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Frequency and Predictors of Hypertrophic Scarring in Pediatric Burns Patients Managed Conservatively in a Burn and Trauma Centre, Peshawar

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Article Info

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Date Received:
02nd August, 2026
Date Revised:
09th September, 2026
Date Accepted:
09th September, 2026

Check for updates

This article may be cited as:
Shah SS, Ullah I, Khan NH, Ullah W, Ahmad R, Ahmad J: frequency and predictors of hypertrophic scarring in pediatric burns patients managed conservatively in a burn and trauma centre, peshawar. J Postgrad Med Inst. 2026;40(3):161-67. http://doi.org/10.54079/jpmi.40.3.3996

Abstract

Objective: To find out the prevalence and predictors of hypertrophic scarring in children with burns who were treated conservatively at a specialized facility.

Methodology: This descriptive longitudinal study was conducted at the Department of Burns and Plastic Surgery, Burn and Trauma Center, Peshawar. Total 217 pediatric patients with superficial or partial-thickness burns in the age group of 2-16 years were recruited using non-probability consecutive sampling technique. The ethical clearance was obtained from Institutional Ethical Committee. All patients underwent conservative management of burns wounds, were assessed during the acute phase on Day 0, Day 7 and Day 14. Final hypertrophic scarring (HTS) assessment was conducted at a minimum of 3 months post-injury and was defined as a scar with elevation ≥ 2 mm and mVSS ≥ 5. Statistical analysis was done using SPSS version 26.0.

Results: Out of 217 patients, 124 (57.1%) were males with mean age of 6.9 ± 3.8 years. Partial thickness burns were found in 135 (62.2%) patients and the mean TBSA was 9.8 ± 4.1 %. The frequency of hypertrophic scarring was 46 (21.2%). Multivariable analysis revealed that prolonged time to complete wound re-epithelialization was the sole independent predictor of HTS (p=0.003), while the effect of burn depth was mediated by healing time. Age, gender and TBSA were not significantly associated with HTS (p>0.05).

Conclusion: The frequency of hypertrophic scarring in conservatively managed pediatric burn patients was 21.2%. Prolonged time to complete wound re-epithelialization was the primary independent predictor of HTS development.

Keywords: burn depth, burns, conservative treatment, hypertrophic cicatrix, modified Vancouver scar scale, pediatrics, wound healing, wound infection

Introduction

Annually around the world, there are about 96,000 child deaths younger than 20 years because of fire-related burns in poor and middle-income countries. Causes of injury include burns related to hot water, oven and iron.[1]

Scarring, which includes hypertrophic scar formation (HTS), is a frequent and inevitable result of deep dermal and full-thickness burns. Hypertrophic scarring can increase contracture and restrict function following a burn injury.[1] It can also affect the cosmetic appearance, produce itching and pain, and decrease quality of life.[2] They usually involve the hands, feet, and face (e.g., nasolabial contracture, microstomia, and eyelid ectropion).[3] Most studies have analyzed ROM in joints damaged by burns. Apart from the limited ROM, its effect depends largely on the number of contractures, the level of traction and restriction, and physical disability or cosmetic deformities of the affected areas.[4]

Recent advances in the treatment of burns have improved the survival rate of severely burned patients. Improved survival demands the intensive management of hypertrophic scars due to the burns. Hypertrophic scarring is caused by an abnormality of the normal healing process that causes excessive inflammation and collagen formation at the affected site. Some of the symptoms of these wounds include pain, itching, redness, and restriction of movement. It is necessary to understand the various treatment options available due to the high prevalence of these scars in children and the accompanying physical, psychological, and social burden.[5]

According to one study of pediatric burns, the prevalence of hypertrophic scarring was 17.2%. Time to healing was found to be the strongest predictor of developing hypertrophic scarring and the earliest development of the hypertrophic scar was observed in a patient who had been healed after 8 days.[6] Another study revealed hypertrophic scarring in 13.5% of the total number of patients. Increased total body surface area (%TBSA), increased time to healing, and deep wounds are some of the three factors noted to increase the prevalence of scarring.[7]

