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Original Research Article

Prevention of Post-Burn Upper Limb Contractures: A Prospective Observational Analysis from a Tertiary Care Centre

Razvi Das[1], Tanmayi Kulkarni[2], Ajinkya Bhosle[3]

[1]Assistant Professor, Department of General Surgery, Assam Medical College & Hospital, Dibrugarh, Assam

[2]Assistant Professor, Department of Pathology D Y Patil Medical College, Hospital and Research Centre, D Y Patil Vidyapeeth, Pimpri, - Pune, Maharashtra 411018

[3]Intensivist, Dept of Critical Care Medicine and Anaesthesia, K J Somaiya Hospital, Mumbai

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Corresponding Author: Dr. Razvi Das

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Abstract

Background: Post-burn contractures of the upper limb remain a major cause of long-term functional disability despite advances in acute burn management. Early institution of preventive strategies such as proper limb positioning, splinting, and physiotherapy can minimise their occurrence. This study aimed to prospectively assess the preventive measures adopted in burn patients with upper limb involvement and evaluate their effectiveness in reducing contracture formation.

Methods: A prospective observational study was conducted among 97 patients admitted with upper limb burns at a tertiary care teaching hospital. Demographic, clinical, and burn-related variables were recorded using a structured proforma. Preventive interventions, including limb positioning, splinting, physiotherapy, and pressure garment application, were instituted as per protocol and monitored during follow-up at 2 weeks, 1 month, 3 months, and 6 months. The presence and severity of contracture were assessed clinically and graded based on range of motion (ROM) restriction. Statistical analysis was performed using SPSS version 26.0, with $p < 0.05$ considered significant.

Results: The mean age of participants was 32.8 ± 11.6 years, with 57.7% males and flame burns being the most common cause (55.7%). Proper positioning and physiotherapy were implemented in over 90% of cases. At 6 months, the overall incidence of contracture was 23.7%, predominantly mild. Contracture development correlated significantly with higher TBSA ($p = 0.001$), deep/full-thickness burns ($p = 0.012$), delayed healing beyond 3 weeks ($p < 0.001$), and delayed initiation of physiotherapy or splinting ($p < 0.001$). Earlier rehabilitation was associated with reduced severity (Spearman's $r = 0.48$, $p < 0.001$).

Conclusion: Early initiation of physiotherapy, proper limb positioning, and adherence to splinting are key determinants in preventing upper limb contractures following burns. A multidisciplinary, protocol-based rehabilitation approach should be emphasized from the acute stage to preserve joint mobility and optimize functional outcomes.

Keywords: Burn injury; Upper limb contracture; Physiotherapy; Splinting; Rehabilitation.

Introduction

Burn injuries are a major cause of morbidity and mortality worldwide, particularly in low- and middle-income countries [1]. According to the World Health Organization (WHO), nearly 11 million people sustain burn injuries requiring medical attention each year, resulting in approximately 180,000 deaths annually, with the majority occurring in developing countries [2]. India alone accounts for an estimated 7–10 lakh burn injuries per year, with about 10%–15% of cases leading to significant disability due to scar contractures [3]. The upper limb is among the most commonly affected anatomical regions, owing to its frequent exposure during domestic and occupational activities [3]. One of the most debilitating sequelae of burn injury is post-burn contracture, a preventable complication that results from excessive scar formation, prolonged inflammation, and soft tissue shortening across joints [4]. Upper limb contractures particularly impair hand and wrist movements, grip strength, and functional independence, severely affecting quality of life and vocational rehabilitation [5]. The reported incidence of post-burn contractures in developing countries ranges between 20% and 35%, with higher rates observed among patients with deep dermal or full-thickness burns and those with delayed wound healing [6].

