Treatment of postburn hypertrophic scaring in skin of color with fractional CO2 laser - A prospective cohort study

Samman Khalid, MBBS,[a] Bianca Sanabria, MA,[b,c] Isabella Tan, BS,[c] Samavia Khan, MD,[b,c] Husnain Khan, FCPS,[a] and Babar Rao, MD[d]

Objective: To evaluate the efficacy of fractional CO2 laser therapy in treating mature hypertrophic burn scars.

Method: A prospective cohort study enrolled burn patients with postburn hypertrophic scars undergoing fractional CO2 laser treatment in Rawalpindi, Pakistan. Patients aged 12 to 80 years were included, receiving 4 laser sessions every 4-6 weeks. Demographic data and scar assessments using the Vancouver Scar Scale and Patient Observer Scar Assessment Scale were collected.

Results: Twenty-five patients with hypertrophic scars received treatment. Vancouver Scar Scale scores showed significant reductions, with improvements in scar vascularity (pre: 0.85 ± 1.085, post: 0.10 ± 0.300, $P < .001$), pigmentation (pre: 2.44 ± 0.673, post: 2.12 ± 0.900, $P = .008$), and pliability (pre: 2.29 ± 1.078, post: 1.39 ± 0.997, $P < .001$). Patients with Fitzpatrick skin types III and IV had notable Vancouver Scar Scale score improvements ($P = .013$, $P < .001$). Patient Observer Scar Assessment Scale scores also decreased significantly post-treatment ($P < .001$).

Conclusion: Fractional CO2 laser therapy shows promise in managing mature hypertrophic burn scars, with improvement in scar appearance, functionality, and symptom relief. Stratification by Fitzpatrick skin type highlights the need for further research to optimize treatment strategies, particularly in populations with darker skin tones. This study underscores the importance of further longitudinal studies on burn scars to enhance outcomes for all burn survivors. (JAAD Int 2025;19:35-42.)

Key words: burns; fractional co2 laser; keloid; scars; skin of color.

INTRODUCTION

Globally, burns pose a significant public health challenge, contributing to approximately 100,000 to 350,000 deaths annually, predominantly in low- and middle-income countries. Survivors of burn injuries experience substantial physical, psychosocial, and financial impacts, a burden felt disproportionately in patients of resource-limited countries and racial and ethnic minorities.[1-3] The morbidity seen in burn injuries stems from the deposition of excess collagen and resulting scar formation, prompting the development of nonpliable, itchy, and painful tissue. Thus, an investigation into the treatment modalities of underlying scar tissue secondary to burns is essential in enhancing patient quality of life.

Numerous nonsurgical scar management approaches for burns exist, including pressure

From the Department of Plastic and Reconstructive Surgery, Holy Family Hospital, Rawalpindi, Pakistan[a]; Center for Dermatology, Rutgers Robert Wood Johnson Medical School, Somerset, New Jersey[b]; Rutgers Robert Wood Johnson Medical School, Piscataway, New Jersey[c]; and Department of Dermatology, Weill Cornell Medicine, New York, New York.[d]

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Correspondence to: Bianca Sanabria, MA, Worlds Fair Dr, Somerset, NJ 08873. E-mail: bianca.sanabria@rutgers.edu.

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garments, cryosurgery, silicone products, intralesional corticosteroids, and microneedling.[4] Surgery remains the primary treatment for refractory scars, albeit with variable outcomes and financial implications. Ablative pulsed CO2 laser, the first laser treatment for burn scars, was associated with edema, oozing, and crusting,[5] which led to the introduction of non-ablative, fractional CO2 lasers, a nonsurgical option with limited side effect profile and condensed recovery period.[5,6] The reduction in secondary damage by non-ablative lasers is through the formation of microscopic vertical channels in the skin surrounded by healthy tissue, which enables rapid healing of the damaged columns.[6]

Fractional CO2 laser treatment promotes scar reduction through photothermolysis and neocollagenesis, reducing scar thickness while improving pigmentation, pliability, and vascularity.[7] However, its efficacy varies based on skin type, with limited evidence on its efficacy for burn treatment in Fitzpatrick skin types IV-VI. Moreover, patients with darker skin tones experience a greater risk of postprocedural pigmentary and scarring-related adverse effects. This study aims to evaluate the outcomes of mature hypertrophic burn scars in patients with darker skin tones in Pakistan.