The present study focuses on the prevalent problem of hypertrophic scarring amongst burn victims in children treated using conservative treatment approach. The prevalence of hypertrophic scarring among children is extremely variable because of numerous factors that range from differences in the population under study to use of different measuring tools and various values in subjective scar scales defining/identifying HTS.[8] According to our knowledge, there is no study in the literature review performed by us in the context of this problem in Pakistan. Apart from the provision of basis for future research, the current study will help us in devising techniques of management and prevention of hypertrophic scarring amongst children suffering from burns. Through prevention of scar formation, it will ensure that the functional impairment does not occur in the future and supporting their psychological well-being during a critical stage of development.

Methodology

This descriptive longitudinal study was conducted at the Department of Burns and Plastic Surgery, Burn and Trauma Cenre, Peshawar from 20th March 2026 to 31st July 2026. The study included a total sample size of 217 pediatric burn patients. The sample size was calculated utilizing the WHO calculator, based on a 95% confidence interval, a 5% margin of error, and an anticipated population proportion of 17.2%.6 Participants were enrolled utilizing a non-probability consecutive sampling technique.

The inclusion criteria strictly comprised patients of both genders, aged between 2 and 16 years, who presented with acute superficial or partial-thickness burn injuries requiring solely conservative management. Patients were excluded if they required any form of surgical management, possessed comorbidities such as immunodeficiency, or had a history of pre-existing keloids. Ethical approval for this study was granted by the Institution Research and Ethical Committee (IREB) at Hayatabad Medical Complex, Peshawar (Approval No: 2896), and the research synopsis was formally approved by the College of Physicians and Surgeons Pakistan (Reference No: CPSP/REU/PLS-2024-325-798). Informed written consent was obtained from the parents or guardians of all patients.

Data Collection Procedure:

A total of 234 pediatric patients initially presented with superficial or partial-thickness burns during the specified study time period and were evaluated for conservative management. However, 17 patients were lost to follow-up before complete wound re-epithelialization. Therefore, the final analyzed sample consisted of 217 patients who completed the study protocol in strict adherence to the inclusion and exclusion criteria.

Upon admission, baseline demographic and clinical information including patient age, gender, residence, causation, Total Body Surface Area (TBSA) calculated via Lund & Browder's chart, injury site, and burn type was recorded on a structured proforma. All patients received standardized conservative wound care involving sterile silver-based dressings. Burn depth was pre-defined and classified according to standard clinical criteria as either superficial or partial-thickness injuries.[19] Superficial burns were defined as injuries involving only the epidermis, clinically characterized by a dry, red appearance that blanches with pressure and lacks significant blister formation. Conversely, partial-thickness burns were defined broadly as injuries extending through the epidermis and into the dermis, clinically

J Postgrad Med Inst 2026;40(3):161-67.
http://doi.org/10.54079/jpmi.40.3.3996

characterized by blister formation, a moist pink or red wound bed, and variable pain depending on the depth of dermal involvement Patient follow-up was divided into two distinct phases: acute wound monitoring and long-term scar assessment. During the acute phase, clinical follow-ups were strictly scheduled on Day 0, Day 7, and Day 14 to assess wound trajectory. Day 14 was utilized as a prognostic milestone for risk stratification. For patients whose wounds were not fully epithelialized by Day 14, clinical monitoring continued continuously during routine dressing changes until complete wound closure was achieved, allowing precise recording of total healing time in days (defined as the duration until the wound no longer required dressings).

Following complete re-epithelialization, patients were transitioned to outpatient follow-up. The final clinical assessment for the primary outcome-hypertrophic scarring was conducted during these subsequent outpatient clinic visits at a minimum of 3 months post-injury, allowing adequate time for physiological scar remodeling to manifest post-closure. Scar were evaluated using the modified Vancouver Scar Scale (mVSS) which is a validated and standardized clinical tool used to quantify hypertrophic scar severity by evaluating four distinct variables: scar pliability, height (thickness), vascularity and pigmentation.[20] The primary outcome, hypertrophic scarring, was operationally defined as the presence of a scar raised by at least 2mm combined with an mVSS of ≥ 5 at this final assessment.

