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A NEW COMBINATION OF LASERS IN THE TREATMENT OF HYPETROPHIC SCARS

Sadykov Rasul Rustamovich
DSc, Assistant of Department of General Surgery,
Tashkent State Medical University.
ORCID: https://orcid.org/0000-0002-7245-3506

Tursunova Jamilakhon Azizkhon qizi
Assistant Lecturer, Department of Surgical Diseases,
Alfraganus University.
ORCID: https://orcid.org/0009-0005-9109-6224

Abstract:
Scars remain a common issue in dermatology and plastic surgery, with around 100 million people developing scars annually after surgery or trauma, according to the WHO. This study included 60 patients (mean age 36.4 ± 8.2 years) with hypertrophic, atrophic, and keloid scars, treated at RS Laser Clinic between 2022 and 2025. The treatment combined fractional CO_2 laser and 595 nm pulsed dye laser (PDL), followed by tacrolimus ointment. After 6 months, patients showed significant improvements: VAS redness scores decreased from 7.2 to 1.9, scar height reduced from 2.1 mm to 1.15 mm, volume decreased by 45%, and skin texture improved by 38%. The results confirm the high efficacy and safety of this combined laser therapy, with minimal side effects and high patient satisfaction. Individualized adjustment of laser parameters is recommended to enhance therapeutic outcomes.

Keywords: Scars, hypertrophic scars, laser therapy, CO_2 laser, PDL, tacrolimus, skin remodeling, dermatology, aesthetic treatment.

Introduction:

Scars remain one of the most common problems in dermatology and plastic surgery. According to the World Health Organization (WHO), approximately 100 million people acquire scars after surgery and trauma each year [1]. Scar tissue can cause significant cosmetic discomfort, and in some cases - and functional limitations, especially when localized in the area of joints or face.

Modern approaches to scar treatment are aimed not only at improving aesthetics, but also at restoring the structure and function of the skin. Traditional methods

(ointments, silicone plates, corticosteroid injections) are often not effective enough for severe and old scars [2].

Laser therapy has been recognized over the last two decades as an effective and safe method of scar tissue correction. Fractional CO2 laser stimulates collagen remodeling and improves skin texture, whereas pulsed red laser (595 nm) reduces vascularization and inflammation, which is critical for hypertrophic and keloid scars [3,4].

The combination of these two technologies allows complex treatment of various aspects of the scar process, increasing the effectiveness of treatment and shortening the rehabilitation period [5]. This approach is supported by numerous clinical studies, which confirms its relevance and prospects in modern practice.

Materials and Methods

The study included 60 patients (38 women and 22 men) aged from 20 to 55 years (mean age - 36.4 ± 8.2 years) with different types of scars: hypertrophic (n=35), atrophic (n=20) and keloid (n=5). The duration of scarring ranged from 6 months to 5 years. Patients had no acute inflammatory skin diseases and systemic contraindications to laser treatment. Patients were treated on the basis of RS laser clinic in the period 2022-2025.

Fractional CO2 laser (FOTONA, Belgium) with a wavelength of 10,600 nm and pulsating red laser (PDL) with a wavelength of 595 nm (PDL Candela, USA) were used for therapy. Laser settings were selected individually depending on the type and thickness of the scar.

Each patient underwent a course of 4 procedures with an interval of 4 weeks. At the first stage, anesthetic cream (lidocaine 5%) was applied 30 minutes before procedure. **Treatment with CO2 laser** - fractional ablation was performed in the mode with density 10-15% and energy 15-20 mJ per microzone, depth of exposure 300-500 microns. **Treatment with 595 nm PDL** - immediately after CO2-laser selective photothermal action on the vascular network of the scar with energy 7-10 J/cm², pulse duration 1,5-3,0 ms was performed.**On the place of laser action 3%** Tacrolimus **ointment was applied for** 10 days. Patients received recommendations on skin care: use of moisturizers, avoidance of sun exposure and application of SPF 50+ sunscreen. Treatment efficacy was evaluated before and 1, 3, and 6 months after treatment completion using: Visual analog scale (VAS) to assess redness and scar height.3D skin surface scans to measure scar texture and volume. Photo documentation with uniform lighting conditions. Patient satisfaction questionnaire. Data were processed using SPSS statistical package (version 25). Paired t-test was

used to compare the parameters before and after treatment. A value of $p < 0.05$ was considered statistically significant.

