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ORIGINAL ARTICLE

In vivo animal histology and clinical evaluation of multisource fractional radiofrequency skin resurfacing (FSR) applicator

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Abstract

Objective. Acne scars are one of the most difficult disorders to treat in dermatology. The optimal treatment system will provide minimal downtime resurfacing for the epidermis and non-ablative deep volumetric heating for collagen remodeling in the dermis. A novel therapy system (EndyMed Ltd., Cesarea, Israel) uses phase-controlled multi-source radiofrequency (RF) to provide simultaneous one pulse microfractional resurfacing with simultaneous volumetric skin tightening. *Methods.* The study included 26 subjects (Fitzpatrick's skin type 2–5) with moderate to severe wrinkles and 4 subjects with depressed acne scars. Treatment was repeated each month up to a total of three treatment sessions. Patients' photographs were graded according to accepted scales by two uninvolved blinded evaluators. *Results*. Significant reduction in the depth of wrinkles and acne scars was noted 4 weeks after therapy with further improvement at the 3-month follow-up. *Conclusion.* Our data show the histological impact and clinical beneficial effects of simultaneous RF fractional microablation and volumetric deep dermal heating for the treatment of wrinkles and acne scars.

Key Words: *lasers and light sources, new technologies, fractional devices*

Introduction

Skin resurfacing has been used for medical and aesthetic purposes for more than 100 years. Ablating the skin removes the upper layer of the skin, allowing the natural mechanism of renewal to form a new layer of healthier and better-looking skin after the procedure. Skin resurfacing can be performed using mechanical devices (dermabrasion), chemical peeling compounds, lasers and radiofrequency (RF) devices. Full surface resurfacing by chemical peels, mechanical dermabrasion or pulsed carbon dioxide (CO_2) laser devices are considered to be very effective treatment options for skin resurfacing (1). However, these full-face procedures are usually quite painful and involve considerable downtime. The concept of fractional skin resurfacing (FSR) using laser devices was developed to address the shortcomings of ablative and non-ablative device modalities (2–4). These systems perform ablation on small microscopic 'dots' of skin, allowing rapid healing with minimal pain and downtime. Although fractional ablation of the epidermis can be achieved with various types of laser systems, the amount of dermal volume that is heated by these lasers is very limited (5–7%). RF devices have been used for many years by dermatologists for focused or larger surface ablation of skin. A fractional RF system allowing simultaneous microablation of 64 microscopic 'dots' was shown to be safe and effective for skin resurfacing and the reduction of wrinkles (5).

In the current study, we examined a novel technology, the FSR applicator. The EndyMed PRO System is an FDA-cleared computerized system that generates pulses of RF energy, which are emitted into the skin, causing a non-ablative deep dermal heating effect, resulting in skin tightening. In addition to the effect of skin tightening, RF energy can be used for ablative treatments, for skin resurfacing. The FDA-cleared FSR handpiece contains a matrix of 112 tiny RF electrodes, allowing for the first time, simultaneous fractional microablation of the epidermis together with volumetric heating of 100% of the dermis. This technology provides the capability to differentiate between microablation and dermal heating, which appears to

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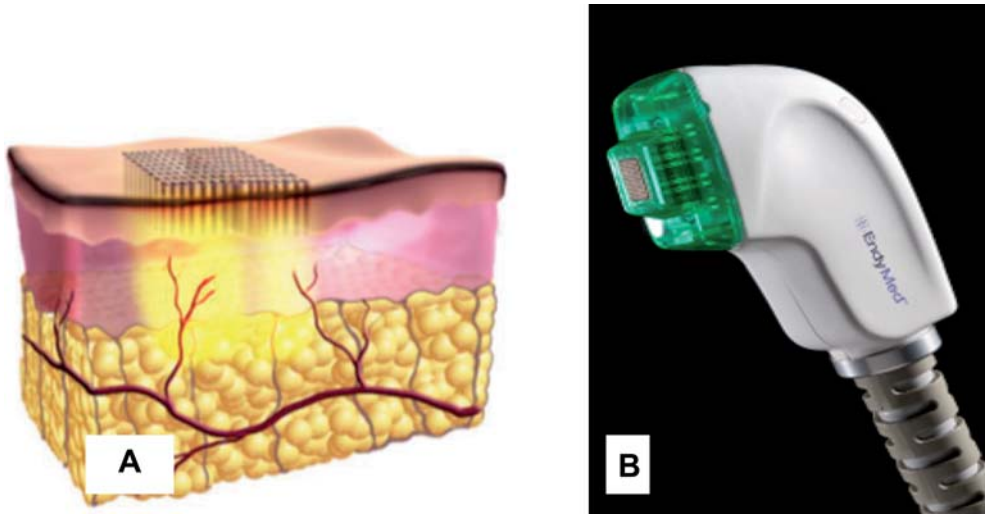

