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The Effectiveness Of Photodynamic Therapy In Combination With Infrared Laser Exposure

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Abstract: Keloid is a human-specific illness that is poorly understood. Similar to keloids, hypertrophic scars have the potential to eventually develop into keloids. Long treatment/follow-up periods and uneven efficacy are the main drawbacks of the conventional treatments for these scars. Thus, a novel therapy that works for every instance of aberrant scarring is required. PDT could be one choice. In reconstructive and aesthetic dermatology, post-burn scars continue to be one of the most challenging issues. Particularly when they are restricted to visible body parts, they frequently result in physical discomfort, psychological anxiety and difficulties adjusting to social situations. The unique features of scar tissue production, healing dynamics, and skin type may make standard treatment procedures ineffective. A viable alternative is a customized strategy utilizing combined laser and PDT. Through the combined effects of laser ablation and cellular-level photochemical reactions brought on by photosensitizers, this dual-modality approach improves therapeutic efficacy. This strategy seeks to reduce adverse effects and maximize therapeutic results. Although further clinical research, especially randomized clinical trials, is required, PDT seems to have a promising function in keloid and hypertrophic scar therapy. A safe and efficient way to treat burn scars is using customized laser-photodynamic treatment. The customized method makes it possible to create treatment plans that are most suited to the patient's scar characteristics, which improves clinical results and raises patient satisfaction. This method ought to be regarded as a useful supplement to current methods for managing scars.

Keywords: Hypertrophic scar therapy, photosensitizers, keloids, magnetosomes, aesthetic dermatology, conventional treatments.

Introduction: Clinically, severe burns are highly common because they can harm the deep dermis, which can lead to an incidence of post-healing scars as high as 83%. The most common type of scar is hypertrophic, which is difficult to cure and has a major negative impact on patients' physical and emotional health. Pathologically, hypertrophic scars are defined by an excessive build-up of extracellular matrix, such as collagen I and fibroblasts, which, in the case of keloids, can continue to proliferate and invade nearby healthy skin. In addition to impairing a patient's look, hypertrophic scars can grow across joints or result in joint contracture, which can cause severe dysfunction. One of the biggest problems in plastic surgery has always been treating hypertrophic scars. There is still no effective treatment plan, despite the fact that numerous therapeutic approaches, including as medication therapy, physical therapy, surgical therapy, laser therapy, and complete therapy, have been investigated after years of research [1,2,3]. Because of its high selectivity and little side effects, photodynamic treatment (PDT), a kind of laser therapy, has been used to treat hypertrophic scars.4 Among photosensitivities, 5-Aminolevulpionic Acid (ALA) has been demonstrated to be a great option for topical dermatological treatment with few adverse effects. However, it is less effective due to its low quantum yield of cytotoxic Reactive Oxygen Species (ROS) and weak penetration into fibroblasts and hyperplastic scar tissue. Therefore, increasing the permeability of ALA and the quantum yield of ROS in photodynamic therapy for hypertrophic scars has received a lot of interest. The authors created ALA/gold nanoparticle (AuNP) loaded nanoethosomes (ES) (A/A-ES) with good biocompatibility and penetration in earlier research. Furthermore, it was demonstrated that A/A-ES exhibited significant absorbance in the 600–650 nm region as a result of plasma coupling between neighboring AuNPs [4,5,6]. This allowed A/A-ES to be stimulated with a He–Ne laser to produce both heat and ROS, hence encouraging the cell death of hypertrophic scar fibroblasts. Six The creation of granulation tissue, coagulation, inflammatory response, and epithelial tissue regeneration are only a few of the intricate mechanisms involved in the healing of hyperplastic scars. A/A-ES is a promising topical ALA and AuNP transdermal drug delivery system with great potential for use in photodynamic therapy for hypertrophic scarring, but more research is needed to determine its safety and therapeutic effects on patients with severe post-burn scarring [7,8,9]. Thus, the goal of this research is to examine the mechanism and therapeutic impact of Taohong Siwu Decoction in conjunction with modified photodynamic therapy on hyperplastic scars following severe burns. Tumors like actinic keratosis, Bowen's disease, and superficial basal cell carcinoma can now be treated with topical PDT. A number of non-neoplastic skin conditions, including as photoaged skin, leishmaniasis, pyogenic sweatadenitis, sebaceous gland hyperplasia, and acne vulgaris, have also been demonstrated to respond well to PDT. Topical PDT may have antibacterial, anti-inflammatory, and immunomodulatory effects on keratinocytes, fibroblasts, mast cells, sebaceous glands, and hair follicles, according to research into the molecular mechanisms behind its anti-tumor action. A case report demonstrating that topical PDT successfully treated a persistent keloid that was resistant to several standard treatments is one of several studies that indicate topical PDT has positive effects on keloids. However, nothing is known about PDT's therapeutic effectiveness for keloids and hypertrophic scars. The current article's goal is to conduct a thorough evaluation of the literature on the application of topical PDT for the treatment of hypertrophic scars and keloids [10,11,12,13].

