NILES

Journal of Laser Science and Applications
journal homepage: https://jlsa.journals.ekb.eg

Cairo University

Efficacy and Safety of Fractional CO_2 Laser Therapy in the Treatment of Post-Traumatic Scars

Abeer Attia Tawfik[1], Amal Osama Hadhoud[2*], Noha Abdallah[1]

[1] Department of Medical Applications of Laser, Dermatology Unit, National Institute of Laser Enhanced Sciences, Cairo University, Giza, Egypt, [2] Department of Dermatology, General Administration of Medical Affairs (Students Hospital), Zagazig University, Zagazig, Egypt

Abstract

The development of scar tissue is a result of healing of wounds that occurred as a result of damaged tissue. Post-traumatic scars have a significant impact on the quality of life of cases, potentially causing psychiatric and emotional disturbances. There are several methods available for managing such scars. In general, the effectiveness of fractional carbon dioxide (CO2) laser therapy for post-traumatic scars has been demonstrated in multiple investigations. In this review, we focused on the effectiveness of fractional ablative carbon dioxide laser in the treatment of post-traumatic scars, whether as a monotherapy or in combination with other techniques. We additionally tried to determine the impact of various factors, including the type of skin, the duration, the shape, the location, and the pigment of the scars, on the outcome. The literature research comprised articles (clinical trials or scientific evaluations) that have been recognized by searching electronic databases such as PubMed within the past five years, as well as the reference lists of the respective articles.

Keyword— scars, fractional CO_2 laser, post-traumatic scars

I. Introduction

Scars are acquired by approximately one hundred million cases every year, with eleven million of them being keloids and four million being burn scars. Children account for seventy percent of these scars. Psychological, aesthetic, social, and physical repercussions may result from abnormal skin scarring [1]. Burns and other traumatic injuries result in the development of traumatic scars in millions of individuals globally each year. Scars frequently develop at the location of tissue injury and may be either hypertrophic or atrophic [2].

It is impossible to achieve a complete enhancement in scars, despite the expectations of cases who are seeking management. However, the quality of life is often enhanced as an outcome of the reduced visibility of scarring that often results from improvements in texture, depth, and pigmentation [3]. However, numerous therapies are accessible; however, each of these treatments has its own disadvantages. The fractional carbon dioxide laser has been successfully utilized for treating scars widely [4]. Fractional CO2 laser apparatus generate controlled micro-wounds in scars, which initiate remodeling response and healing of wound that propels the treated scar tissue toward a more normotrophic state [5]. The goal of this review to assess the safety and effectiveness of fractional carbon dioxide laser either as a monotherapy or combined with other treatments for post traumatic scars.

II. Methodology

Utilizing the following keywords: "post-traumatic scars," "fractional CO2 laser," & "laser therapy for scars," articles (scientific reviews or clinical trials) have been recognized for this review by searching electronic databases such as PubMed & the reference listings of the relevant articles. The search was conducted for articles related to the studied modalities that were published in the period from January 2020 to September 2024. Authors, year of publishing, design of the study, participants included in each trial, age group, type of intervention, laser power, pulse duration, density level and depth level study follow-up duration, clinical response and complications were retrieved from the selected studies.

III. Results and Discussion

Nine studies were found using fractional CO_2 laser, whether used as monotherapy or combined with other therapies in cases having post traumatic scars. Mohamed et al. (2022) performed an investigation that involved twenty cases, four of whom were men and sixteen of whom were women, who were afflicted by scars following burns & post-traumatic atrophic scars. Fractional carbon dioxide Laser was administered to each case on a monthly. For each case, eight sessions have been utilized ablative CO2 fractional laser has been utilized as a monotherapy for the management. All cases were monitored for three months

Received 10th December 2024
Accepted 17th January 2025
Corresponding author: Amal Osama Hadhoud Email: amal.hadhoud@live.com

following the final treatment and achieved optimal outcomes with no recurrence, with an average of six interventions per scar. The clinical response of the cases to therapy and the enhancement of scars were evaluated by comparing photographs taken before and after the last therapy session, which was conducted six months post-treatment. The results of treatment and cases satisfaction have been evaluated on a quartile grading scale & scored individually on a scale of zero to four. The treatment response was excellent in sixty-five percent of cases, very good in fifteen percent of cases, and good in twenty percent of cases. It was determined that fractional carbon dioxide laser is a safe & efficient management for moderate to severe scars following trauma, particularly in younger cases (fifteen to thirty-five years old) with skin type II, without regard for the location of the scar [6].