The development of contractures is multifactorial and influenced by burn depth, extent of injury, infection, prolonged immobilization, and inadequate early rehabilitation [7]. Evidence suggests that wound closure delayed beyond three weeks markedly increases the risk of contracture formation [8]. Preventive measures—including early grafting, proper limb positioning, splint application, and supervised physiotherapy—are well-established strategies to minimize this risk [9]. Despite these interventions, contracture prevention often remains suboptimal in resource-limited settings due to insufficient awareness, limited rehabilitation personnel, and poor patient compliance [10]. Given the functional and psychosocial impact of upper limb contractures, early preventive rehabilitation forms an essential component of burn management. However, there is a paucity of prospective data evaluating the real-world effectiveness of preventive strategies during the acute and post-acute phases of burn recovery in the Indian context [11,12]. Therefore, the present study was aimed to prospectively assess the preventive measures adopted for upper limb contracture formation among burn patients and to evaluate their outcomes over the course of treatment and follow-up.

Materials and Methods

Study Design and Setting: This was a prospective observational study conducted in the Department General Surgery at a tertiary care teaching hospital, over a period of 24 months from January 2023 to December 2024. The study was designed to evaluate the preventive measures instituted for the avoidance of upper limb contractures among patients with burn injuries and to assess their effectiveness during hospitalization and follow-up. Ethical approval was obtained from the Institutional Ethics Review Board (IERB) prior to commencement of the study.

Study Population and Eligibility Criteria: All patients admitted with acute burns involving the upper limb were screened for inclusion. Patients of either sex, aged above 12 years, with superficial partial-thickness, deep partial-thickness, or full-thickness burns affecting the upper extremity were included after obtaining informed written consent. Patients with pre-existing upper limb deformities, associated fractures, neurological deficits, or those lost to follow-up within one month were excluded. A total of 97 patients fulfilling the inclusion criteria were enrolled consecutively.

Data Collection and Baseline Assessment: A structured proforma was used to collect demographic details, burn characteristics, and clinical findings. The parameters recorded included age, sex, occupation, total body surface area (TBSA) burnt, depth of burn, cause of injury, and time interval between injury and initiation of treatment. The anatomical sites of upper limb involvement (shoulder, elbow, wrist, hand) were documented. Baseline photographs and range of motion (ROM) measurements were taken at admission to serve as reference for follow-up comparisons.

Preventive Measures and Interventions: All patients received standard burn care including fluid resuscitation, wound management, and analgesia according to institutional protocols. Specific preventive interventions for contracture were instituted early in the course of treatment. These included proper limb positioning, application of splints, and initiation of physiotherapy as soon as tolerated. The affected limb was positioned in a functional anti-deformity posture—shoulder in abduction and external rotation, elbow in extension, wrist in slight extension, metacarpophalangeal joints in flexion, and interphalangeal joints in extension.

Splinting was carried out using thermoplastic or plaster splints to maintain the desired position, especially during rest and at night. Splints were checked daily for comfort, pressure points, and hygiene. Physiotherapy included active and passive range-of-motion exercises, stretching, and functional activities. Patients were encouraged for early mobilization and regular limb elevation to reduce edema. Pressure garments were advised following wound healing or graft take to control hypertrophic scarring.

Follow-up and Outcome Assessment: Patients were followed up at 2 weeks, 1 month, 3 months, and 6 months post-injury. During each visit, limb position, compliance with splint and exercise regimen, wound healing status, and joint mobility were evaluated. The presence or absence of contracture at each joint was assessed clinically and graded based on restriction of range of motion and functional limitation. The degree of contracture was classified as mild (<25% loss of motion), moderate (25–50%), or severe (>50%). Photographic documentation and goniometric measurements were performed for objective assessment.

Data Management and Statistical Analysis: All collected data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics such as mean, standard deviation, and percentages were used for quantitative variables, while categorical variables were expressed as frequencies and proportions. The incidence of contracture formation was calculated, and associations with demographic or clinical factors such as age, burn depth, TBSA, or compliance with preventive measures were analyzed using Chi-square test or Fisher's exact test for categorical data and Student's t-test for

continuous variables. A p-value < 0.05 was considered statistically significant.