Figure 1. (A) 3DEEP fractional RF skin resurfacing (FSR) technology allowing simultaneous fractional ablation of epidermis and deep volumetric non-ablative dermal heating. (B) FSR handpiece; 112 contact points (300 μm).

be the optimal multilayer treatment to affect aged skin and atrophic acne scars (Figures 1 and 2).

The present study was conducted in order to evaluate the efficacy and safety of the FSR applicator of the EndyMed Pro System for skin resurfacing. This report describes the cumulative results of 30 patients who completed the facial wrinkle and acne scar improvement treatments.

Methods

In vivo animal study

After ethics committee approval, one female pig (Type Large white X Landrace, 15 kg) was chosen for the study. The subject was anesthetized using ketamin, xylazin and isofluran. To simulate human treatment protocol, Emla cream was applied to the animal skin for 30 min and wiped with a moistened gauze pad. The EndyMed PRO FSR handpiece was used for treatment at multiple energy setting (62, 40 and 20 mJ/pin). Immediately after the treatment, 3 days after the treatment and 14 days after the treatment, 4-mm punch biopsies were harvested for histological analysis. Skin samples were fixed in formalin solution (10%) and then processed with H&A and examined microscopically by a board-certified dermatologist.

Clinical study

The study included 26 subjects (23 females and 3 males, ages 28–71, mean age 55 years) with moderate to severe wrinkles (WES), Fitzpatrick skin type II–V and 4 subjects (3 females and 1 male, ages 23–40, mean age 33.7 years for a total of 30 patients.

Patients were assessed by two independent board-certified dermatologists at baseline and 1 month after the end of the treatment sessions by photographic analysis and improvement. All 30 patients (4 male, 26 female), ages 23–71 years (average 51.9 ± 14.1), were enrolled in the study after meeting all inclusion/exclusion criteria and providing a signed informed consent form.

Prior to the FSR treatment, the treated areas was assessed visually as to skin relevant parameters and photographed in a standardized method using

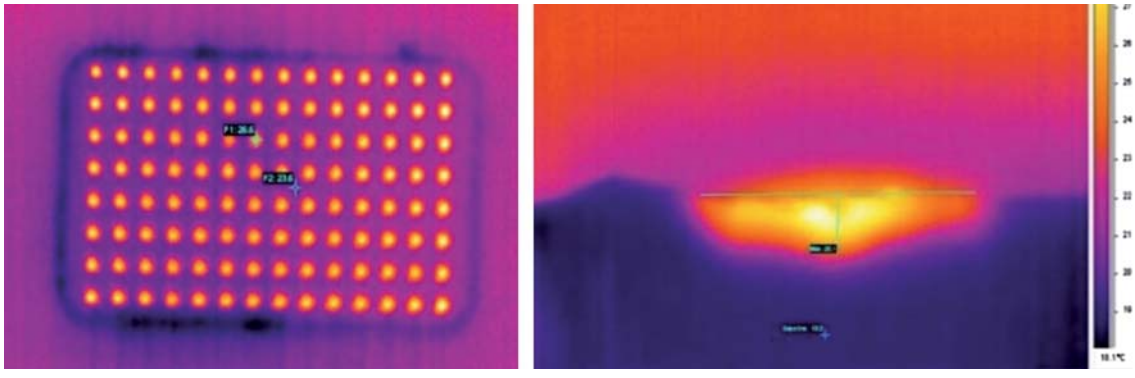

Figure 2. Thermal image of the FSR tip. Left: 112 contact points for fractional skin resurfacing of the epidermis. Right: simultaneous volumetric heating to a depth of 2.9 mm.