Sharma et al. (2024) recruited forty-seven cases, who were separated into 3 groups: a post-acne scar group consisting of fourteen cases, a post-burn scar group consisting of seventeen cases, and a post-traumatic scar group consisting of sixteen cases. Detailed histories have been obtained, and clinical examinations have been conducted. Aesthetic results have been assessed utilizing clinical photographs, and the Patient and Observer Scar Assessment Scale (POSAS) has been utilized for recording the total scores of patients and observers at baseline, one, and three months. Each group underwent fractional CO2 laser therapies, which have been conducted every four weeks for a total of 3 consecutive sessions. Post-burn and post- traumatic wounds were treated with fractional carbon dioxide laser treatments utilizing the SmaXel CO2 laser (IDS Ltd., Republic of Korea) with pre-installed settings: energy/dot of 45 millijoules (mJ), pulse duration of 1.9 milliseconds (ms), density level of fifteen, and depth level of one. The most significant distinction has been noticed in the case of facial scars, followed by scars on the neck, and scars on the hand were minimal in both the patient and observer groups. The overall condition of scars was significantly impacted by even a single session of fractional carbon dioxide laser treatments. The quality of scars is enhanced and skin texture is significantly improved by fractional carbon dioxide laser therapy. The treatment is more effective on scars following trauma in comparison with on post-burn and post-acne scars [1]. In a retrospective investigation to assess the effectiveness of fractional ablative carbon dioxide laser for the management of a variety of scars, including those that are not acne scars. Forty-two cases with sixty-seven scars underwent surgery by Maninder et al. in 2022 to investigate the impact of various factors, including skin type, location, shape, duration, and pigment, on the result. Scar types include post-traumatic (43), post-burn (15), post-surgical (5), & post-folliculitis (5). The scars were managed with ablative fractional carbon dioxide laser utilizing the Microxel MX-7000 machine, which operates at 230VAC, single phase, 50/60Hertz, and has a power output of 1–40 W. The power output is 45–60 mJ for superficial atrophic scars and depth level 1, and 70 mJ for hypertrophic scars. The density level was 15 for both varieties, and the pulse duration varied from 1.5 to 3 ms. Fractional laser was administered during each laser session, with a ten percent overlap and two passes. The percentage enhancement and quartile scale were used to grade the enhancement in accordance with the investigator and patient global assessments (IGA & PGA). The ablative fractional carbon dioxide laser has been discovered to be a beneficial modality for non-acne scars in skin of pigment. It enhances the appearance of hypertrophic and atrophic scarring that have occurred after burns and post-traumatic injuries. Post-traumatic scars, scars without hyperpigmentation, scars with a shorter duration (less than six months), and scars with a lighter skin type yielded superior outcomes [3].

In 2024, Osman & Kassab conducted an investigation in which 32 cases who have post-surgical immature and post-traumatic scars (less than 1-year-old) and mature scars (more than 1-year-old) have been categorized into 2 groups based on the age of the scars: group A (fourteen cases with immature new scars) and group B (eighteen cases with mature elderly scars). Group A and B were once again arbitrarily separated into 2 equal groups to receive either Er:YAG or CO2 AFL. The Er:YAG AFL (Fotona Xs dynamics, Slovenia) has been operated with the following parameters: a hand piece PS01, a brief pulse mode (300 microseconds), an energy flux of 800–1000 mJ/cm^2, a spot size of 7 millimeters in diameter, a frequency of five to seven hertz, a pixel size of 250–350 μ, and a density of sixty to seventy pixels. Power ten to fifteen W, dwell time 600 microsecond (μs), spacing 700 micrometers (μm), density level (three to five percent), and smart stack, level 2 were the parameters of the CO2 AFL (Smartxide DOT, DEKA, Italy). Five consecutive Er:YAG and CO2 laser sessions have been carried out on a monthly basis, with a monitoring visit scheduled for three months following the final session. The effectiveness of Er:YAG and CO2 AFL in scar reduction was similar, as demonstrated by their data. Moreover, mature scars yield inferior outcomes when contrasted with infantile scars [7].

Additionally, Meynköhn et al. (2021) conducted a retrospective investigation that included 16 cases with facial lesions. A single session of an ablative, fractional, ultra-pulsed CO2 laser with a wavelength of 10600 nanometers (Ultrapulse®, Lumenis, Dreieich, Germany) has been conducted. The manufacturer's recommendations have been followed in the adjustment of the individual parameters for each scar type. Potential treatment modalities involve the Deep FX mode, the Active FX mode, and the Total FX mode, which is a hybrid of the Deep F and Active FX modes. The Deep FX mode has been utilized to induce production of collagen in the dermis and perform deep fractional ablation. The frequency levels for the Deep FX mode were set to three hundred to four hundred hertz, with energy levels ranging from 15 to 22.5 mJ and density levels of five to fifteen percent. The Active FX mode has been utilized for ablation of superficial scar and to alleviate scar tension. Energy levels of 100-125 mJ and levels of density of one to three percent were established for the Active FX mode, with frequency levels ranging from 100-150 hertz. For combination therapy (Total FX). Twelve cases underwent an additional CO2-AFL session three months later. They have demonstrated that the cases valued the enhancement of scar quality and appearance, which had significant impacts on the cases' quality of life. Additionally,

CO2-laser therapy had a beneficial impact on physician-based scar assessment. The response to CO2-AFL was consistent regardless of the cause, thickness, or maturation of the scar (mature scars aged over two years). Consequently, the concept of facial scar management should encompass CO2-AFL therapy [8].