CAPSULE SUMMARY

- This study enhances understanding of scar management by evaluating fractional carbon dioxide laser therapy's effectiveness for hypertrophic burn scars in skin of color, highlighting improvements in vascularity, pigmentation, and pliability.
- These findings suggest fractional carbon dioxide laser therapy as an effective treatment for hypertrophic burn scars in skin of color, highlighting a safe, personalized approach for dermatologists.

METHODOLOGY

We conducted a prospective cohort study of burn patients who underwent fractional CO2 laser treatment of postburn hypertrophic scars to improve appearance, functionality, and symptoms. The study was reviewed and approved by the Research and Ethical Committee at Rawalpindi Medical University and Allied Hospitals of Rawalpindi (RefNo.293/IREF/RMU/2022). Informed consent was obtained from all study participants.

Patient selection

A nonprobability consecutive sampling technique was employed to recruit participants from the Department of Dermatology at Benazir Bhutto Hospital and the Department of Plastic Surgery at Holy Family Hospital located in Rawalpindi, Pakistan. Patients presenting with postburn hypertrophic scarring, aged between 12 and 80 years, irrespective of gender, resulting from any form of burn or thermal injury were included. Patients with postinflammatory pigmentary changes, atrophic scars, or keloids/keloid tendencies were excluded. Additionally, patients who were unable to tolerate laser therapy or topical/local anesthesia due to hypersensitivity were excluded. Individuals who had undergone a course of isotretinoin within the preceding 6 months were also excluded, as were those afflicted with infectious diseases or documented mental disorders.

Laser treatment

Participants underwent 4 sessions of fractional CO2 laser therapy for hypertrophic scars at Benazir Bhutto Hospital, Department of Dermatology, every 4-6 weeks. For the first 3 sessions, follow-ups were conducted every 4 weeks, then 2 weeks after the fourth session. Before laser therapy, topical anesthesia (15.6% lidocaine) was applied to the treatment area, supplemented with local lidocaine injections, if necessary. Postsession, the treatment area was covered with sterile gauze and topical antibiotic application for 3 days.

The Tru Technology Fractional CO2 laser with specifications of 30 W power and 10,600 nm wavelength was utilized. Laser parameters were tailored case by case, within the following range: 15-100 mJ/microthermal treatment zone, interval 1.0-1.5 ms, sequential scan mode, spot size 0.3-1.5 mm, and spot area 5.0×5.0-20×20 mm. A stamping technique with 10% to 20% overlap between regions ensured full coverage.

Data collection

Demographic data were collected for each patient including, age, sex, Fitzpatrick skin type, and past medical and surgical history. Burn data, including mechanism of injury, location, total body surface area (% BSA), time elapsed since initiation of treatment, and previous treatments, were collected.

Before and after 4 sessions of laser treatment, Vancouver Scar Scale (VSS) and Patient Observer Scar Assessment Scale (POSAS) scores were measured. The VSS and the observer portion of POSAS were completed by a plastic surgeon, blinded to previous scores, while the patient component of

Abbreviations:

BSA: body surface area
OSAS: Observer Scar Assessment Scale
POSAS: Patient Observer Scar Assessment Scale
PSAS: Patient Scar Assessment Scale
TBSA: total body surface area
VSS: Vancouver Scar Scale

POSAS was completed by participants. In cases of literacy challenges, interviews were conducted by a third-party member to complete relevant portions of the data collection form.