Data Analysis:

Data entry and statistical analyses were performed using SPSS version 26.0. Quantitative variables such as patient age, TBSA, and time to healing were expressed as means and standard deviations (SD). Categorical variables, including gender, burn site, and hypertrophic scarring, were presented utilizing frequencies and percentages. Stratification was performed to identify risk factors, and post-stratification analyses were conducted using the Chi-square test for categorical variables and the independent sample t-test for normally distributed continuous variables. A p-value of ≤ 0.05 was considered statistically significant.

Results

Total 234 patients initially evaluated, 17 were lost to follow-up before complete wound epithelialisation; the final analysed sample comprised 217 patients. Demographic and clinical characteristics of the selected cohort can be seen in Table 1. The selected patient group revealed a slight prevalence among males i.e. 124 patients (57.1%) against 93 females (42.9%). The mean age of the study group was 6.9 ± 3.8 years. The predominant group of patients had partial-thickness burns (135, 62.2%), and the mean TBSA was 9.8 ± 4.1%. The mean time to achieve full wound healing for all patients was 15.7 ± 6.4 days. After completing conservative treatment and achieving full wound healing, the incidence rate of hypertrophic scarring (HTS) in the pediatric cohort was 46 patients (21.2%).

In order to find out the possible clinical and demographic predictors of HTS formation, bivariate analysis was performed, and its results are summarized in Table 2. In the analysis of TBSA, the mean TBSA was a little bit higher in the group of HTS patients (10.6 ± 4.0%) compared to that in the non-scarring group (9.6 ± 4.1%), but the difference was not statistically significant (p = 0.141). However, in terms of clinical evaluation of the TBSA, patients with injuries that exceeded 10% TBSA showed an increased tendency for scar formation (54.3% in the HTS group) compared to patients with lower values; however, this difference did not reach statistical significance (p = 0.089).

Prolonged time to complete wound re-epithelialization emerged as a highly significant predictor of later scar formation. Patients who eventually developed HTS during long-term follow-up had a significantly prolonged acute healing phase, taking an average of 19.4 ± 6.6 days for their wounds to fully close, compared to 14.7 ± 5.9 days in patients who did not develop HTS (p < 0.001), which is depicted in Figure 1. Moreover, another important risk factor identified in initial bivariate analysis was burn depth. The differences in the scar formation tendency between patients with partial-thickness injuries (28.1%) and superficial burns (9.8%) were statistically significant (p = 0.002). However, demographic variables such as patient age (p = 0.371) and gender (p = 0.792) had no effect on scar formation process.

To identify true independent risk factors for HTS and control for confounding variables, a multivariable binary logistic regression was performed including burn depth, TBSA, and time to healing as covariates. The model revealed that time to complete wound re-epithelialization was the only statistically significant independent predictor of HTS development (p = 0.003). Specifically, for every one-day increase in the time required for complete healing, the odds of developing a hypertrophic scar increased by 10.7% (Adjusted Odds Ratio [aOR] = 1.107; 95% CI: 1.036-1.183). When controlling for healing time, burn depth lost the statistical significance it had demonstrated in the bivariate analysis (p = 0.387, aOR = 1.618), indicating that the effect of burn depth on scar formation is primarily mediated by the prolonged time required for re-epithelialization. TBSA remained non-statistically significant in the multivariable model (p = 0.812, aOR = 0.989).