In the study of Keshk et al., in 2024, thirty patients with single or multiple immature hypertrophic scar (within one year) were included. In the same patient, single or multiple scars were divided randomly into treated areas and control areas. The treated areas were submitted to 5 sessions of fractional carbon dioxide laser combined with long pulsed Nd:YAG laser with one month in between sessions. The control areas did not receive any treatment. The treated areas were subjected to fractional CO_2 10600 nm Laser (D.S.E Seoul, Korea) using a fluence of 40 mj, pulse duration 600 µs, density 5, stack 3, density of dots was 25/cm^2. Shape and size of scanning area was adjusted according to the shape and width of the lesion. Ice cooling was applied immediately after fractional CO_2 laser session. Then after 30 min, long pulsed Nd:YAG 1064 nanometers laser (Fotona XP focus Ljubljana, Slovenia) was applied for the treated area with a fluence of 50 J/cm^2, pulse duration 20 ms, spot size 5 mm, repetition rate 2 HZ and 2 passes on the treated area. Zimmer air cooling system was used during laser session (Zimmer cryo6 air chiller New Delhi). The scar areas treated with combined fractional CO_2 laser and long pulsed Nd:YAG laser showed superior significant clinical improvement with Vancouver Scar Scale (VSS) and POSAS than areas that did not receive any treatment (except for the pigmentation parameter of both VSS and POSAS), especially six months following last treatment. No significant side effects for laser therapy have been noticed [9].

To evaluate the effectiveness of 2 laser-based methods, namely the pulsed dye laser (PDL) and the ablative fractional carbon dioxide laser (AFCL), and their combination in enhancing various aspects of burning scars, irrespective of the type of scar, such as hypertrophic or keloid scars.

A clinical trial was conducted in 2024 by Kivi et al. on cases who were experiencing hypertrophic or keloid burning scars. Three groups of cases have been randomly assigned to receive management with pulsed dye laser alone, ablative fractional carbon dioxide laser alone, or a combination of the two. All cases have been visited prior to and forty days following their most recent treatment session. The combined therapy may be significantly more effective in enhancing the pathological characteristics and appearance of wounds than each individual therapy. This efficacy was predominantly observed in wounds that were immature (less than one year) [10]. Cases were categorized into five categories by Tan et al. (2021), based on the time of the initial laser treatment following injury. Cases who have been treated within one month of their injury comprised the 1st group. The 2nd group of cases received treatment within one to three months of the injury. Cases who received treatment within three to six months of their injury included in the 3rd group. In the fourth group, cases have been treated within six to twelve months of their injury. The last group consisted of cases who were treated more than twelve months after the injury. The AFCL has been established in deep mode with a density range of five to ten percent and an energy range of fifteen to thirteen mj. Parameters for peripheral mode treatment included a density range of forty percent and an energy range of 70–150 mJ. Depending on the size & shape of the lesion, the light spot's shape and size have been determined. An energy range of 15–30 mJ for the deep mode corresponded to a treatment depth of 550–800 µm. Treatment depths of 50–150 µm were associated with the energy range of 70–150 mJ for the superficial mode. All cases were administered both the superficial and deep modes. The laser's dose was contingent upon the scar's thickness. A greater laser dose was administered to scars with greater height. Ablative fractional carbon dioxide laser therapy was applied to early-stage burn lesions in this research, and both its safety and effectiveness were demonstrated. Laser therapy for burn cases may be most effective when administered within one month of injury. As objective modalities, durometry and colorimetry were effective in evaluating wounds [11].

In order to assess the effectiveness of a CO2 laser in hypertrophic scars, Won et al. (2022) utilized its low-energy mode on cases under the age of twelve. The two extremities of each hypertrophic scar have been randomly separated to the control and experimental groups, while the center portion has been deemed a transition zone and wasn't analyzed. Each hypertrophic scar has been separated into three equal parts. A Fractional carbon dioxide Skin Resurfacing System (Alma Lasers) with a pixel 7 × 7 hand piece has been utilized to administer a total of 3 laser treatments at 1-month intervals. The energy level was set to 30 mJ/pixel (low) for one to two cycles with a density of five percent, and the anesthetic, SR, was selected as the mode. In a pediatric population, hypertrophic lesions were enhanced by low-energy CO2 fractional laser therapy. Consequently, a low-energy CO2 laser that causes less procedure pain might be more suitable for kids with hypertrophic scars [12].

IV. Conclusion

In the hands of an appropriately trained practitioner, Fractional carbon dioxide laser exhibits excellent safety and effectiveness in treatment of post traumatic scars. Using more than one modality of treatment can give better and faster results. The change in laser power, pulse duration, density and depth level affects the treatment of different scars. A greater laser dose was administered to scars with greater height, while atrophic scars required lower laser doses. Early intervention shows better results. Thus, we hope fractional CO_2 laser becomes more widely available to cases with scars. Additional research is required to verify its long-term effectiveness and the optimal protocol of treatment, particularly when utilized in conjunction with other modalities. The optimal implementation of these treatments in clinical practice for management of scars will be facilitated by a more comprehensive understanding.

Conflict of interest: None.

Funding: Not applicable.

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