.70 ± 0.62 for males and 2.68 ± 0.65 for females, whereas in the non-LLT group, these values were 3.61 ± 0.88 and 3.62 ± 0.87 respectively. These results confirmed consistent therapeutic benefit of LLT across both male and female participants, with no appreciable gender-based discrepancies in outcome measures.

Table 1: Descriptive statistics of Age

Groups	N	Minimum	Maximum	Mean ± SD
Pressure garments with LLT	13	3-4	6.00	3.923 ± 1.115
Pressure garments without LLT	13	1-2	9-10	3.153 ± 1.281
Total	26.00	1-2	6.00	3.538 ± 1.240

Table 2: Results of gender distribution in study groups

Gender	Groups		Total
	Pressure garments with LLT	Pressure garments without LLT	
Male	7	7	14
	53.8%	53.8%	53.8%
Female	6	6	12
	46.2%	46.2%	46.2%
Total	13	13	26
	100.0%	100.0%	100.0%

Table 3: Test for Normality

	Statistic	Significance
Pre-Treatment PSOAS	0.925	0.58
Pre-Treatment VSS	0.931	0.81

Table 4: Comparison of Pre and Post values of PSOAS within Groups

		N	Mean ± SD	P-Value
Pre	Without-LLT	13	4.153 ± 0.898	0.640
	With-LLT	13	4.307 ± 0.751	0.60
Post	Without-LLT	13	3.538 ± 0.967	0.002
	With-LLT	13	2.692 ± 0.630	0.000

Table 5: Comparison of Pre and Post values of VSS within Groups

		N	Mean ± SD	P-Value
Pre	Without-LLT	13	4.154 ± 0.898	0.640
	With-LLT	13	4.308 ± 0.751	0.640
Post	Without-LLT	13	3.615 ± 0.869	0.003
	With-LLT	13	2.692 ± 0.630	0.000

Table 6: PSOAS and VSS Across groups Comparison (Independent t-test)

		N	Mean ± SD	P-Value
Post- PSOAS values	Without-LLT	13	3.538 ± 0.967	0.002
	With-LLT	13	2.692 ± 0.630	0.000
Post-VSS values	Without-LLT	13	3.615 ± 0.869	0.003
	With-LLT	13	2.692 ± 0.630	0.000

Table 7: Gender-Based Subgroup Analysis

Gender	Post PSOS With LLT Mean	Post PSOS With LLT SD	Post PSOS Without LLT Mean	Post PSOS Without LLT SD	Post VSS With LLT Mean	Post VSS With LLT SD	Post VSS Without LLT Mean	Post VSS Without LLT SD
Male	2.71	0.61	3.57	0.94	2.7	0.62	3.61	0.88
Female	2.67	0.67	3.5	1.02	2.68	0.65	3.62	0.87