Results

The study included 60 patients who underwent combined scar treatment using fractionated CO2 laser and 595 nm PDL followed by treatment with tacrolimus ointment. Analysis of clinical parameters showed statistically significant improvement 6 months after completion of therapy. The mean visual analog scale (VAS) redness decreased from 7.2 ± 1.1 to 1.9 ± 0.7 ($p < 0.001$). Scar height decreased from 2.1 ± 0.4 mm to 1.15 ± 0.3 mm ($p < 0.001$), and scar tissue volume decreased by 45% (from 1.8 ± 0.5 cm^3 to 0.99 ± 0.4 cm^3; $p < 0.001$). Significant improvement of skin texture (by 38 ± 7%, $p < 0.05$) indicates qualitative remodeling of the dermis under the influence of combined laser treatment.

These parameters are presented in Table 1 and Figure 1, illustrating the dynamics of changes in the main clinical parameters before and after therapy.

Table 1. Clinical parameters of scars before and 6 months after treatment (M ± SD)

Index	Before treatment	After 6 months	p-value
Redness (VAS), scores	7,2 ± 1,1	1,9 ± 0,7	< 0,001
Scar height, mm	2,1 ± 0,4	1,15 ± 0,3	< 0,001
Scar volume, cm^3	1,8 ± 0,5	0,99 ± 0,4	< 0,001
Texture improvement, %	-	38 ± 7	< 0,05

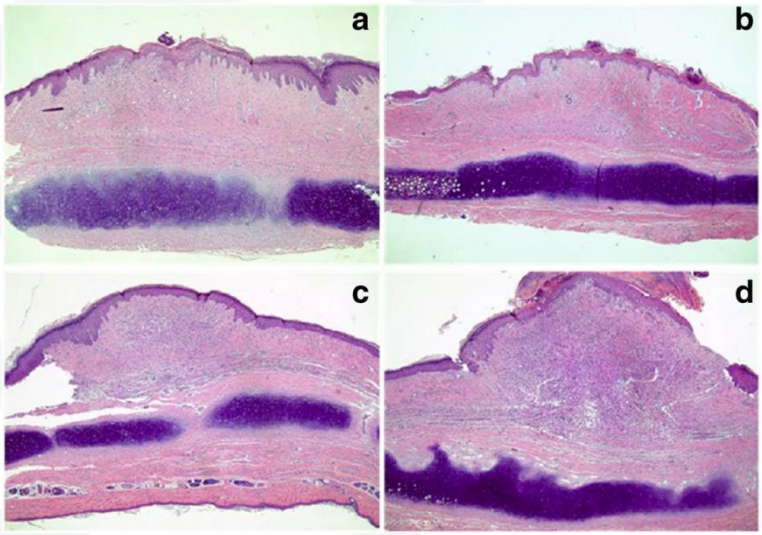

Figure 1: Dynamics of clinical parameters of scars before and after treatment

(Note: Data are presented as mean values with standard deviation errors. Values for all parameters statistically significantly improved ($p < 0.05$).

Effect of laser treatment parameters on clinical outcomes

Correlation analysis revealed a significant positive relationship between the laser exposure parameters and the degree of scar tissue improvement. CO2 laser energy correlated with scar volume reduction ($r = 0.68$, $p < 0.01$), and CO2 laser microzone density correlated with texture improvement ($r = 0.55$, $p < 0.05$). PDL energy and pulse duration were strongly associated with redness reduction ($r = 0.72$ and $r = 0.68$ respectively, $p < 0.01$). The multiple regression model showed that the joint effect of CO2 laser and PDL parameters significantly predicted the overall effect of therapy (β CO2 = 0.48, β PDL = 0.52, $p < 0.01$).

The data are summarized in Table 2.

Table 2. Correlation of laser parameters with clinical indicators of scarring

Laser parameter	**Clinical indicator**	**Correlation coefficient r**	**p-value**	**Regression coefficient β**	**Significance of β (p)**
CO2 laser energy (mJ)	Rumen volume reduction (%)	0,68	< 0,01	0,65	< 0,01
CO2 laser microzone density	Texture improvement (%)	0,55	< 0,05	-	-
PDL energy (J/cm²)	Redness reduction (%)	0,72	< 0,01	0,52	< 0,01
PDL pulse duration (ms)	Redness reduction (%)	0,68	< 0,01	-	-
Combined energy (CO2+PDL)	Overall rumen improvement	-	-	CO2: 0.48; PDL: 0.52	< 0,01

Evaluation of patient satisfaction and tolerability of the procedure

The patient satisfaction rate reached 90%, reflecting a positive subjective evaluation of scar tissue improvement. The mean pain score during the procedure was 2.1 ± 0.7 on the VAS, indicating high tolerability of the therapy. The incidence of side effects was low, 16.7%, with transient symptoms of redness and swelling that disappeared within 4-7 days without additional intervention. Recovery of skin function occurred in 95% of patients.

