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BRIEF REPORT

Integrated cooling-vacuum-assisted 1540-nm erbium:glass laser is effective in treating mild-to-moderate acne vulgaris

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Abstract Acne treatment by a mid-infrared laser may be unsatisfactory due to deeply situated acne-affected sebaceous glands which serve as its target. Skin manipulation by vacuum and contact cooling may improve laser-skin interaction, reduce pain sensation, and increase overall safety and efficacy. To evaluate the safety and efficacy of acne treatment using an integrated cooling-vacuum-assisted 1540-nm erbium:glass laser, a prospective interventional study was conducted. It included 12 patients (seven men and five women) suffering from mild-to-moderate acne vulgaris. The device utilizes a mid-infrared 1540-nm laser (Alma Lasers Ltd. Caesarea, Israel), which is integrated with combined cooling-vacuum-assisted technology. An acne lesion is initially manipulated upon contact by a vacuum-cooling-assisted tip, followed by three to four stacked laser pulses (500–600 mJ, 4 mm spot size, and frequency of 2 Hz). Patients underwent four to six treatment sessions with a 2-week interval and were followed-up 1 and 3 months after the last treatment. Clinical photographs were taken by high-resolution digital camera before and after treatment. Clinical evaluation was performed by two independent dermatologists, and results were graded on a scale of 0 (exacerbation) to 4 (76–100 % improvement). Patients' and physicians' satisfaction was also recorded. Pain perception and adverse effects were evaluated as well. All patients demonstrated a moderate to significant improvement (average score of 3.6 and 2.0 within 1 and 3 months, respectively, following last treatment session). No side effects, besides a transient erythema, were observed. Cooling-vacuum-assisted 1540-nm laser is safe and effective for the treatment of acne vulgaris.

Keywords Acne · Laser treatment · Erbium:glass · Cooling vacuum

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Introduction

Acne vulgaris is a common skin condition affecting billions of individuals worldwide. Its pathogenesis is not fully understood, yet it is primarily a disease of the pilosebaceous unit, postulated to include three main elements: increased sebum production mainly due to hormonal influence, obstruction of follicular openings, and proliferation of *Propionibacterium acnes* (*P. acnes*) [1]. Subsequent inflammation often occurs, leading to the development of inflammatory acne lesions in the form of papules, pustules, nodules, and cysts. Although often a self-limiting condition experienced by teenagers, it is estimated that more than 10 % of the population still experience acne above the age of 30 [2, 3]. Furthermore, scarring is a recognized sequel of acne. The actual extent and incidence of residual scarring remains unknown, yet one study found acne scars in 1 % of adult population [4]. Multiple treatment options exist: topical application of anti-acne agents often have limited efficacy, and systemic treatments carry the risk of substantial side effects.

Visible light and infrared light and laser sources have become common physical modalities in acne treatment. They target the pilosebaceous glands and the *P. acnes* [5, 6]. Since sebaceous glands are mainly situated in the mid-dermis, the depth of penetration of the laser beam is of crucial importance.

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Thus, a laser in the mid-infrared range can target the dermal sebaceous glands, which typically reside about 1000 μm under the stratum corneum.

It is assumed that a laser exerts its beneficial influence on acne by photothermal and photochemical activities: The optical energy heats the water volume encompassing sebaceous glands causing their photothermal destruction, and at the same time, visible light activates endogenous porphyrins of *P. acnes* leading to free radical formation and ultimately to photochemical destruction via a photodynamic reaction destroying the pilosebaceous unit [7–9]. However, limited depth of penetration may prevent both the visible and the mid-infrared laser light to effectuate the desired effect at the pilosebaceous units.

An external vacuum (pneumatic) application combined with mid-infrared laser might increase the depth of penetration by radially stretching the acne-affected skin. A simultaneous cooling of the treated skin might decrease local thermal side effects.

The 1540-nm wavelength laser was already found to have a beneficial effect in acne vulgaris [10–12]. This report describes our preliminary clinical experience with a novel cooling-vacuum-assisted erbium:glass (Er:glass) 1540-nm laser for the treatment of mild-to-moderate acne.