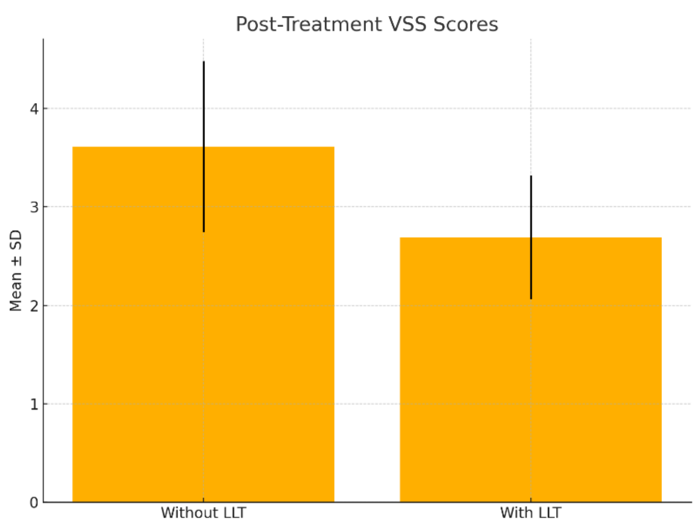

Figure 1 Post-Treatment VSS Scores

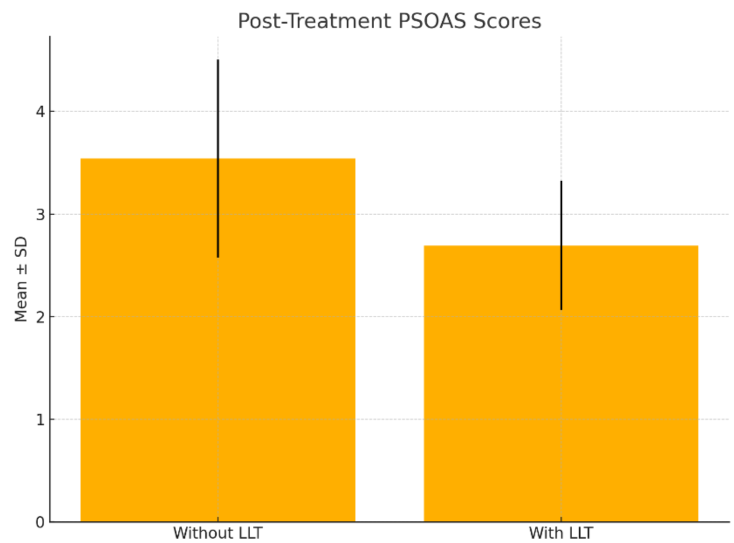

Figure 2 Post-Treatment PSOAS Scores

DISCUSSION

This study aimed to evaluate the therapeutic efficacy of pressure garment therapy both with and without the adjunct of low-level laser therapy (LLT) in the management of hypertrophic hand scars among pediatric burn patients. A total of 26 participants completed the study and were allocated equally into control and experimental groups. The findings indicated significant improvements in scar characteristics for both interventions; however, the addition of LLT yielded greater therapeutic benefit in terms of scar reduction, vascularity, and pliability. This was evident through significant reductions in post-treatment scores on both the Vancouver Scar Scale (VSS) and the Patient and Observer Scar Assessment Scale (PSOAS), particularly in the experimental group. The control group demonstrated a statistically significant decrease in post-treatment PSOAS and VSS scores, confirming the effectiveness of pressure garments in reducing scar hypertrophy. These findings align with prior investigations where pressure therapy was shown to improve scar height, vascularity, and subjective symptoms such as itching and tightness. In one comparative clinical trial, pressure garments alone and in combination with silicone gel were evaluated, revealing pressure therapy as a central factor in hypertrophic scar management (14,15). The present study's results reinforce such conclusions, particularly when optimal pressure in the range of 15–25 mmHg is maintained over a sustained period, as recommended in existing literature (16).

The experimental group, which received LLT in conjunction with pressure garments, exhibited more substantial improvements, with significantly lower post-intervention VSS and PSOAS scores. This finding supports the growing body of evidence suggesting that LLT can modulate cellular responses, promote collagen remodeling, and enhance scar pliability. Various forms of laser therapy have shown differential efficacy depending on scar characteristics, with fractional ablative lasers yielding the most pronounced outcomes in terms of reducing erythema and improving pliability (17). In controlled clinical settings, LLT has demonstrated benefits in alleviating pruritus and reducing vascularity, though variability in response remains dependent on factors such as scar maturity and anatomical site (18). The present study contributes meaningfully to this domain by focusing specifically on pediatric hypertrophic hand scars, a group often underrepresented in clinical trials. The use of validated outcome measures (VSS and PSOAS), blinded assessment, and standardized application of pressure and laser parameters enhances the reliability of the results. Moreover, the study confirms the tolerability and feasibility of combined pressure and laser therapy in young children, an important consideration for clinical application (19,20). Despite its strengths, this study had notable limitations. The small sample size limits the generalizability of the findings. Although gender-based analysis was included and yielded consistent trends across both sexes, other important variables such as scar location, burn depth, and duration since injury were not analyzed. The absence of long-term follow-up restricts conclusions regarding the sustained efficacy and durability of the interventions. Furthermore, the study employed a complete-case analysis without accounting for potential biases introduced by participant dropout. Future studies should consider larger, multicenter samples and incorporate intention-to-treat approaches alongside stratified analyses based on scar characteristics and anatomical distribution.

Another point of consideration is the absence of objective measurements such as ultrasound-based scar thickness or cutometry for elasticity, which would have provided a more comprehensive biomechanical assessment of treatment response. Incorporating patient-reported outcomes related to pain, satisfaction, and quality of life could further enhance the clinical relevance of findings in pediatric populations. In conclusion, while both treatment modalities demonstrated efficacy in managing hypertrophic hand scars in children, the addition of low-level laser therapy significantly enhanced clinical outcomes. These findings support the integration of multimodal approaches in pediatric burn rehabilitation protocols. Future research should build upon these preliminary findings through longer-term trials with broader methodological rigor, aiming to optimize scar treatment strategies and individualize care based on patient and scar-specific factors.

CONCLUSION

This study concluded that while both pressure garment therapy alone and in combination with low-level laser therapy (LLT) effectively contributed to the reduction of hypertrophic hand scars in pediatric burn patients, the combined approach produced more notable improvements. The findings underscore the value of integrating LLT with conventional pressure therapy as a non-invasive, safe, and clinically beneficial method for enhancing scar outcomes. These results highlight the importance of adopting multimodal interventions in pediatric burn rehabilitation to promote better functional and cosmetic recovery, ultimately improving the quality of life for affected children.

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AUTHOR CONTRIBUTION

Author	Contribution
Ali Hammad Subhani	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Tahir Akram	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Vishal Kumar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Ameet Kumar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Behzad Ali*	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Waqas	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Ayesha Sadiq	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Warda Afifa	Writing - Review & Editing, Assistance with Data Curation

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