Results

The study enrolled 97 patients with acute burns involving the upper limb. The mean age was 32.8 ± 11.6 years, ranging from 14 to 62 years, with a male predominance (57.7%). The majority were homemakers (29.9%) and labourers (22.7%), reflecting the high-risk occupational exposure in these groups. Flame burns constituted the leading cause (55.7%), followed by scald injuries (26.8%) and electrical burns (11.3%). The mean total body surface area (TBSA) affected was 21.4 ± 8.2%, with deep partial-thickness burns being the most frequent (47.4%). Among the anatomical regions, the hand (69.1%) and elbow (45.4%) were most commonly involved. The mean time to admission was 1.8 ± 1.2 days, and the average hospital stay was 18.6 ± 6.9 days, indicating moderate burn severity with early presentation in most cases (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (n = 97)

Parameter	Category	Frequency (%)/Mean ± SD
Age (years)	–	32.8 ± 11.6
Gender	Male	56 (57.7%)
	Female	41 (42.3%)
Occupation	Homemaker	29 (29.9%)
	Labourer	22 (22.7%)
	Student	18 (18.6%)
	Office worker	13 (13.4%)
	Others	15 (15.4%)
Cause of burn	Flame	54 (55.7%)
	Scald	26 (26.8%)
	Electrical	11 (11.3%)
	Chemical	6 (6.2%)
Total Body Surface Area (TBSA)	–	21.4 ± 8.2%
Depth of burn	Superficial partial thickness	34 (35.1%)
	Deep partial thickness	46 (47.4%)
	Full thickness	17 (17.5%)
Site of upper limb involvement	Shoulder	15 (15.5%)
	Elbow	44 (45.4%)
	Wrist	28 (28.9%)
	Hand	67 (69.1%)
Time to admission (days)	–	1.8 ± 1.2
Hospital stay (days)	–	18.6 ± 6.9

Preventive interventions were initiated early and implemented in the majority of patients. Proper limb positioning was maintained in 95.9%, and splinting was applied in 80.4%, with a mean initiation time of 2.4 ± 1.2 days post-burn. Physiotherapy—including active and passive range of motion exercises—was started in 91.7% of patients within 2.9 ± 1.0 days. Pressure garments were prescribed in 66% of cases after wound healing or graft take, usually by the third week (20.6 ± 4.3 days). Additionally, patient and caregiver education on home-based exercise and compliance was achieved in 88.7% of cases (Table 2).

Table 2: Distribution of Preventive Measures Adopted in Study Population (n = 97)

Preventive Measure	Implemented	Initiation Time (days post-burn)
	Frequency (%)	Mean ± SD
Proper limb positioning	93 (95.9%)	0.8 ± 0.4
Splint application	78 (80.4%)	2.4 ± 1.2
Early physiotherapy (active/passive exercises)	89 (91.7%)	2.9 ± 1.0
Pressure garment use (after wound healing/grafting)	64 (66.0%)	20.6 ± 4.3
Patient/family education on home exercise	86 (88.7%)	–

At the end of 6 months, 74 patients (76.3%) showed complete preservation of limb mobility with no contracture. The overall incidence of contracture was 23.7%, with 13 patients (13.4%) developing mild, 7 (7.2%) moderate, and 3 (3.1%) severe restriction of motion. Most contractures were localized to the elbow and hand joints, often associated with deep burns or delayed physiotherapy (Table 3).