Patients and methods

Patients

Inclusion criteria Patients above the age of 17 years suffer from mild-to-moderate acne vulgaris.

Exclusion criteria Prior treatment with ablative laser, any laser, or photodynamic therapy 3 months prior to enrollment; systemic isotretinoin therapy within 6 months prior to enrollment; topical treatment with alpha hydroxy acids, retinoids products, salicylic acid, or vitamins C and D; or derivatives 14 days prior to enrollment. Pregnancy, age below 17 years, and excessive sun exposure during the course of study were additional exclusion criteria.

Standardized high-resolution digital photography of the treatment area was performed for each patient at baseline, before each treatment, and at 1 and 3 month follow-up visits.

Burton acne (BAS) was used to quantify acne severity [grade 0=no lesions, grade 1=subclinical acne, grade 2=comedonal acne, grade 3=mild acne, grade 4=moderate acne (many inflamed papules and pustules), grade 5=severe nodular acne, and grade 6=severe cystic acne with scarring].

Treatment

Patients were treated using a mid-infrared 1540-nm Er:glass laser (Harmony XL, Alma Lasers Ltd.) receiving four to six treatments with 2-week intervals. The number of treatment sessions was determined by clinical improvement.

Er:glass laser device operates with integrated cooling-vacuum-assisted apparatus which permits retraction of the treated skin area closer to the surface prior to lasing (thus bringing the sebaceous unit and the laser closer to each other) and at the same time activates a continuous contact cooling of the tip (thus protecting the outer skin layers from thermal damage).

The treatment areas were disinfected prior to each treatment. Protective eyewear was utilized during treatments. Treatments were applied to the face, neck, chest, and/or back. Laser settings included spot size 4 mm, fluence of 500–600 mJ/pulse, three to four stacked pulses emitted at a rate of 2 Hz, and up to two passes per treatment session. All settings were pre-adjusted and dependent on patient's tolerability and comfort.

Outcome measures

Clinical evaluation was performed by two independent dermatologists at each office visit and at 1 and 3 months after the last treatment session. Follow-up evaluations included lesion counts of both inflamed and non-inflamed lesions as well as an evaluation of the overall improvement in acne appearance based on a quartile scale of improvement graded as 0 (exacerbation), 1 (1–25 % improvement), 2 (26–50 % improvement), 3 (51–75 % improvement), or 4 (76–100 % improvement).

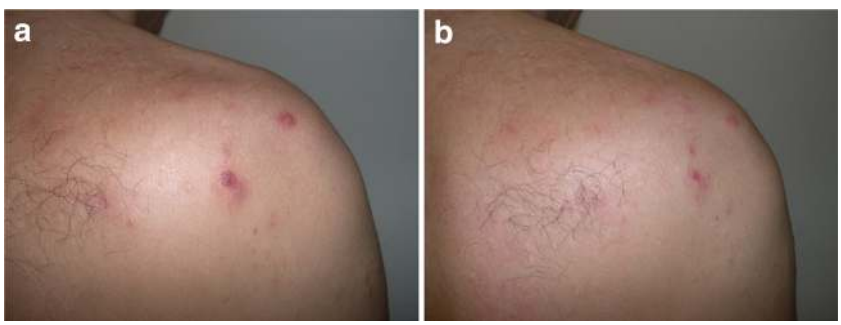

Fig. 1 **a** The right shoulder area of a 19-year-old male patient before treatment. **b** The right shoulder area of a 19-year-old male patient after a single treatment