Discussion

This study evaluated the frequency and clinical predictors of hypertrophic scarring (HTS) in pediatric burn patients managed conservatively. However, The frequency of HTS in this study population was found to be 21.2%, which sits below the 32-72% reported range in the literature among children treated with conservative measures for burns.9 Our frequency is

Table 1. Baseline Demographic and Clinical Characteristics of Pediatric Burn Patients (n = 217)

Variable	Frequency (n)	Percentage (%) / Mean ± SD
Age (Years)	—	6.9 ± 3.8
Gender		
Male	124	57.1%
Female	93	42.9%
Burn Depth (Type)		
Superficial (1st Degree)	82	37.8%
Partial-Thickness (2nd Degree)	135	62.2%
Total Body Surface Area (TBSA %)	—	9.8 ± 4.1
Time to Complete Healing (Days)	—	15.7 ± 6.4
Hypertrophic Scarring (HTS) Outcome		
Developed HTS	46	21.2%
Did not develop HTS	171	78.8%

Note: Data presented as Mean ± SD for continuous variables and Frequency (%) for categorical variables.

Table 2. Bivariate Analysis of Risk Factors Associated with Hypertrophic Scarring

Risk Factor	Total (n=217)	HTS Present (n=46)	HTS Absent (n=171)	p-value
Age (Years) *	6.9 ± 3.8	6.5 ± 3.8	7.0 ± 3.9	0.371
Gender				0.792
Male	124	25 (20.2%)	99 (79.8%)	
Female	93	21 (22.6%)	72 (77.4%)	
Burn Depth				0.002
Superficial	82	8 (9.8%)	74 (90.2%)	
Partial-Thickness	135	38 (28.1%)	97 (71.9%)	
TBSA (%) *	9.8 ± 4.1	10.6 ± 4.0	9.6 ± 4.1	0.142
TBSA Categories, n (%)				0.089
≤ 10%	102 (59.6%)	21 (45.7%)		
> 10%	69 (40.4%)	25 (54.3%)		
Time to Healing (Days) *	15.7 ± 6.4	19.4 ± 6.6	14.7 ± 5.9	< 0.001

* Mean ± Standard Deviation; Independent Samples t-test. † Frequency (Row %); Pearson Chi-Square test. Bold p-values: statistically significant at p ≤ 0.05

moderately higher than those reported in a well-endowed British Paediatric Burns Centre by Chipp et al.[6] (17.2%) and another high-volume North American Centre by Willoughby et al.[7] (13.5%). These differences are likely attributable to the distinct challenges of a resource-constrained setting. Although not directly measured as independent variables in this cohort, factors such as delayed patient presentation, limited availability of advanced dressings, and higher baseline risks of wound infection are common in our region and are recognized contributors to delayed wound healing which is a known trigger for HTS development.[10,13] Similar results were found in Mongolian paediatric burn patients by Enkhtuvshin et al.[14] which is another similar resource-constrained scenario. Inter-study variations in HTS frequency are further exacerbated by the different lengths of follow-up, varying threshold values of scar scales used, and the lack of a standard definition

J Postgrad Med Inst 2026;40(3):161-67.
http://doi.org/10.54079/jpmi.40.3.3996

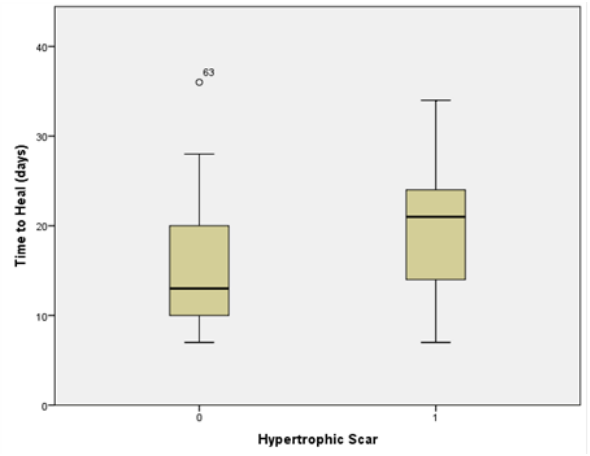

Figure 1: Time to Complete Healing by Hypertrophic Scarring Outcome.

of HTS. This point was explicitly noted by Ball et al.[8] and in the design of our study as well.