Table 3: Incidence of Upper Limb Contracture at 6-Month Follow-up (n = 97)

Presence of Contracture	Frequency (%)
No contracture	74 (76.3%)
Mild contracture (<25% ROM loss)	13 (13.4%)
Moderate contracture (25–50% ROM loss)	7 (7.2%)
Severe contracture (>50% ROM loss)	3 (3.1%)

Analysis of determinants showed that contracture formation was significantly associated with larger burn surface area, greater burn depth, delayed healing, and non-adherence to rehabilitation measures. Patients who developed contractures had a mean TBSA of 26.2 ± 7.4% compared to 19.9 ± 7.5% among those without ($p = 0.001$). Similarly, deep or full-thickness burns were more frequent in the contracture group (87.0% vs 58.1%, $p = 0.012$). Delayed wound healing beyond 3 weeks was strongly correlated with contracture formation (78.3% vs 29.7%, $p < 0.001$). Early physiotherapy initiation within 3 days (94.6% vs 47.8%, $p < 0.001$) and good splint compliance (87.8% vs 52.2%, $p = 0.002$) significantly reduced the risk of contracture (Table 4).

Table 4: Factors Associated with Development of Upper Limb Contracture (n = 97)

Variable	Contracture Present (n = 23)	No Contracture (n = 74)	p-value
	Frequency (%) / Mean ± SD		
Age (years)	34.9 ± 12.4	32.1 ± 11.2	0.134
Gender (Male/Female)	14 (60.9%) / 9 (29.1%)	42 (56.8%) / 32 (43.2%)	0.893
TBSA (%)	26.2 ± 7.4	19.9 ± 7.5	0.001
Depth of burn (deep/full-thickness)	20 (87.0%)	43 (58.1%)	0.012
Delay in wound healing (>3 weeks)	18 (78.3%)	22 (29.7%)	<0.001
Physiotherapy initiated within 3 days	11 (47.8%)	70 (94.6%)	<0.001
Splint compliance (good)	12 (52.2%)	65 (87.8%)	0.002

Statistical significance determined by Chi-square and t-tests; $p < 0.05$ considered significant.

A statistically significant positive correlation was observed between delay in physiotherapy or splint initiation and contracture severity. Later commencement of physiotherapy correlated with higher grades of contracture ($r = 0.48$, $p < 0.001$), while delayed splint use also showed a moderate correlation ($r = 0.39$, $p = 0.003$). The timing of pressure garment application after wound healing correlated modestly with severity ($r = 0.31$, $p = 0.017$) (Table 5).

Table 5: Correlation Between Timing of Preventive Measures and Contracture Severity

Preventive Measure	Initiation Time (days)	Mild Contracture	Moderate/ Severe Contracture	Spearman's r	p-value
	Mean ± SD				
Physiotherapy start time	2.9 ± 1.0	3.6 ± 1.1	5.1 ± 1.3	0.48	<0.001
Splint initiation time	2.4 ± 1.2	3.1 ± 1.0	4.2 ± 1.5	0.39	0.003
Pressure garment application (days post-healing)	20.6 ± 4.3	23.1 ± 5.4	25.4 ± 6.2	0.31	0.017

r = Spearman's correlation coefficient; Early = ≤3 days post-burn; Late = >3 dayspost-burn.

Discussion

This prospective observational study involving 97 burn patients, and the overall incidence of post-burn contractures observed in this study (23.7%) aligns with previously reported studies byHendriks et al., Fanstone et al.,Wibawa et al., and Fanstone et al., from developing countries, ranging between 20% and 35% [13-16]. In a study by Gupta et al., upper limb contractures occurred in 27.8% of cases, predominantly among patients with deep dermal burns and delayed rehabilitation initiation [17]. Similarly, Tyagi et al., emphasized that early physiotherapy and splinting reduced contracture incidence to less than 20% in centers with dedicated burn rehabilitation teams [18].

Our findings corroborate the results of Shukla et al., who observed that contractures were significantly associated with delayed wound healing beyond three weeks ($p < 0.01$) and poor splint compliance ($p < 0.05$) [19]. In contrast, centers emphasizing structured physiotherapy reported lower rates (around 15%), highlighting the role of institutional rehabilitation protocols.Moreover, Shankar et al., reported that

early mobilization within 48 hours after grafting led to improved functional recovery without compromising graft integrity — consistent with our observation that physiotherapy started within three days significantly reduced contracture occurrence ($p < 0.001$) [20].