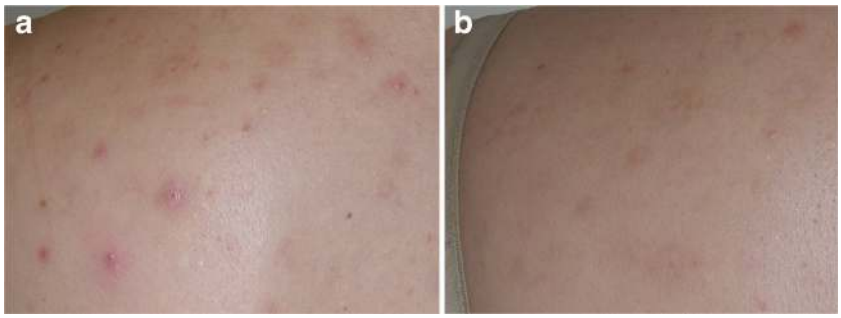

Fig 2 **a** The back of a 23-year-old female patient before treatment. **b** The back of a 23-year-old female patient after a single treatment

Patients' and physicians' satisfaction were assessed as well at the final follow-up visit (graded on a score of 1–5, 1 being not satisfied and 5 being very satisfied).

Pain perception and adverse effects were also appraised: the physician assessed the incidence of post-treatment reactions (including erythema, edema, dyspigmentation, blistering, flaking, dryness, and/or pruritus) using a 0 to 3 grading scale (0=none, 1=mild, 2=moderate, and 3=severe) at each treatment and follow-up visit and recorded any additional side effects (such as bruising).

Results

Twelve subjects (seven male and five female), 17 to 27 years of age (mean age 19±1.6), with Fitzpatrick skin types II to VI were enrolled. All patients had at least 10 (mean 16±5.1) inflammatory and non-inflammatory lesions (mean 12±3.4) at baseline, and their severity was rated as grade 3 and grade 4 (mean 3.6±0.2) using the BAS at their screening visit. All 12 patients completed treatment (four to six sessions, mean=4.6 ±0.4) and follow-up visits at 1 and 3 months after the last treatment session.

Improvement in acne appearance occurred gradually over the course of the treatment sessions; all patients demonstrated moderate to significant improvement (average 3.6 and 2.0 points of improvement on the quartile scale used for outcome assessment), 1 and 3 months following the last session, respectively. Figures 1, 2, 3, and 4 portray representative cases.

Mean lesion count drop per patient was 21.2±3.8 (12.5 and 8.6 for inflammatory and non-inflammatory lesions, respectively).

Patients' self-rated satisfaction was ranged between "satisfied" (four patients) to "very satisfied" (eight patients)—at the final study visit.

Side effects were mild and included slight erythema and edema in all patients that decreased in severity and percentage of affected patients as treatment progressed. No reports of edema were noted at the 1 or 3 month follow-up visits.

Discussion

Previous studies demonstrated intense pulse light (IPL) treatment in the blue range for the treatment of acne, with or without vacuum usage, yet with variable clinical success [13–15]. The efficacy of blue light is modest and variable and results in a 30–60 % reduction in acne lesion count compared to baseline [16–19]. A high-intensity, narrow-band, blue light source (405–420 nm) makes use of the endogenous production of coproporphyrin III and protoporphyrin IX by *P. acnes*. Blue light is effective in the photoactivation of porphyrins, but its clinical efficacy is limited by the poor percutaneous penetration caused by the short wavelength. Furthermore, previous studies with vacuum-assisted mechanism for the treatment of acne vulgaris utilized IPL sources rather than lasers [20, 21].

The pneumatic device is a pulsed light device that utilizes a vacuum apparatus to approximate the skin to the light source,

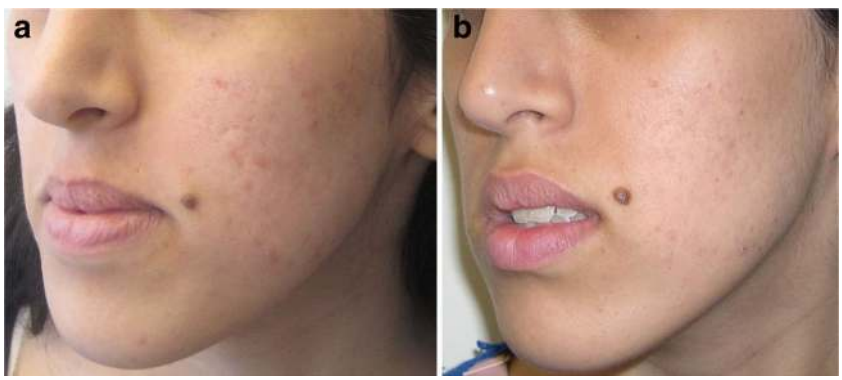

Fig. 3 **a** The face of a 25-year-old female patient before treatment. **b** The face of a 25-year-old female patient 1 month after completing three treatment sessions