Table I. Scale of clinical improvement.

0	No improvement
1	1–25% improvement
2	26–50% improvement
3	51–75% improvement
4	76–100% improvement

high-resolution digital photography in order to allow comparison and assessment of skin texture improvement following treatment.

Topical anesthesia (EMLA) was applied 30 min prior to treatment initiation. Treatment area was cleaned thoroughly with a wet gauze (to remove lotion and makeup) followed by 70% alcohol. The skin was dried using dry gauze. The treatment tip was positioned area intended for treatment and an RF pulse was released. For the second RF pulse, the tip was repositioned next to the previously treated spot and another pulse was emitted. The procedure was repeated until the entire area intended for treatment was covered.

The use of a moisturizing cream (Ortho Dermatologics Topical Emulsion, Biafine) was recommended post treatment. Patients were seen for follow-up evaluation 1 week and 1 month after the treatment.

Clinical improvement and overall improvement in skin texture was assessed and graded by two physicians who were blinded to the study and the patients. Improvement was considered by baseline, pre-treatment photographs and photographs taken at 1-month follow-up visit. Evaluation of the clinical improvement was based on a quartile scale of improvement (Table I).

The safety of the procedure was also evaluated by monitoring the occurrence of potential procedure-related side effects. During the treatment, subjects were asked to rate their overall pain level on a 3-point scale (mild, moderate and severe pain). In addition, the treated areas were visually assessed for skin responses, including edema, erythema, hypopigmentation, hyperpigmentation and textural changes following treatment. It is expected that following a skin resurfacing procedure, the skin is red for a few hours, and microcrusts are formed 2 days following treatment. Microcrusts usually disappear 5–7 days following treatment.

Results

In vivo animal study

Specimen slides taken immediately after treatment revealed arrays of small coagulative thermal lesions surrounded by undamaged epidermal tissue. Treatment pulses of 62 mJ/pin caused ablation of 200 μm and coagulation depth up to 300 μm, energy of 40 mJ/pin caused ablation of 150 μm and coagulation depth up to 200 μm and energy of 20 mJ/pin caused ablation of 80 μm and coagulation depth up to 120 μm (Figure 3). The area of non-coagulative volumetric heating cannot be seen on H&E stain. The histologies taken 3 days after therapy showed, in all energy settings, dry crusting over the treatment zones with full healing of the epidermis and dermis underneath (Figure 3). In the 14-day specimens, there was a replacement of the crusts/debris by a