The predominance of hand and elbow involvement in our cohort (69.1% and 45.4%, respectively) is consistent with patterns reported in Indian studies by Salam et al., and Gupta et al., as these joints are highly mobile and susceptible to post-burn scarring [21,22]. The demographic trend in our study, with young adults and homemakers/labourers most affected, mirrors the high-risk population identified in South Asian burn epidemiology as observed in the studies by Meng et al., and Puri et al., reflecting occupational exposure and domestic fire hazards [23,24].

Post-burn contractures result from fibrotic scar tissue contraction, imbalance between collagen deposition and remodeling, and the prolonged immobilization of healing joints [25]. During the proliferative phase of wound healing, myofibroblast activity and collagen cross-linking contribute to tissue shortening if joint mobility is restricted [26]. Preventive interventions—particularly splinting in anti-deformity positions and early mobilization—help maintain soft-tissue length, joint capsule integrity, and prevent adhesion formation [27].

Our finding that delayed physiotherapy and splinting correlated positively with contracture severity ($r = 0.48$ and $r = 0.39$, respectively) underscores the critical time-dependent window for rehabilitation during the early post-burn period. Similarly, pressure garments, though used in only two-thirds of patients due to economic constraints, help in scar maturation by applying uniform pressure, reducing capillary proliferation and hypertrophic scarring. Thus, the combined mechanical and physiological effects of early rehabilitation play a central role in contracture prevention [28].

The higher contracture rate among patients with deep or full-thickness burns can be explained by extensive dermal destruction, delayed epithelialization, and secondary scarring [29]. In our cohort, TBSA >20% and healing time >3 weeks were strong predictors of contracture formation, reaffirming the need for early wound closure through grafting and meticulous postoperative positioning [30].

Clinical Implications and Future Directions: This study reinforces the pivotal role of early, structured rehabilitation in preventing upper limb contractures following burn injuries. Emphasis should be placed on immediate post-injury limb positioning, timely initiation of physiotherapy within 72 hours, and consistent splinting throughout the healing period [25]. Training nursing staff and caregivers to maintain anti-deformity positions and perform simple range-of-motion exercises can significantly improve outcomes, especially in settings with limited physiotherapy resources [26]. Institutional burn care protocols should incorporate a multidisciplinary approach integrating surgeons, physiotherapists, and occupational therapists from the time of admission. Future studies with larger cohorts, longer follow-up durations, and inclusion of functional scoring systems could further strengthen the evidence base. Additionally, exploring cost-effective pressure garment alternatives and community-based rehabilitation models would enhance accessibility and sustainability in low-resource environments [27].

Strengths and Limitations: The major strength of this study lies in its prospective design with serial follow-up and standardized assessment of preventive interventions in a real-world tertiary care setting. Objective documentation through goniometric measurements and photographic records adds reliability to outcome evaluation. Furthermore, inclusion of both surgical and non-surgical burn cases provides a comprehensive overview of contracture prevention strategies applicable to diverse clinical scenarios.

However, certain limitations must be acknowledged. Being an observational study, causality cannot be firmly established. The sample size ($n = 97$), though adequate for exploratory analysis, may limit generalizability to broader populations. Variability in patient compliance and rehabilitation intensity post-discharge might have influenced long-term outcomes. The study did not employ validated functional outcome scales (e.g., DASH or QuickDASH), which could have provided additional insight into patient-perceived disability. Despite these limitations, the study provides valuable context-specific data on practical preventive measures relevant to the Indian healthcare system.

Conclusion

In summary, the present study highlights that contractures of the upper limb remain a preventable complication of burn injury when appropriate interventions are instituted early. Early physiotherapy, splinting, and consistent limb positioning significantly reduce both incidence and severity of contractures. These findings underscore the need for timely, multidisciplinary, and protocol-driven rehabilitation as an integral part of burn management to preserve function and improve quality of life.

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