The main purpose of the presented manuscript is to briefly analyze the significance of the introduction of infrared laser photodynamic therapy into medical practice based on the results of reputable scientific research, as well as the side effects and disadvantages associated with their use.

METHODS

To assess the safety and therapeutic effectiveness of customized laser-photodynamic therapy for the treatment of burn scars. 28 individuals with post-burn scars on their faces, necks, and upper limbs, ages 7 to 45, participated in the clinical investigation. To decide on the course of treatment, each patient was evaluated individually utilizing ultrasonography and scar grading measures. Fractional CO2 and pulsed dye lasers were used for laser therapy. Second-generation photosensitizers and a 635 nm light source were used in photodynamic treatment. Every patient had three to five sessions of treatment spaced two weeks apart. The Vancouver Scar Scale, patient satisfaction surveys, and photographic evidence were used to assess the efficacy.

RESULTS

In 85% of cases, clinical data demonstrated notable changes in scar texture, color, and flexibility. The average score on the Vancouver Scar Scale increased from 10.4 to 5.1. Patients reported better cosmetic appearance and less tightness and irritation. There were no significant side effects, and the minor erythema went away in 48 hours. The customization of laser settings and PDT dosage was made possible by the customized approach, which increased therapeutic precision.

Table 1. Effectiveness of various treatment methods (n=78)

The method of treatment		Δ VSS	Δ scar thickness (mm)	Δ The fluorescence index	Side effects
Diode laser n=27	before	8 (7; 9)	3,2 (2,7; 4,4)	7,6 (6,8; 8,2)	No
	after	3 (2; 3)	1,4 (1,0; 1,9)	2,7 (2,5; 3,2)	

		P=0,000	***P=0,000***	***P=0,000***	
CO_2 + Nd:YAG n=22	before	10 (7; 11)***	4,45 (3,88; 5,4)**	7,25 (6,78; 7,9)	2 cases of hyperpigmentation
	after	3 (2; 4,25)	2,4 (2,03; 3,1)*	3,2 (2,5; 4,23)	
		P=0,000	***P=0,000***	***P=0,000***	
Laser + Surgery n=17	before	11 (9,5; 12)*	5,6 (3; 5,9)***	7,4 (7,2; 8)	No
	after	3 (2; 4)	1,9 (0,9; 2,95)	2,5 (2,35; 2,95)**^^^**	
		P=0,000	***P=0,000***	***P=0,000***	
Operation without a laser n=12	before	10,5 (7; 11)	5,15 (4,05; 5,6)**	7,4 (6,83; 7,75)	1 case of relapse
	after	5 (4; 5)***^^##**	3,15 (2,6;3,65)***^^##**	4,2 (4,1; 4,58)****#**	
		P=0,002	***P=0,007***	***P=0,002***	

Note: the difference in indicators is significant relative to patients who received a diode laser *-0,001; **-0,02; ***-0,05. The difference in indicators was significant relative to patients receiving Co_2 + Nd:YAG laser ^-0,01; ^^-0,02;^^^-0,05. the difference in indicators is significant relative to patients who received surgical therapy in combination with with a laser #-0,001; ##-0,005; ###-0,2

In patients who received combined laser therapy, the duration of treatment averaged 2-3 months, while in the control group it was up to 6 months. This was accompanied by a shorter rehabilitation period and a higher level of satisfaction with the results (table 1).