Statistical analysis

Data from baseline visits and after treatment were analyzed in SPSS version 29 (IBM SPSS Statistics). Before and after for all VSS and POSAS measures were compared using a pre-post paired sample T-test. Two-tailed *P*-values <0.05 were considered significant.

RESULTS

Twenty-five patients with hypertrophic burn scars were treated at the Benazir Bhutto Hospital. The average age was 28.48 years, ranging from 15 to 65 years, with 41.5% being females (17) and 19.5% males. A total of 41 burn injuries were treated, with an average of 1.64 burns per patient. The average % body surface area was 7.54 (2.5-18) and the average time elapsed from burn to treatment was 3.79 years. Flame was the leading cause of burns, representing 43.9% of the cases, and a large number of burn injuries occurred on the upper limbs, accounting for 61.0%. Patient characteristics are shown in Table I.

VSS

Treatment of burns with fractional CO2 laser therapy significantly reduced the average Vancouver Scar Scale from 7.37 ± 2.74 to 4.88 ± 2.16 ($P < .001$). When assessing scar characteristics before and after treatment, a significant reduction in the mean vascularity, pigmentation, and pliability score was observed. Vascularity decreased from 0.85 ± 1.085 to 0.10 ± 0.300 ($P < .001$) and pigmentation decreased from 2.44 ± 0.673 to 2.12 ± 0.900 ($P = .008$). These findings can be observed clinically in Fig 1. Table II shows that the average score for pliability decreased from 2.29 ± 1.078 to 1.39 ± 0.997 ($P < .001$).

When stratified according to Fitzpatrick skin type, a reduction in average VSS score was observed in patients with Fitzpatrick skin types III [6.11 ± 1.691 to 3.44 ± 1.740 ($P = .013$)] and IV [7.90 ± 2.893 to 5.30 ± 2.184 ($P < .001$)]. The VSS variable pigmentation was assessed by Fitzpatrick skin type. The average pigmentation score significantly decreased after treatment in patients with Fitzpatrick skin type III [2.11 ± 0.601 to 1.44 ± 1.014 ($P < .001$)], but no significant changes were observed for those with Fitzpatrick skin type IV [2.50 ± 0.682 to 2.27 ± 0.785 ($P = .070$)].

Significant improvements in pliability, as measured by the VSS score, were observed in burns treated with the fractional CO2 laser within 1 year (2.53 ± 1.007 to 1.65 ± 0.996, $P < .001$) and between 1 and 5 years postburn (2.56 ± 0.892 to 1.56 ± 0.892, $P < .001$). However, no significant change was noted for scars treated more than 5 years after the burn [1.25 ± 1.035 to 0.50 ± 0.756, $P = .080$]. The time from burn injury to treatment initiation also influenced outcomes, with scars treated within 5 years showing better improvement in VSS scores (Table III).

POSAS

The POSAS was utilized to assess observer and patient perspectives of scar quality before and after treatment. A significant reduction in the combined average of the Observer Scar Assessment Scale (OSAS) and Patient Scar Assessment Scale (PSAS) scores, before and after treatment, was observed. The total POSAS score decreased from 86.98 ± 24.08 to 54.90 ± 26.96 ($P < .001$).

OSAS

To evaluate alterations in scar characteristics before and after treatment, variables of the OSAS score, such as vascularity, pigmentation, relief, and pliability, were analyzed (Table II). Treating hypertrophic scars with fractional CO2 laser led to a reduction in average vascularity [3.90 ± 1.814 to 2.05 ± 1.532 ($P < .001$)] and pigmentation [6.41 ± 2.345 to 4.32 ± 2.150 ($P < .001$)]. A notable reduction in surface irregularities, measured by the average relief score [5.51 ± 2.461 to 3.34 ± 2.466 ($P < .001$)], and suppleness of the scar, reflected by the average pliability score [5.46 ± 2.491 to 3.29 ± 2.472 ($P < .001$)], was observed. The average total OSAS score reduced from 39.44 ± 13.092 to 25.41 ± 13.611 ($P < .001$).