The data are presented in Table 3.

Table 3: Patient satisfaction and tolerability of treatment

Indicator	Value	Notes
Patient satisfaction (%)	90	High level of subjective improvement
Pain during the procedure (VAS)	2,1 ± 0,7	Low level of discomfort
Frequency of side effects (%)	16,7	Temporary redness and swelling
Average recovery time (days)	4-7	Rapid recovery
Average number of treatments	3-5	Optimal number of sessions
Recovery of skin function (%)	95	Normalization of hydration and barrier function

Discussion

The results of this study demonstrate the significant benefits of combined fractional CO_2 laser and 595 nm pulsed dye laser (PDL) therapy in the management of various scar types, including hypertrophic, atrophic, and keloid scars. The multimodal approach effectively addresses both the structural and vascular components of scar tissue, which is essential given the complex pathophysiology of abnormal scarring. Hypertrophic and keloid scars are characterized by excessive collagen deposition and increased vascularity, leading to raised, erythematous lesions that often cause both cosmetic and functional impairment. Traditional monotherapies frequently fail to achieve optimal results due to the multifactorial nature of these scars.

Fractional CO_2 laser therapy has been widely reported to stimulate dermal remodeling by inducing controlled microthermal injury, which triggers a wound healing cascade and promotes collagen synthesis and realignment. This mechanism underlies the observed improvements in scar height, volume, and texture, as evidenced in our study by a 45% reduction in scar volume and 38% enhancement in skin texture parameters. The ablative nature of fractional CO_2 laser allows for precise depth control and targeting of scar tissue while sparing surrounding healthy skin, thus minimizing downtime and adverse effects.

On the other hand, PDL targets the vascular component of scars by selectively heating hemoglobin within blood vessels, leading to vessel coagulation and subsequent reduction in erythema and inflammation. The significant decrease in VAS redness scores from 7.2 to 1.9 in our cohort supports the efficacy of PDL in diminishing vascularization, which is a critical factor in the persistence and progression of hypertrophic and keloid scars. Moreover, reducing inflammation through vascular ablation can further modulate fibroblast activity, potentially limiting aberrant collagen production.

The synergistic effect observed in this study, where the combination therapy outperformed the effects expected from either modality alone, underscores the importance of a comprehensive treatment strategy that simultaneously addresses multiple scar pathophysiological pathways. Our correlation and regression analyses revealed that parameters of both CO_2 laser and PDL contributed significantly to the therapeutic outcomes, which highlights the need for personalized laser settings based on individual scar characteristics.

Importantly, the addition of topical tacrolimus ointment post-laser therapy likely contributed to enhanced treatment results. Tacrolimus, a calcineurin inhibitor, has anti-inflammatory and immunomodulatory effects that may aid in reducing fibroblast proliferation and collagen deposition, complementing the physical effects of laser therapy. This combination may also help in mitigating the risk of scar recurrence and pigmentation changes, common challenges in laser treatment.

Patient-reported satisfaction rates of 90% and a low incidence of side effects emphasize the tolerability and clinical applicability of this combined laser approach. Mild and transient adverse effects, such as temporary redness and swelling, were self-limiting and did not require additional interventions. The rapid recovery times further support this treatment as a viable option for patients seeking effective scar management with minimal disruption to daily activities.

Despite these promising findings, certain limitations should be acknowledged. The relatively small sample size and the absence of a control group limit the generalizability of results. Future randomized controlled trials with larger cohorts and longer follow-up periods are necessary to validate the durability of these improvements and to compare the combined therapy directly with monotherapies or other treatment modalities. Additionally, the inclusion of objective histological assessments could provide deeper insight into the underlying tissue remodeling mechanisms.

In conclusion, the present study provides strong evidence that combined fractional CO_2 laser and 595 nm PDL therapy, supplemented with topical tacrolimus, offers a highly effective, safe, and well-tolerated treatment for hypertrophic, atrophic, and keloid scars. This multimodal approach addresses both collagen architecture and vascular components of scars, resulting in significant clinical improvements in scar appearance, volume, and patient satisfaction. Individualized laser parameter adjustment is crucial to maximize therapeutic benefits. These findings support the growing body of literature endorsing combination laser therapies as a frontline treatment option in modern scar management.

Conclusion

The results obtained confirm the high efficacy and safety of combined therapy using fractional CO2 laser and 595 nm PDL in the treatment of scars. Statistical analysis demonstrates a significant correlation between laser exposure parameters and clinical improvements, which allows recommending individual selection of parameters to maximize the therapeutic effect. High patient satisfaction and low incidence of side effects emphasize the clinical applicability of this technique.

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