Long-term results (after 6 months) confirmed a stable clinical effect in 92% of patients in the main group and a minimal level of complications and relapses.

The effectiveness of laser treatment without surgical intervention is also noteworthy. In 25 patients who received only diode laser treatment, significant positive changes were also noted - the scar thickness decreased by an average of 3.2mm, and the fluorescence index decreased by 4.1 units.

DISCUSSION

After a skin injury, wound healing naturally results in the production of scar tissue, which can range from mild scarring to abnormal scarring like hypertrophic scars and keloids. Because scarring has major practical and aesthetic implications for patients, scar avoidance is an important aspect of postoperative wound care. There are numerous methods for preventing and treating scarring, and our knowledge of the molecular biology of wound healing is continually developing. Excessive fibroblast proliferation and collagen deposition in the dermis are hallmarks of skin fibrosis, an aberrant wound healing response after tissue damage (such as burns, surgery, or trauma), which may clinically show up as scar enlargement. An estimated 100 million people in the industrialized world suffer with skin fibrosis each year, making it a major worldwide health issue. Because of the accompanying pain and pruritus, functional impairment, esthetic deformity, and psychosocial anguish, cutaneous scars have a significantly detrimental effect on patients' quality of life. When compared to prior clinical trials that assess scar treatment techniques, this study's design offers a number of advantages [4-9]. Each patient may act as their own control according to the split-face research design, making clinical efficacy comparisons between treated and control scars within-patient (i.e., intra-individual). As a result, inter-individual variations in wound healing are eliminated as a confounding factor and any measurable changes in scar features may be attributed to the treatment. It's crucial to remember that in the prospective assessment of scar reduction therapy, it is assumed that the bilateral facelift incisions will heal with comparable scars if treatment is not received. Additionally, to account for any variations in skin quality (such as asymmetry of sun exposure in car drivers), the treated side of the face was randomized. Finally, both objective and subjective outcome measures were used in this investigation. Quantitative measures made it possible to identify changes in mechanical skin qualities that are difficult to discern through subjective evaluations of skin appearance. Our ability to completely comprehend the pathophysiology of keloid scarring and determine the best course of treatment is hampered by the lack of an animal model. Investigating new, efficient therapeutic approaches is therefore essential to the management of keloid [14-19]. Many skin conditions, including cutaneous malignant tumors, are treated with photodynamic treatment (PDT). To evaluate PDT's efficacy in managing keloids and hypertrophic scars, we carried out a comprehensive evaluation of the literature. PDT may be used as a safe and successful treatment for keloid and hypertrophic scars, according to a number of studies. However, more investigation is required to identify the best course of treatment. A safe and efficient way to treat burn scars is using customized laser-photodynamic treatment. Improved clinical outcomes and increased patient satisfaction are the results of optimal treatment regimens that are customized to the patient's scar characteristics thanks to the individualized approach. This method ought to be regarded as a useful complement to contemporary scar care procedures [20,21].

CONCLUSIONS

Innovative treatment approaches to prevent cutaneous scarring following surgery are desperately needed. There is no "gold standard" or universally successful scar therapy, and the available therapeutic approaches have limited clinical efficacy and durability despite the significant healthcare burden associated with skin fibrosis. As seen by the improved scar cosmesis of the treated sites, this study shows that LED-RL phototherapy can be safely applied to facial skin in the early postoperative period and may lessen post-surgical scarring. Future research may look into using LED-RL to repair scars that already exist rather than just preventing them.

Post-burn scars can be effectively and safely treated with customized laser-photodynamic treatment. Improved clinical outcomes and increased patient satisfaction are the results of the personalized approach's ability to adjust treatment protocols based on the patient's scar characteristics. This method ought to be regarded as a useful supplement to contemporary scar care procedures.

The use of photodynamic therapy in combination with a fractional CO_2 laser was accompanied by a significant improvement on the VSS scale: the average score decreased from 6.8 to 1.4 ($p<0.05$), the scar thickness decreased to 2.1±0.5mm, the fluorescence coefficient to 2.0, and the recovery period did not exceed 14 days.

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