Time to wound healing proved to be the most powerful and statistically significant predictor of HTS formation ($p < 0.001$). Patients with HTS had about five more days to heal their wounds completely compared to patients without HTS. This result supports the landmark work done by Chipp et al.,[6] demonstrating that each additional day of healing increases the probability of HTS formation by 1.138 times, reinforcing the clinical adage that 'every day counts' in pediatric burn care. The same relation is proven by the Chinese national expert consensus (2023), reporting HTS rates of 56.5% if the healing times were between 22-30 days, reaching 85.7% in cases with healing times more than 30 days.[10] In our setting, late presentations because of geographic distance, socioeconomic constraints, and lack of burn awareness, along with poor wound care at an early stage, become the key factors in delay in wound healing and HTS occurrence. These findings strongly support early presentation protocols, community-level burn first-aid education, and highlight the potential utility of advanced antimicrobial dressings to minimize infection and accelerate re-epithelialization, though dressing-specific outcomes were not directly evaluated in this study.[17]

Conversely, burn depth was found to be an independent and statistically significant predictor of HTS ($p = 0.002$) in our initial bivariate analysis, with partial thickness burns resulting in an HTS rate nearly three times that of the superficial burns. However, as demonstrated by our multivariable regression model, this effect is largely mediated by delayed healing times. This finding is corroborated by Willoughby et al.,[7] who determined the odds ratio of HTS for deep wounds at OR = 13.324 ($p < 0.001$). The pathogenesis of the phenomenon has already been explained: partial thickness burns, especially those with reticular dermal involvement, alter the usual proportion between various fibroblast subpopulations and lead to the formation of fibrotic phenotype with abundant extracellular matrix production and formation of hypertrophic scar characterized by a raised and reddened firm tissue.[9] Mistry and Issa[11] have shown that even in the presence of conservative management deep partial thickness burns of children have higher risk of long-term scarring in comparison with superficial burns regardless of the necessity of surgery later on. Consequently, this information is useful for burn triage with partial thickness burns requiring intensified wound surveillance, more frequent dressing changes, and prophylactic treatment of scars.

In contrast to Willoughby et al.,[7] who in their large retrospective study have revealed that high TBSA is a significant predictor of HTS development (OR = 1.497, $p < 0.001$), there was no statistically significant relationship between TBSA and HTS ($p = 0.142$) in our study. There are some methodological reasons for this contradiction rather than real biological one. First of all, our study sample contained only 217 cases, which is much less than in Willoughby et al.'s study where 2,016 cases were used, and we had insufficient statistical power to detect the effect of continuous predictors. In addition, conservative management criterion of our study automatically narrowed the range of TBSA since large burns are usually treated surgically and consequently were excluded from the sample. The small difference in means between TBSA in the HTS positive group (10.6 ± 4.0%) and HTS negative group (9.6 ± 4.1%) contributed to it too. Larger prospective multicentre studies are needed to resolve this question definitively in the Pakistani context.

There were no statistically significant relationships between either patient age ($p = 0.371$) or gender ($p = 0.792$) and HTS in our study population. Jordan et al.[13] found a male gender preponderance in paediatric burn epidemiology using the WHO Global Burn Registry but could not identify this as a predictor of scar quality. Even though younger patients have physiological advantages in terms of higher fibroblast proliferative ability and cellular density in the dermis, these qualities seem not to consistently act as protective factors against HTS in the case of wound-level variables being dominant.[9] The presence of more young patients (43.8%) with mostly scald burns of limited severity might have diluted any scar-age signal in this dataset. The lack of predictive significance of gender is consistent with virtually all burn scar literature, and our findings do not oppose the general trend.