When stratified by Fitzpatrick skin type, a significant reduction in OSAS score was seen skin types III [34.00 ± 9.138 to 17.67 ± 8.902 ($P < .0010$] and IV [42.27 ± 13.180 to 28.63 ± 13.843 ($P < .001$)]. A marked decrease in pigmentation was also observed for skin types III [5.89 ± 2.261 to 3.33 ± 2.121 ($P = .005$)] to and IV [6.80 ± 2.265 to 4.77 ± 2.046 ($P < .001$)].

Time since burn did not significantly affect the overall OSAS score (Table III). However, improvements in both relief and pliability were consistent across all scar ages, showing significant changes at

Table I. Clinical characteristics

Clinical characteristics (N = 25)	
Age (y)	
Mean	28.48 ± 15.04
Range	15-65
Sex	
Female	17 (41.5%)
Male	8 (19.5%)
Fitzpatrick skin type	
I-II	0
III	7 (17.1%)
IV	17 (41.5%)
V	1 (2.4%)
VI	0
TBSA of burn injury (%)	
Mean	7.54 ± 3.918
Time elapsed (y)	
Mean	3.79 ± 5.25
Burn etiology	
Flame	18 (43.9%)
Oil	2 (4.9%)
Contact*	2 (4.9%)
Scald	1 (2.4%)
Acid/chemical	1 (2.4%)
HVEB†	1 (2.4%)
Location	
Face	10 (24.4%)
Upper limbs	25 (61.0%)
Lower limbs	4 (9.8%)
Trunk	2 (4.9%)
Previous treatment	
Skin graft	12 (29.3%)
Conservative	10 (24.4%)
Flaps	1 (2.4%)
NIL‡	1 (2.4%)
Other	1 (2.4%)

*Contact with hot metal.
†High voltage electric burn.
‡Nothing.

each time interval. Specifically, relief scores showed significant reductions for burns treated within 1 year (6.29 ± 2.312 to 3.76 ± 2.611, $P < .001$), between 1 and 5 years (5.88 ± 2.473 to 3.56 ± 2.707, $P < .001$), and after 5 years (3.13 ± 0.991 to 2.00 ± 0.926, $P = .002$). Similarly, pliability scores significantly decreased for scars treated within 1 year (45.06 ± 2.090 to 3.82 ± 2.698, $P < .001$), between 1 and 5 years (5.69 ± 2.750 to 3.44 ± 2.581, $P < .001$), and after 5 years (3.13 ± 0.991 to 1.88 ± 0.991, $P < .001$).

PSAS

To evaluate patient perspectives on alterations in scar characteristics before and after fractional CO2 treatment, components of the PSAS score were analyzed. A significant change was noted in patients' overall assessment of their scar compared to normal skin, as indicated by the overall opinion score of PSAS, when comparing before and after treatment (Table II). Symptomatic improvement in pain and itching (Table II), were also noted.

PSAS scores were analyzed according to Fitzpatrick skin type and a significant decrease in the average PSAS score was noted for skin types III, IV, and V (Table III). When assessing changes in color score of PSAS across Fitzpatrick skin type, a marked decrease in pigmentation was observed for skin types III [8.56 ± 2.351 to 4.89 ± 2.571 ($P = .006$)], IV [8.57 ± 1.657 to 5.97 ± 2.189 ($P < .001$)], V [8.57 ± 1.675 to 5.97 ± 2.189 ($P < .001$)].

Time from burn occurrence to the initiation of treatment with fractional CO2 laser did not affect the outcomes, as a significant difference in average PSAS scores was noted across all time intervals (Table 5). The stiffness variable of the OSAS score was analyzed according to the time elapsed. Elapsed time did not impact the stiffness score, as a significant reduction was observed for burns treated within 1 year [7.06 ± 2.487 to 4.06 ± 2.680 ($P < .001$)], between 1 and 5 years [7.50 ± 1.789 to 4.50 ± 2.989 ($P < .001$), and more than 5 years [3.50 ± 2.390 to 1.25 ± 1.581 ($P = .038$)].