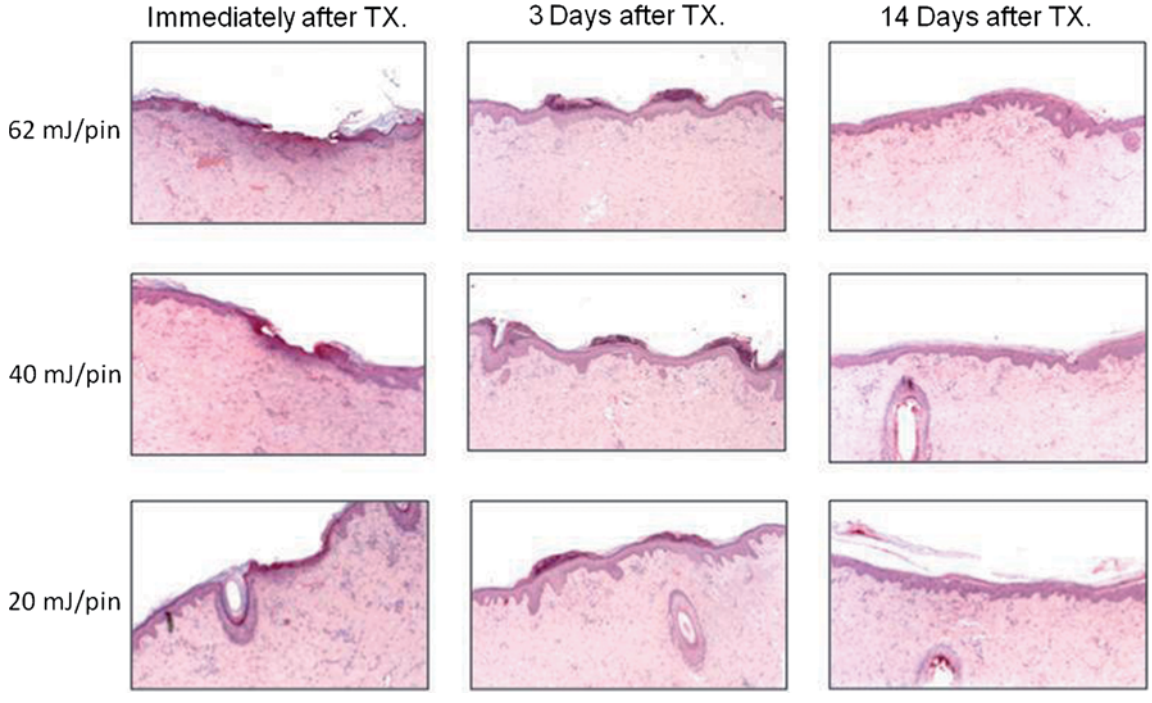

Figure 3. Histology of *in vivo* pig skin immediately, 3 days and 14 days after treatment. Ablation/healing timeline summary according to the different energies delivered. The area of non-coagulative volumetric heating cannot be seen on H&E stain.

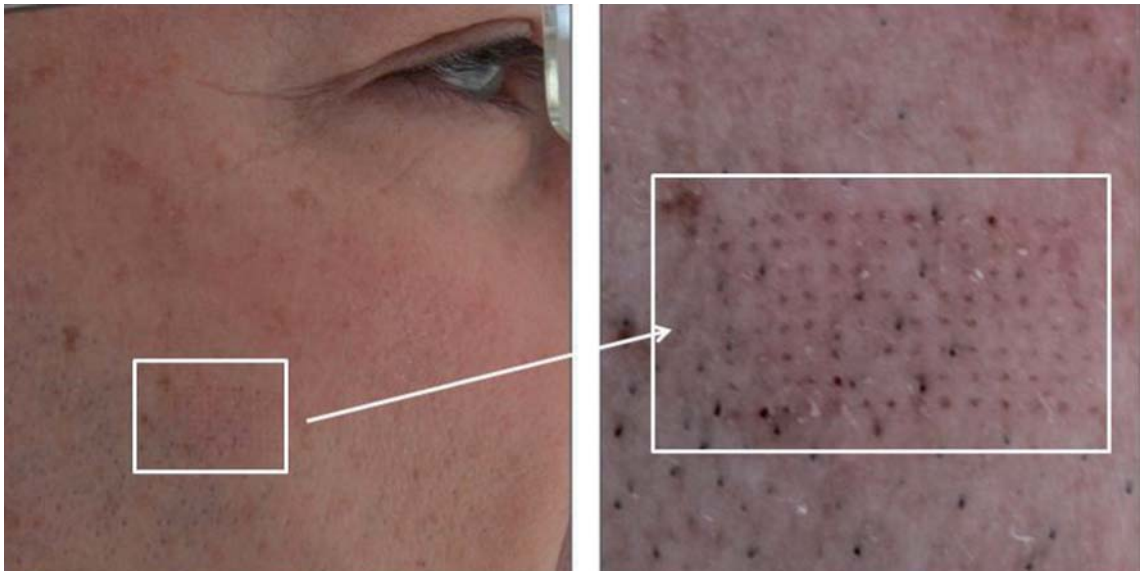

Figure 4. Appearance of small, dry, 300 μm crusts 40 h after treatment. These crusts resolve after 5–7 days.

normal-looking stratum corneum with complete healing of the epidermis and dermis (Figure 3). Analysis of the energy delivered to the skin versus ablation and coagulation shows a clear dose/effect relationship.

Clinical study

All 30 patients completed the course of the treatment protocol. All patients completed the 1-week and 1-month follow-up. No unexpected adverse side effects were detected or reported. As expected, patients' skin was red for a few hours following treatment, micro crusts formed 1–2 days following treatment and resolved within 5–7 days following treatment (Figure 4). In two patients, the crusts resolved after 10 days. There were no incidences of infections, scarring, hypopigmentation or any other serious complications. All patients showed significant improvement in skin texture as a result of the treatment (Figures 5–8).