The public health importance of HTS among patients from LMICs goes well beyond the wound itself. Patel et al.[12] reported sustained physical, psychological, and social morbidities, including joint movement restriction, anxiety, depression, and burdens of social exclusion, in paediatric burn victims, which are exacerbated in countries without access to specialized scar rehabilitation. Hendriks et al.[16] found that HTS and burn contractures, which are left untreated in LMICs, often result

in highly resource-consuming corrective surgery many years after injury which is a burden of morbidities that is entirely preventable. Thus, the finding of an average healing time greater than 19 days being associated with HTS represents a clear actionable cut-off point, and the burn units in LMICs should introduce monitoring systems to escalate wound management when healing has not proceeded as planned by Day 14. Systematic monitoring of scar evolution by using photography and mVSS scoring beyond Day 14, as described by Edger-Lacoursière et al.,[15] will allow for early detection of HTS and implementation of conservative scar modulation approaches. This is also validated by the recently issued Clinical Practice Guideline for Pediatric Scar Prevention and Treatment, where the recommendation for re-epithelialization taking more than 14 to 20 days, as it greatly increases the risk of aberrant dermal remodeling, is emphasized, along with the standard risk stratification starting on Day 14.[18] It is our empirical finding that HTS-positive pediatric patients need 19.4 ± 6.6 days to heal. This underlines the clinical usefulness of introducing a protocol for systematic day-14 escalation in low-resource tertiary burn centers.

There are some strengths of this study. This is the first published study that addresses HTS frequency and factors predicting HTS in conservative management of paediatric burns in Pakistan, filling an important gap in the South Asian burns literature. The study uses prospective data collection along with validated mVSS for a consistent outcome measurement. Structured proforma along with the operational definition of HTS ensured the reduction of any possible ascertainment biases.

There are several limitations in the current study which need to be acknowledged. The present study is a single centre study and hence its results are not generalizable to other institutions or demographics. Although the use of validated and commonly used tool, the mVSS, ensures validity of the measurement, the subjective evaluation of vascularity and pliability cannot be ruled out in mVSS. A further limitation is that partial-thickness burns were not explicitly sub-categorized into superficial-partial and deep-partial thickness injuries in our dataset, which carry different pathophysiological risks for HTS. Additionally, the genetic and phenotypic profile of our cohort must be considered. The Pakistani population predominantly falls within Fitzpatrick Skin Types IV-VI. Darker skin phenotypes are well-established, massive independent drivers of aberrant dermal remodeling and HTS formation. The lack of documented Fitzpatrick Skin Type stratification for individual patients in our cohort represents a limitation, and we strongly recommend its inclusion as a standard variable in future regional burn registries. Nutritional status, micronutrient adequacy, and socio-economic variables affecting wound healing are also not documented in this study due to resource constraints. Lastly, the descriptive longitudinal design does not allow for making any causative inference. In future researches, a follow up period of at least six months after wound healing, multi-centric study design, an objective tool for scar measurement, and documenting of Fitzpatrick skin type are important considerations in order to establish a more robust and generalisable evidence base for HTS prevention in Pakistani and broader South Asian paediatric burn populations.

Conclusion

Hypertrophic scar formation in conservatively treated children with burns at this facility occurred in 21.2% of patients. Prolonged time to wound re-epithelialization was the sole independent predictor of HTS, fully mediating the effect of burn depth. Age, gender, and total body surface area were not significantly associated with HTS. Expediting wound closure is important strategy for preventing hypertrophic scarring in this population.

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Authors' Contribution Statement

SSS contributed to the conception, design, acquisition, analysis, interpretation of data, drafting of the manuscript, and critical review of the manuscript. IU contributed to the conception, design, acquisition, critical review of the manuscript, and final approval of the version to be published. NHK contributed to the conception, design, acquisition, critical review of the manuscript, and final approval of the version to be published. WU contributed to the acquisition, analysis, and interpretation of data. RA contributed to the acquisition, analysis, and interpretation of data. JA contributed to the acquisition, analysis, and interpretation of data. All authors are accountable for their work and ensure the accuracy and integrity of the study.

Conflict of Interest

Authors declared no conflict of interest

Grant Support and Financial Disclosure

None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.