Complications

In this study, 2 patients with facial burns experienced hyperpigmentation following treatment. Additionally, 2 patients developed temporary vesicle formation, and transient erythema was noted in several cases, resolving within 2-3 days post-treatment.

DISCUSSION

Burn injuries pose a significant global health threat, especially affecting those in low- and middle-income countries and marginalized groups. Burn survivors commonly encounter enduring physical, psychological, and financial difficulties, largely attributed to the development of hypertrophic scars. This study seeks to assess the efficacy of fractional CO2 laser therapy in treating mature hypertrophic burn scars, with a specific focus on patients with darker skin tones in Pakistan.

Burn scars can lead to considerable cosmetic and functional issues, along with other symptoms related to scarring, including pain and itching.[8] The impact on patients' quality of life is often not captured by objective measures of scars, using, the patient scar assessment score in our study enabled us to assess patient perspectives on scar symptom improvement following treatment, including changes in pruritus, pain, and color. Objective measures often fail to fully capture the impact of scars on patients' quality of life.[8] By using the PSAS in our study, we observed patients' perspectives on improvements in scar

Fig 1. Images (**A**) (before treatment) and (**B**) (after treatment): 15-year-old male, right-hand burn, secondary to flame. Images (**C**) (before treatment) and (**D**) (after treatment): 45-year-old female, left-foot burn, secondary to flame. Images (**E**) (before treatment) and (**F**) (after treatment): 45-year-old female, right-hand burn, secondary to flame. Images (**G**) (before treatment) and (**H**) (after treatment): 65-year-old female, left-hand burn, secondary to flame. Images (**I**) (before treatment) and (**J**) (after treatment): 65-year-old female, right-hand burn, secondary to flame.

Table II. Pre-and post comparison of VSS, OSAS, and PSAS scores

	Mean	SD	*P* value
VSS			
Vascularity			
Pre	0.85	1.085	<.001
Post	0.10	0.300	
Pigmentation			
Pre	2.44	0.673	.008
Post	2.12	0.900	
Pliability			
Pre	2.29	1.078	<.001
Post	1.39	0.997	
Height			
Pre	1.78	0.759	<.001
Post	1.29	0.814	
Total			
Pre	7.37	2.736	<.001
Post	4.88	2.159	
OSAS			
Vascularity			
Pre	3.90	1.814	<.001
Post	2.05	1.532	
Pigmentation			
Pre	6.41	2.345	<.001
Post	4.32	2.150	
Thickness			
Pre	5.32	2.494	<.001
Post	3.68	2.573	
Relief			
Pre	5.51	2.461	<.001
Post	3.34	2.466	
Pliability			
Pre	5.46	2.491	<.001
Post	3.29	2.472	
Surface area			
Pre	6.44	2.191	<.001
Post	4.37	2.310	
Overall			
Pre	6.39	1.948	<.001
Post	4.12	2.368	
Total			
Pre	39.44	13.092	<.001
Post	25.41	13.611	
PSAS			
Painful			
Pre	3.98	3.387	<.001
Post	1.73	2.062	
Itching			
Pre	5.05	3.930	<.001
Post	2.95	2.854	
Color			
Pre	8.44	1.858	<.001
Post	5.68	2.241	
Stiff			
Pre	6.54	2.647	<.001
Post	3.68	2.859	
Thickness			
Pre	7.12	2.722	<.001
Post	4.83	2.664	
Irregular			
Pre	7.51	2.336	<.001
Post	4.71	2.695	
Overall			
Pre	8.90	1.758	<.001
Post	5.93	2.621	
Total			
Pre	47.54	13.060	<.001
Post	29.24	14.876	

OSAS, Observer Scar Assessment Scale; *PSAS*, Patient Scar Assessment Scale; *VSS*, Vancouver Scar Scale.

symptoms after treatment, including changes in functionality, itching, pain, and color to elucidate the potential impact on quality of life.