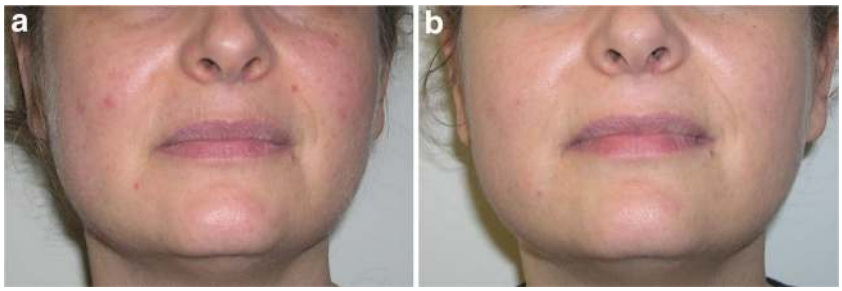

Fig. 4 **a** The face of a 26-year-old female patient before treatment. **b** The face of a 26-year-old female patient 1 month after completing three treatment sessions

thus enabling higher penetration of optical energy without increasing the intensity of the light pulse. The device used for photopneumatic therapy combines suction pressure and broadband pulsed light (400–1200 nm) for the treatment of comedonal and inflammatory acnes. Presumably, the application of negative pressure to the skin surface physically evacuates trapped sebum and necrotic cells. Moreover, the suction stretches the skin within the treatment tip, thereby reducing the concentration of competing chromophores, such as melanin and hemoglobin, so that the light selectively targets the intrinsic *P. acne*-derived porphyrins [12].

Gold et al. [11] in a prospective study of 18 subjects with mild-to-severe acne demonstrated significant reductions in lesion counts for both inflammatory and non-inflammatory acne lesions in 11 patients after a series of four photopneumatic treatments performed at 3-week intervals.

We herein report for the first time the clinical efficacy of an integrated cooling-vacuum-assisted mid-infrared laser (Er:glass 1540 nm) for the treatment of mild-to-moderate acne.

The 1540-nm wavelength is in the mid-infrared part of the spectrum. Due to the high wavelength, deep penetration of photons and thermal energy is accomplished.

The high-absorption coefficiency of the 1540-nm mid-infrared wavelength of the Er:glass by water yields a bulk heating of the dermis, where the sebaceous glands are located.

Epidermal protection with cooling is essential for mid-infrared lasers, as epidermal necrosis and blistering might develop due to non-specific absorption of water. Skin cooling can reduce the side effects without decreasing the energy utilized, thus enhancing the clinical efficacy of lasers. It should be noted that bulk cooling methods have been previously proved unsuccessful in improving the clinical outcome, probably because they acted non-selectively by cooling not only the epidermis but also the end target, leading to a reduction in laser-induced thermal damage [22].

Therefore, the good clinical improvement seen in our study might be explained by the synergistic effects of the vacuum-assisted and continuous contact cooling that enable epidermal protection without compromising the energy quantity generated, thus facilitating targeting of deep-situated acne lesions.

The data demonstrated a gradual and significant improvement in acne appearance over the course of treatment, with concomitant reduction in inflamed and non-inflamed lesion counts. Treatment discomfort was negligible to minimal for all subjects with minimal severity of post-treatment skin responses.

Conclusions

Our study demonstrates the efficacy and safety of the integrated cooling-vacuum-assisted 1540-nm erbium:glass laser for the treatment of mild-to-moderate acne.

Further studies with more participants and longer follow-up periods are due in order to establish long-term effectiveness.

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Compliance with ethical standards

Conflict of interest None.

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