Photographic analysis of pre and post treatment of the digital images was conducted by two blinded board-certified dermatologists, according to the generally accepted quartile skin improvement scale (9). Analysis, according to the quartile scale, revealed improvement in all (100%) patients according to both reviewers. Average clinical improvement at 1-month follow-up was 2.5 (± 0.78) according to the first reviewer and 1.83 (± 0.70) according to the second reviewer. Furthermore, analysis of the frequency of improvement degree revealed that both reviewers found that the degree of improvement was moderate to good (25–75% improvement) in most of the study participants (83.3% according to first reviewer and 66.7% according to the second reviewer). These results support significant improvement in skin texture as a result of the treatment.

Figure 5. Significant decrease in number and depth of deep perioral wrinkles with tightening effects over the cheeks and jaws. Before and 1 months after two EndyMed FSR treatments (3–4 W/20–40 msec) (20–40 mJ/pin).

Figure 6. Significant decrease in number and depth of atrophic and ice pick acne scars. Left: Before. Right: One month after one EndyMed FSR treatment (3–4 W/20–40 msec) (20–40 mJ/pin).

Discussion and conclusions

Thirty patients were treated for face wrinkle and acne scar improvement and were followed for 3 months following last treatment. In order to evaluate treatment efficacy, pre- and post-treatment photographs were introduced to two uninvolved physicians for blinded evaluation.

FSR, according to the treatment parameters investigated in this study, resulted in clinical improvement in the skin texture of patients with both wrinkles and acne scars. The incidence of complications was much lower than that seen following traditional ablative resurfacing (1,2,6). These findings are consistent with a recent study by Chapas et al. (7), who also examined similar technology for the improvement of skin texture (acne scarring).

Fractional resurfacing with RF results in dry microablation, thus downtime is shorter and the risk for side effects, such as infection, are minimal as compared to laser resurfacing methods that result in open wounds. Clinically, the affected areas are erythematous and mildly edematous after treatment, but resolve within a few hours. This rapid healing is likely related to the persistence of healthy unaffected tissue that remains between the ablated pulses after ablative fractional resurfacing (3,4).

The data reported in this study demonstrate that this FSR applicator of the EndyMed PRO system offers a safe and effective technique to improve skin texture. In our study, analysis revealed improvement (according to the quartile scale) in all patients according to both blinded reviewers. Furthermore, analysis of the frequency of improvement degree reveals that

Figure 7. Full correction in a deep atrophic acne scar. Left: Before. Right: Two months after 3 EndyMed FSR treatments (3–4 W/20–40 msec) (20–40 mJ/pin).

Figure 8. Significant decrease in number and depth of atrophic and ice pick acne scars (3–4 W/20–40 msec) (20–40 mJ/pin). (A: before treatment; B: at 1 month follow-up.) Full correction in deep atrophic acne scars. Two months after 3 EndyMed FSR treatments.

both reviewers found that the degree of improvement was moderate to good (25–75% improvement) in most of the study participants.

The intrinsic disadvantage of current laser fractional systems is the low volume of dermal heating (narrow laser beam) and the inability to differentiate between epidermal ablation and dermal heating. Fractional lasers must be used at a higher laser power in order to increase volumetric heating in the dermis. This will significantly increase epidermal ablation downtime and possible side effects, such as prolonged erythema and post-inflammatory hyperpigmentation. Decreasing laser power will provide good epidermal results with little or no dermal effect.

In conclusion, the results of this study clearly indicate that this innovative FSR applicator offers effective and safe face wrinkle and acne scar improvement. This technology provides the unique ability to treat epidermis and dermis simultaneously. Fractional microablation for skin texture at the epidermal layer and significant full volume dermal heating for collagen remodeling of aged skin and atrophic acne scars at the dermal layer are the mechanisms of action of this therapeutic approach.

Declaration of interest: Neil Sadick, Honorarium. Sato, no conflict of interest. Harth, stock holder and salary. Hila and Ido, salary. Palmisano, no conflict of interest.

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