Consistent with previous research, this study indicates that fractional CO2 laser treatment significantly reduces scar severity, particularly improving vascularity and pigmentation, which are important features of scar presentation.[9,10] Patients also noticed improvements in functionality, reporting enhanced pliability and decreased stiffness. Notably, pigmentation scores showed some variability, particularly across Fitzpatrick skin types III and IV, with reductions in pigmentation being more pronounced in type III. However, patients with type IV saw less consistent results, suggesting that outcomes may be less predictable in darker skin types. This variability in pigment response is an important consideration when counseling patients with darker skin types on potential results. Given the increased susceptibility of these skin types to pigmentary alterations, patients should be advised on the possible need for multiple sessions and the likelihood of temporary pigmentation changes. Scar age also appeared to influence outcomes, with newer scars generally responding more favorably. Thus, underscoring the need for a personalized approach in managing expectations, particularly for patients with darker skin tones, while reaffirming the favorable safety profile of the treatment, as complications were mild and self-limiting.

Individuals with melanin-rich skin types are more prone to pigmentary alterations following laser resurfacing treatments due to disruption of melanosomes and reduced inflammation.[11,12] In this study, fractional CO2 laser treatments notably reduced pigmentation in Fitzpatrick skin types III and IV, as evidenced by PSAS and OSAS measurements. However, VSS outcomes were inconsistent, likely due to our small sample size

Table III. Pre- and postcomparison of total VSS, OSAS, and PSAS score of patients, stratified Fitzpatrick skin type and elapsed time

	Mean	SD	*P* value
Vancouver Scar scale			
Fitzpatrick			
III			
Pre	6.11	1.691	.013
Post	3.44	1.740	
IV			
Pre	7.90	2.893	<.001
Post	5.30	2.184	
V			
Pre	5.00	-	-
Post	5.00	-	
Elapsed time			
<1 y			
Pre	8.53	2.239	<.001
Post	5.35	2.234	
1-5 y			
Pre	7.63	2.680	<.001
Post	5.13	1.962	
>5 y			
Pre	4.38	1.506	.200
Post	3.38	1.923	
Observer Scar Assessment score			
Fitzpatrick			
III			
Pre	34.00	9.138	.04
Post	17.67	8.902	
IV			
Pre	42.27	13.180	<.001
Post	28.63	13.843	
V			
Pre	21.50	0.707	.164
Post	12.00	2.828	
Elapsed time			
<1 y			
Pre	45.06	11.305	<.001
Post	27.71	14.764	
1-5 y			
Pre	40.25	13.269	<.001
Post	26.75	14.224	
>5 y			
Pre	25.88	4.643	.002
Post	17.88	6.707	
Patient Scar Assessment score			
Fitzpatrick			
III			
Pre	49.22	16.732	.005
Post	26.67	12.865	
IV			
Pre	48.33	11.406	<.001
Post	30.97	15.506	
V			
Pre	28.00	1.414	.049
Post	15.00	0.00	
Elapsed time			
<1 y			
Pre	53.18	11.865	<.001
Post	32.71	15.956	
1-5 y			
Pre	49.56	10.683	<.001
Post	28.88	16.653	
>5 y			
Pre	31.50	5.264	<.001
Post	22.63	2.973	

VSS, Vancouver Scar Scale; *OSAS*, Observer Scar Assessment Scale; *PSAS*, Patient Scar Assessment Scale.

and the inclusion of only one patient with Fitzpatrick skin type V, preventing evaluation of changes in Fitzpatrick skin type V. Despite variable effects based on the time elapsed since burn injury, treatment initiated more than 5 years postinjury resulted in significant improvements in VSS score. This underscores the efficacy of fractional lasers in treating hypertrophic scars in skin of color and emphasizes the importance of early intervention for enhanced cosmetic and functional outcomes.

Conflicts of interest

None disclosed.

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